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# The protection of mental privacy in the area of neuroscience

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Societal, legal and  
ethical challenges

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STUDY

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# The protection of mental privacy in the area of neuroscience

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## Societal, legal and ethical challenges

Advances in (neuro)technological development have led to an increase in the use and accessibility of neurotechnologies (NT), allowing brain activity to be recorded, analysed and manipulated by neurotechnological devices. While they were originally used only for clinical purposes, they are becoming more and more attractive for healthy populations willing to enhance their cognitive or physical abilities. Consumer-grade devices can be acquired and used by lay persons without supervision in work, education and entertainment environments.

This state of affairs raises a multitude of open questions and the possibility of threats to data security and privacy, as well as neuropsychological, ethical and societal implications. As a result, the Neurorights Foundation (NRF) was formed in 2017 to investigate and discuss these questions and make them visible to the public. This study addresses the NRF's claims and suggestions and evaluates the need for their proposed 'neurorights'. Disciplinary evaluations of the issues at stake are followed by recommendations and policy options.

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## Executive summary

Neurotechnologies are essential for the recovery and preservation of physiological and mental health and thus quality of life among clinical patients. However, technological advances and research findings have led to these technologies being applied outside the clinical domain. For example, cognitive enhancement is being used in work, education and entertainment environments, for which consumer-grade devices can be bought freely on the market and used without supervision.

As devices can be hacked and data is mostly stored in business-owned cloud services that are mainly located outside the EU, the question of data security arises. Hacking attacks can cause psychological and physiological harm and threaten the mental identity of users. Their use in work and education environments requires explicit consent and strong regulations, as there is a danger of burnout, rising stress levels, and misuse by authorities as well as private enterprises. Also, the high reputation of neuroscience, combined with the immense seductive power of neurotechnological devices, make them inseparable from 'neuromyths' and 'neuro-enchantment'. This also makes users of neurotechnologies highly prone to manipulation.

The non-profit 'Neurorights Foundation' was founded in 2017 to address these questions and possible threats by raising public awareness and campaigning for ethical neurotechnologies. As part of their mission, the Foundation proposes the following five 'neurorights': 'the right to mental privacy', 'the right to personal identity', 'the right to free will', 'the right to equal access to mental augmentation' and 'the right to protection from algorithmic bias'. These rights are closely linked to justice for the individual, as they indicate which interventions and restrictions on the individual are considered unjust. This necessarily applies not only to isolated individuals, but to all individuals within a socio-political structure, which gives prominence to aspects such as solidarity, co-determination and equality.

However, it is unclear how the neurorights called for by the Neurorights Foundation will be regulated, and our initial analyses have shown that the rights enshrined in the European Convention on Human Rights and the Charter of Fundamental Rights of the European Union may well provide a suitable legal framework. Instead, if new human and/or fundamental rights are introduced, existing rights might be restricted, and new regulatory gaps might emerge. Additionally, there is a lack of established case law for new rights. It is therefore advisable to consider addressing the challenges of neurotechnologies through regulations and directives.

Based on these findings, we make the following recommendations:

- (i) Investigate technology-centred risk evaluations to complement the risk evaluation in the AI Act.
- (ii) Track public communications on neurotechnologies to promote fair communication on their benefits but also on their limitations and risks.
- (iii) Discontinue formulations of neurorights at the level of human and fundamental rights and promote more specific and practically applicable legal formulations.
- (iv) Fund research to fill gaps in the existing literature.
- (v) Support EU neurotechnology providers by implementing a legal basis and thereby preventing data distribution on non-European servers.
- (vi) Investigate whether general standards for neurotechnological devices are sufficient or if new standards should be created.

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## List of abbreviations

BCI	Brain Computer Interface
DBS	Deep Brain Stimulation
ECJ	Court of Justice of the European Union
ECtHR	European Court of Human Rights
EU	European Union
NF	Neurofeedback
NGO	Non-governmental organization
NRF	Neurorights Foundation
NT	Neurotechnology/Neurotechnologies
OECD	Organisation for Economic Co-operation and Development
tES	transcranial electric current stimulation
TMS	transcranial magnetic stimulation
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization

## 1. Introduction

By the means of modern **neurotechnologies** (NT) brain activity can be recorded, analysed, and manipulated for the purposes of rehabilitation of a clinical population or augmentation of a healthy population. Originally, NT were merely used in the medical and therapeutical domain but because of the recent (neuro)technological developments, an increase in access and portability, as well as the successful application in a clinical population, those technologies have become interesting for augmentation purposes in a healthy population (Abdulkader et al., 2015). This is to either increase cognitive skills, relaxation and self-care, support in everyday tasks in smart-home applications, or for mere entertainment purposes such as to control video games via brain activation. NT are an indispensable element for the recovery and preservation of the physiological and mental health and thus quality of life of clinical populations. But since those technologies are manufactured and distributed as consumer-grade devices that can be bought and used by laypersons on an everyday basis with barely or even no supervision, numerous threats arise.

The use and processing of personal data of such devices raises several concerns and entails a multitude of open questions on possible moral and psychological implications, safety hazards, and data security. While single examples of NT may seem to be highly relevant for the individual considered in isolation, work and school environments may also be affected by the individual use of these technologies and societal and more widespread implications arise. There are first considerations on using NT in workplaces or in schools to increase productivity through attention monitoring. Consumer-grade devices are rather easy to use and follow the principle of 'plug-and-play'. As a result, new norms may need to be established. The optimisation of the self is taking primacy over other organisational and institutional goals at the expense of other social values and relations. It begs questioning how a society's notion of disability is co-constructed through these technologies. However, not all NT work superficially. Some of them need to be surgically implanted on or within the brain. The differences in invasiveness, risks, complications, side-effects, and degree of commitment to the product required by invasive and non-invasive NT is not clear to the public.

The implications and consequences of both NT methods are manifold and differ drastically. From an ethical perspective, it is necessary to devote particular attention to NT, as its genuine field of action is the brain. Interventions and manipulations on the brain harbour immense disruptive potential insofar as they influence the autonomous actions and self-perception of the individual. Furthermore, in the case of devices used for performance enhancement beyond medical applications, it is important to consider what changes they can trigger within society, what dependencies they create and to what extent and at what price these devices offer any improvement of people's lives in real terms.

In 2017 a group of researchers founded the predecessor of the Neurorights Foundation (NRF), an organisation dedicated to elaborate and deal with all these arising questions and spread awareness on NT-related threats. As a main future goal, they propose neurorights that should protect NT users from data misuse and protect their mental privacy. Precisely, the following five neurorights are proposed: 'the right to mental privacy', 'the right to personal identity', 'the right to free will', 'the right to equal access to mental augmentation' and 'the right to protection from algorithmic bias'. These rights will be analysed as the wording has changed since 2017. In our study, we will focus on the right to mental privacy although at times not exclusively. As the NRF names the neurorights 'human rights' a closer look will be taken to the existing human rights framework and the existing primary and secondary EU law.

Disciplinary studies in the fields of neuropsychology, sociology, ethics, and law will investigate and evaluate the topic of NT with its benefits and possible threats. They will address the aims and goals

of the NRF and its proposed neurorights and put them in relation to existing laws. Afterwards, we will present a synthesis of our findings in the form of the examination of four concrete use cases.

The results of those use cases provides the basis for the formulation of recommendations as well as policy options and their assessment.

## 2. Methodology

This interdisciplinary engagement with NT combines different methodological approaches and builds on the strengths of each perspective. The study is desk research-based and will bring together literature from each discipline to allow policy makers to make a well-rounded assessment of the efficacy, threats, and potentials of different types of NT in relation to individuals, certain socio-demographic groups and for specific social domains. This will provide policy makers with a comprehensive view on NT and their neuropsychological, legal, ethical, and societal implications.

### 2.1. Terminological assessment

To establish common ground on shared terminology, we will first identify important terms in key publications from the NRF. The sociological study will then apply these keywords as thematic codes for the further literature study. The neuropsychological team, in addition, will produce a list of technical definitions of NT so that the assessments from the different disciplines are technically accurate.

Starting from this shared understanding, the individual disciplines will employ their own methodologies to answer their research questions and meet their research objectives. In general, this is a literature study that systematises and integrates insights from each perspective. Where specific methods will be applied, these will be elucidated in the individual section. In the following subsections, we will briefly outline the individual sections' approach.

### 2.2. Methodology: Neuropsychology

To introduce and discuss state-of-the-art neurotechnological methods, the neuropsychological part will conduct a scientific literature review and research claims and promises of consumer grade devices to put them into comparison. This literature review involves a characterization of NT regarding their degree of invasiveness, degree of commitment required by the NT from the user, as well as the quality and quantity of evidence regarding the efficacy and specificity of the typical outcomes related to each NT. Moreover, we will address aspects of public communication of findings about NT with a focus on the occurrence of imprecisions and the so called 'neuro-enchantment', i.e. the influence neuro-hype wielding over critical thinking. To come to a synthesis in the end the neuropsychological part will also construct four possible use cases to use as a foundation.

### 2.3. Scoping review: Problematisation of neurotechnologies

Building on the systematisation of the state-of-the-art of NT, the sociological part will conduct a scoping review focussing on the ways different NT are envisaged to be used across three important social domains: education, work, and entertainment. In particular the review will focus on how NT are problematised and what kinds of (social) problems they are anticipated to address. Further methodological considerations will be explicated in the corresponding section below.

### 2.4. Methodology: Ethical assessment

For the ethical part, the literature in favour of establishing neurorights will be analysed in regard to the intellectual foundations found in the history of ideas (e.g. freedom of thought and conscience, privacy). Their conclusions are checked for blind spots and logical gaps. In addition, the proposed neurorights will be placed in the context of the human rights and fundamental values of the EU.

The ethical classification of NT in general will be based on a rudimentary technology assessment with a special focus on socio-ethical principles, which are concerned with the individual and their relationship to society.

## 2.5. Methodology: Legal assessment

The legal section will examine the neurorights proposed by the NRF by analysing in detail the publications available on the NRF website. This will be done to link them to the existing legal system at the level of human and fundamental rights as well as primary and secondary EU law. In the use cases it is shown that the proposed neurorights will not add value at the human rights level.

## 2.6. Synthesis

As this report progresses, we will conduct a workshop across the research team to formulate policy options and recommendations for the Members of the European Parliament. This will be informed by the research findings of each individual project, where we collectively identify discipline-specific gaps that are relevant for policy makers' consideration. It could potentially serve to identify the need for the introduction of new rights. Our consolidation culminates in the review of specific use cases. The use cases will be based on plausible scenarios (based on our research findings) and will then provide a solutions-based approach. These will involve both invasive and non-invasive NT in medical and non-medical context.

## 3. Neurotechnologies

### 3.1. Invasive neurotechnologies

The usage of invasive NT requires neurosurgical procedures where electrodes or stimulation devices are placed directly on or respectively within the brain. There are different degrees of invasiveness among NT. Electrode grids placed in the extradural space are less invasive because they do not perforate brain tissue and can be more easily removed. Sensors placed at the subdural space as well as those perforating the brain tissue (e.g. the Neuralink system) are considerably more invasive (Yadav et al., 2020).

#### 3.1.1. Types and application fields

One of the most frequently used invasive methods is Deep Brain Stimulation (DBS) which works with an implantable pulse generator (known as IPG) sending impulses to modulate brain circuits and measure pathological brain activity. It is mentioned to be one of the most important devices in clinical neuroscience developed in the last twenty years (Lozano et al., 2019). Its use is indicated for Parkinson disease, major depression, or obsessive-compulsive disorder among others (Cagnan et al., 2019). The usage has been increasing over the years and it is estimated that 244,000 devices have been globally implanted (Wong et al., 2022). Still, it is poorly understood how DBS works exactly and which neural effects it causes (Zarzycki & Domitrz, 2020).

Next to the DBS, implantable Brain-Computer Interface (BCI) systems are another frequently used method in this field. They can record and interpret brain activation via electrodes placed on the brain and give patients the opportunity to communicate and move through brain activation without muscle activity in patients with for example Amyotrophic Lateral Sclerosis (AMS) or tetraplegia (Abdulkader et al., 2015). Patients can learn how to control devices with controlled brain-activation patterns via individually adapted systems, entailing several days, even weeks of training. Hence, trained BCI-systems are only specialised on the respective user (Abdulkader et al., 2015). Not only computers and neuroprostheses can be controlled, but researchers also made it possible for patients with implanted BCI devices to feel touch and sensation with fully robotic arms (Ganzer et al., 2020).

#### 3.1.2. Advantages and disadvantages

In invasive NT, relevant neuron assemblies can be directly stimulated and recorded with a high level of precision and specificity. It is also free from artefacts resulting through the barrier of skull, skin, hair, and muscle activity. With such invasive methods, deeper brain areas that cannot be recorded superficially from the scalp surface can be reached (Manahan-Vaughan, 2018). Also, DBS is often described as somewhat reversible technology, where switching off the pulse generator results in the resurgence of original cognitive and motor symptoms (Alomar et al., 2017). However, the surgical procedures necessary for the implantation of invasive NT devices are not without any potential risks. They can be divided into four groups: perioperative (e.g. seizures, haemorrhages), postoperative (e.g. hematoma, behavioural changes), technical (e.g. electrode failure, malfunctioning of pulse generator) and stimulation-induced side effects (e.g. dysarthria, confusion) (Baylis, 2013). However, besides those physiological side effects, several psychological consequences also threaten the patients of invasive NT methods. Since those invasive devices influence core aspects of the individual self, they can cause considerable levels of stress and fear as well as distortions of self-representation and feelings of agency. Some patients report personality changes and self-estrangement when experiencing the changes associated with brain stimulations (Baylis, 2013). However, such reports cannot solely be ascribed to the stimulation devices themselves but more as a secondary phenomenon due to treatment adjustments (Baylis, 2013). Symptom changes after years of living with a chronic illness, such as a sudden reduction or even

elimination of symptoms, risky surgeries, the resulting reactions of the surroundings of a patient can influence personality factors of patients (Gilbert et al., 2017). This makes a proper (mental) preparation of the users indispensable. There are attempts for presurgical training with the support of virtual reality (VR) (Iamsakul et al., 2017). However, indirect positive effects of DBS on learning and memory have been reported in patients with implants (Suthana & Fried, 2014), while others report impairments in executive functions (Martínez-Martínez et al., 2017) and verbal fluency (Ehlen et al., 2014).

All the possible risks and complications of such surgeries are also the reason why invasive NT hitherto have a very restricted scope of use in case of ultimate medical necessity and not for entertainment or enhancement in healthy participants. For healthy populations, non-invasive methods are the primary choice. However, there are attempts of Elon Musk's enterprise 'Neuralink' to change the regulation to limit invasive devices to a clinical population to implant Neuralink chips in the healthy human brains for enhancement purposes. While this was rejected by the US Food and Drug Administration (FDA) at the beginning due to safety risks, they approved Neuralink chips for the tests on a clinical population (PRIME Study; Neuralink's Clinical Trial) in May 2023 after preliminary animal trials (Drew, 2024). On their website, Neuralink even propagates this 'clinical step' as a means to an end to obtaining permission for implants in a healthy population (We raise legal, ethical and social issues related to this example in [Use case 1: Invasive NT for patients with](#), below).

## 3.2. Non-invasive neurotechnologies

Other than invasive NT, electrodes or optodes of non-invasive NT devices are only superficially attached to the scalp via for example electrode caps or headbands, to measure electric current fluctuations on the scalp (Angrisani et al., 2017) or changes in brain oxygenation of cortical regions (Mihara & Miyai, 2016). Further, the brain can be non-invasively electro-magnetically stimulated via transcranial magnetic stimulation (TMS) and transcranial electric current stimulation (tES). Neural activity can hereby be modulated by applying small doses of a magnetic impulse, direct current, alternating current or electric stimulation with random noise (Cinèl et al., 2019).

### 3.2.1. Types and application fields

One very popular example of non-invasive methods that use those NT is Neurofeedback (NF). NF is a specific form of biofeedback, where users learn how to modulate their own brain activation by getting it fed back visually, auditory or in a tactile manner. It has been previously used in interventions to reduce attention deficit hyperactivity disorder (ADHD) symptoms, to strengthen and train cognitive functions in for example stroke or multiple sclerosis patients among many others (Marzbani et al., 2016). There are also non-invasive BCI applications where users learn how to control external devices, such as prostheses or spelling devices for speech production (Guy et al., 2018). Also available are consumer devices for neurostimulation, where manufacturers promise to reduce depression<sup>1</sup> or increase attention and focus<sup>2</sup>. Another method that relies on non-invasive NT is the brain-to-brain-interface in humans (BBI or B2BI) (Jiang et al., 2019). Here, information is extracted from a 'Sender-brain' and delivered to a 'Receiver-brain', combining neuroimaging and -stimulation. That way, brains can directly communicate with each other. This ranges from very basic forms where participants 'receive' information from brain to brain from another person and give answers manually via a keyboard, instead of a mere brain activation-controlled device up to highly sophisticated ones where communication is solely based on NT (Rao et al., 2014). One example of such BBI system is the BrainNet device. Most of the previous set-ups were unidirectional with only a few allowing bidirectional communication between brains. However, this cannot be understood as

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<sup>1</sup> E.g. <https://www.flowneuroscience.com/>

<sup>2</sup> E.g. <https://www.getliftid.com/>

thought transmission between two people, but as some sort of classification task. The 'sender' either focuses on a 17 Hz flashing LED light or a 15 Hz flashing LED light. Focusing on either of them will lead to a slightly different brain activation, this pattern is recognized by the system and leads to a stimulation on the brain of the other person via an external device. Participants recognize this and can act accordingly. Also, in 2019 the first attempt to include more than two involved brains has been made with multiple senders and one receiver (Nam et al., 2021). This field of NT devices and inter-brain-communication is accompanied by the visions of rehabilitation support in a therapist-patient setting. Here again arises the question of mental privacy and security. Because of ethical and security concerns, this has only been attempted with non-invasive devices in healthy populations (Jiang et al., 2019).

Besides those clinical and experimental research applications, non-invasive methods are available for the general population. Commercially available consumer-grade devices can be bought and used without supervision of professionals by the everyday consumer. They are advertised for different purposes, such as relaxation (<https://chooseemuse.com/>) and cognitive enhancement. Cognitive enhancement refers to the enhancement of psychological, mainly cognitive abilities such as intelligence, attention, or creativity in healthy individuals (Nagl-Docekal & Zacharasiewicz, 2022). Accordingly, the natural limitations of humans should be overcome (Almeida & Diogo, 2019). This could be the increase/training of cognitive functions and neural efficiency such as executive functions, memory, language or visuospatial processing (Antal et al., 2022), but also the help to meditate/relax or engage in any other form of self-care practices. Also, they are also used in rehabilitation clinics for clinical populations, having experienced stroke, multiple sclerosis, or ADHD among others (Marzbani et al., 2016). However, the usage of non-invasive devices also includes some threats that are often overlooked but are known as problematic in the professional field of science.

### 3.2.2. Advantages and disadvantages

As non-invasive methods are only applied superficially on the scalp, only the cortex regions can be recorded and stimulated, but no deeper brain regions. Hence, also different application fields arise. External recording makes the signal of scalp-EEG very prone to body- and head movement and eye-movement artefacts (Wexler & Thibault, 2019). Further, when cables are pulled and mechanical pressure is applied to the electrodes the signal can be externally influenced. Therefore, EEG measurements obtained under more naturalistic conditions, in which users are allowed to move their eyes, heads and even the whole body naturally, are expected to be heavily contaminated with artefacts not easily distinguishable from brain activity. In comparison to eye-movement and muscle artefacts, brain-activity-related EEG data is very weak, and is found in the range of  $\mu\text{V}$ , as the signal has to make its way through scalp, dura mater, skin, and hair whereby the electrical signals from muscles are very strong and easily overlay the delicate brain signals. Accordingly, even very subtle frowning, blinking, laughing etc. disturbs the signal to an irreparable extent. This limits the possibilities of interactions and movement of the users and should be considered during the application. Unfortunately, in practice these problems are barely addressed at all. Near-infrared spectroscopy (NIRS) is more robust compared to scalp-EEG. It is a non-invasive NT that applies near-infrared to the scalp via optodes and measures the light that is not absorbed. Here, different parameters can tell whether specific brain areas have oxygenated or deoxygenated blood. With this method one can infer activity levels of brain areas. NIRS is not so much affected by movements, however it is very sensitive to bright environments.

One of the main problems in the field of commercial NT is that only little is known on possible negative side-effects. This flaw has been recognized by the scientific community (Ros et al., 2020; Thibault & Raz, 2017) but has not impacted the way these interventions are advertised and implemented yet. Scientific publications primarily report anecdotally on whether effects were reported by study participants or not, but rarely multiple different aspects of cognitive functions are

tested and reported (Kober et al., 2015; Thibault & Raz, 2017). But even if rare, there is some evidence that for example training of NF can result in adverse effects for the users. This has been found in a NF training where its influence on memory performance was checked and one feedback group showed a decrease in performance in short- and long-term memory after the training (Kober et al., 2015). This could be due to re-allocations of cognitive resources during the training process, meaning an increase in one domain goes hand in hand with a decrease in another (Sturm et al., 1997). Accordingly, Iuculano showed in a stimulation study with transcranial electric stimulation (tES) that cognitive enhancement via stimulation shows impairments of cognitive functions depending on the function that should be enhanced and the stimulated brain region (Iuculano & Cohen Kadosh, 2013). What is more as longitudinal studies, as well as follow-up studies are scarce, barely any long-term effects are known yet in relation to possible adverse effects of non-invasive NT applications. Studies mostly go over the course of several weeks and it is not clear whether longer and regular usage over several months up to years can have adverse effects. This is especially problematic, since some of those applications, such as NF, are already used on a regular basis in neurotherapeutic settings and are advertised for daily use for healthy populations. Another problem is the unreliability of commercial EEG systems with bad data quality. The functioning and feedback of NT data is only as good as the technical specifications the devices allow. When cables are not well isolated, artefacts are not subtracted out, environmental noise is not referenced out properly such as power line hum, then the classification algorithm puts all this noise into its calculation and no proper feedback can be given. Devices advertised for enhancement and augmentation alone are superficially regulated, so that no strong obligation exists to measure brain signals with a minimum level of quality. Several commercially available devices are prone to primarily record artefacts. Head bands such as Emotive or Muse seem to be recording more facial artefacts than brain activation as electrodes have to be placed directly over facial muscles (Whitham et al., 2007). Dry electrodes are preferred over wet electrodes, which have greater noise levels and show greater impedances (Mathewson et al., 2017). So, it remains open if that can also result in adverse effects. Thibault and Wexler concluded in their review on consumer devices that there is only little evidence that they actually record brain activity or reflect the brain states and activities they are claiming to measure (Wexler & Thibault, 2019).

Also, severe problems with algorithmic bias have been common in the EEG NF practice for decades, without raising much interest of practitioners and researchers (Hamilton-Bruce et al., 1991). The so-called quantitative EEG (qEEG) is supposed to be a set of norms to evaluate the brain activation patterns observed in specific individuals and decide about the need for intervention and treatment. QEEG (aka 'neurometry') is described similar to traditional psychological diagnostics. As shown in a recent Monte Carlo study (Wood et al., 2024), qEEG does not have the same properties as usual psychological instruments but is rather prone to yield false-positive diagnostics of abnormalities in the EEG. Crucially, the stability of the measurements obtained with qEEG is in practice much lower than expected from the reported test-retest reliability scores usually reported. Scores obtained at a given measurement may diverge dramatically at a next measurement just by force of randomness. The combination of (i) a high proneness to produce false-positive values combined with the (ii) low stability of the scores is particularly problematic, for it indicates the initial presence of an abnormality in the brain waves, which requires NF training, and its spontaneous remission at a second measurement, which is taken typically after several sessions of NF training (Wood et al., 2024).

### 3.3. Discrepancies of research and practice

An issue that we face in the domain of consumer NT applications is the great discrepancy between what is promised by manufacturers and therapists and what is scientifically underpinned. There are several meta-analyses (Loriette et al., 2021) and reviews showing efficacy in the complementary treatment of ADHD symptoms (Riesco-Matías et al., 2021), depression (Fernández-Alvarez et al.,

2022), cognitive enhancement in healthy (deBettencourt et al., 2015) and clinical (Breteler et al., 2010) populations or improvement of symptoms in chronic pain (Haller et al., 2013). Nevertheless, efficacy is still disputed with hindsight of possible placebo effects. Several studies showed no differences between sham and real treatment protocols in NF trainings (Schabus et al., 2017), introducing the question of a possible super placebo (Thibault et al., 2017) and possible explanation (Witte et al., 2018) attempts against this. Still, NF practitioners in the EU have a generous freedom of interpretation regarding what is supposed to be scientific evidence of efficiency of NF treatment.

Also, discrimination is, as elsewhere already manifoldly stated, a serious problem in the field of BCI. Not only because of factors of ethnicity, socio-economical state, affordability and availability of devices but also on a usability level. About 30% of all the BCI users are not able to willingly alter their own brain activation and are so-called non-responders. This issue is defined as BCI-illiteracy and the reasons are multifactorial but not yet well understood. One reason might be that feedback designs aren't appealing/engaging enough, too little focus/attention/motivation from the users but also some reasons might be of brain-morphological nature and cannot be influenced by users or practitioners (Allison & Neuper, 2010; Thompson, 2019). Brain structure is very individual, and it can be that neuron assemblies necessary to control a BCI system are hidden in sulci or are 'drowned' by louder neuron assemblies nearby. Some signal patterns also inter individually vary in their intensity and amplitude, hence for some BCI applications such signal patterns can be too small to be recognized. Hence, some methods are more suitable for specific users than others, still only little is known about this issue. This is something that is not yet communicated in clinical practice, wherefore clinicians are not even aware of this problem as it is not part of their formal training as NF practitioners (Thibault et al., 2018). Moreover, commercially available systems do not inform about this as well. Again, about one hour of NF training in a clinical office is very expensive. So, while it is clear that NF and BCI-systems are useful and powerful tools, the precise mechanisms of action still need to be investigated more in double-blind sham-controlled studies with long-term prospects.

Still, consumer-grade devices overlook such open questions and set up untenable promises.

### 3.4. Cybersecurity and privacy

One of the main ethical and legal concerns of the use of NT is, as with any other modern and digital technology, the risk of Cyberattacks and being hacked. This not only accounts for invasive systems but equally, or especially, for non-invasive systems. NT handles a multitude of sensible user data, namely brain data, personal information about possible health issues, concentration etc. This could lead to extraction of PIN (Martinovic et al., 2012), data and identity theft (Li et al., 2015). In 2016 a research group termed this threat as 'brainjacking', describing the *'ability of attackers to exert malicious control over brain implants'* (Pycroft et al., 2016). They describe two different categories of attacks, blind and targeted attacks and state an increase in potential attack methods alongside an increase of complexity of invasive NT therapies.

Adaptation of DBS protocols can be done wirelessly. Wireless data transfer can pose a security hazard. A research group under Sundararajan tested the security of a commercially available portable EEG system 'Emotiv Insight' that can be used with a smartphone app (Bernal et al., 2022). The device worked with Bluetooth Low Energy and the research group were able to perform a *man-in-the-middle attack*, enabling it to force unwanted tasks on the BCI to intercept and modify information. Intercepted data could also be modified and sent back to the Emotiv system or data transfer to the system could be blocked, so that the device could not connect to the smartphone. Such attacks are even possible when data is encrypted. Data can be saved and private data can be obtained. When it comes to smartphone-based BCI applications, the risks already originate in smartphone safety issues. Private data can be accessed, transferred and analysed so that hackers can attack users of BCI devices (Li et al., 2015). While the effects are neither lethal nor assumed to be

of long-lasting effect, they are unpleasant and have a high risk of psychological burden (Pycroft et al., 2016).

Several countermeasures have already been proposed, some of which are regular firmware updates, the standardization of the manufacturing processes of the NT devices and loggings as well as bug reports. Also, the firmware of most IPGs is designed in a way that problematic and dangerous stimulation parameters are locked out. It remains open whether attackers can bypass such rules. A summary of attack types can be found at (Pycroft et al., 2016). Most of these issues are more problematic and relevant for invasive NT devices. For those we distinguish between recording and stimulating devices. Devices for recording primarily pose the risk for data theft and data security as seen above or device manipulation so that it does not work properly anymore. However, there are also situations in which technologies conceived to work as a recording device can be manipulated to work as a stimulation device and vice-versa. The exploration of these scenarios is decisive to mitigate effects of the so called neurocrime (Ienca et al., 2022). However, until now, no brainjacking cases have been noted outside the research setting. What has previously been recorded is malicious control of implantable insulin pumps and cardiac defibrillators (Markosian et al., 2020).

### 3.5. Neuro-enchancement and manipulation

Post-industrial societies have neuroscience in high account because of the properties culturally attributed to the brain. The brain is seen as the material site of the self and the individual mind. Accordingly, the patterns of activity measurable in an individual brain and the opportunity to interact directly with the brain are seen as a privileged (Littlefield, 2018). The high reputation of neuroscience and its seductive neuro-devices (Giattino et al., 2019) does not prevent the perpetuation of the so-called 'neuromyths', i.e. beliefs about the brain enjoying high popularity despite being scientifically wrong (van Elk, 2019). This is called 'Neuro-enchancement' in the literature, termed by Armin Raz and his colleagues (Ali et al., 2014).

Beyond resilient incorrect beliefs, some forms of reasoning seem to be impervious to scientific facts. This phenomenon has been named 'intuitive metaphysics' and describes how an intuitive commitment to specific beliefs such as that of free will may prevail over scientific evidence during decision making. Peoples' intuitive ideas about an indeterminist free will are imported into and intrude with their representation of neuroscientific scenarios (Rose et al., 2017). In an experimental scenario, participants were confronted with a hypothetical scenario in which scientists perfectly and deterministically predicted the behaviour of a person. Even in face of this information, participants were still convinced that even in a perfect prediction scenario those persons could decide differently and according to a free will.

This phenomenon poses a significant problem which is mostly overlooked. Neuro-enchancement describes that people are more likely to believe in products that advertise the ability to measure, stimulate or otherwise interact with the brain (Ali et al., 2014). This is shown by the multitude of products even unrelated to neuro, like the NEURO Roundbrush, NeuroGum, Neuro Water or NeuroSocks that can be bought in shops and online. This persuasion even works when participants are university students trained in neuro-methods and hence know about the fact that products like this cannot scientifically work. Even though engineer students knew mind-reading is impossible, they still were not more suspicious about an alleged mind-reading machine (Ali et al., 2014). Further, Olson and colleagues could show that when participants would be made to believe that a machine could read their attitudes towards a topic, they would rather believe the machines assessment of their individual attitudes over their own (J. A. Olson et al., 2023). Studies like this show impressively, how easily the human mind can be manipulated through NT, despite the fact that it was only in a simple experimental setting. Those are similar effects resulting from magic tricks, where magicians can influence the decisions of an audience in 98% of the time (M. C. Olson et al., 2023). Further, they conducted a study where they set-up the experimental setting of telling the participants of a

machine that could influence their thoughts. In decision-making tasks this led to a reduced feeling of agency in the participants and longer reaction times (M. C. Olson et al., 2023). This raises the question on how marketing campaigns and consumer-grade NT systems can influence our decisions and attitudes and the feeling over our own agency and perception of free will. This calls for studies similar to those from Armin Raz and Jay Olson to better evaluate possible problems of NT and how to solve them. Experiments like this show the threat of NT devices to the assessment ability of its users. One can only speculate how such manipulations would work outside the experimental setting on lay people with no prior knowledge on neuro-related topics.

Such blind trust in NT devices can have fundamental consequences. In India, Brain Electrical Oscillation Signature Profiling (BEOS) has been used for interrogating alleged criminals similar to a polygraph test in court, even though reliability was by no means proven (Conitzer et al., 2019).

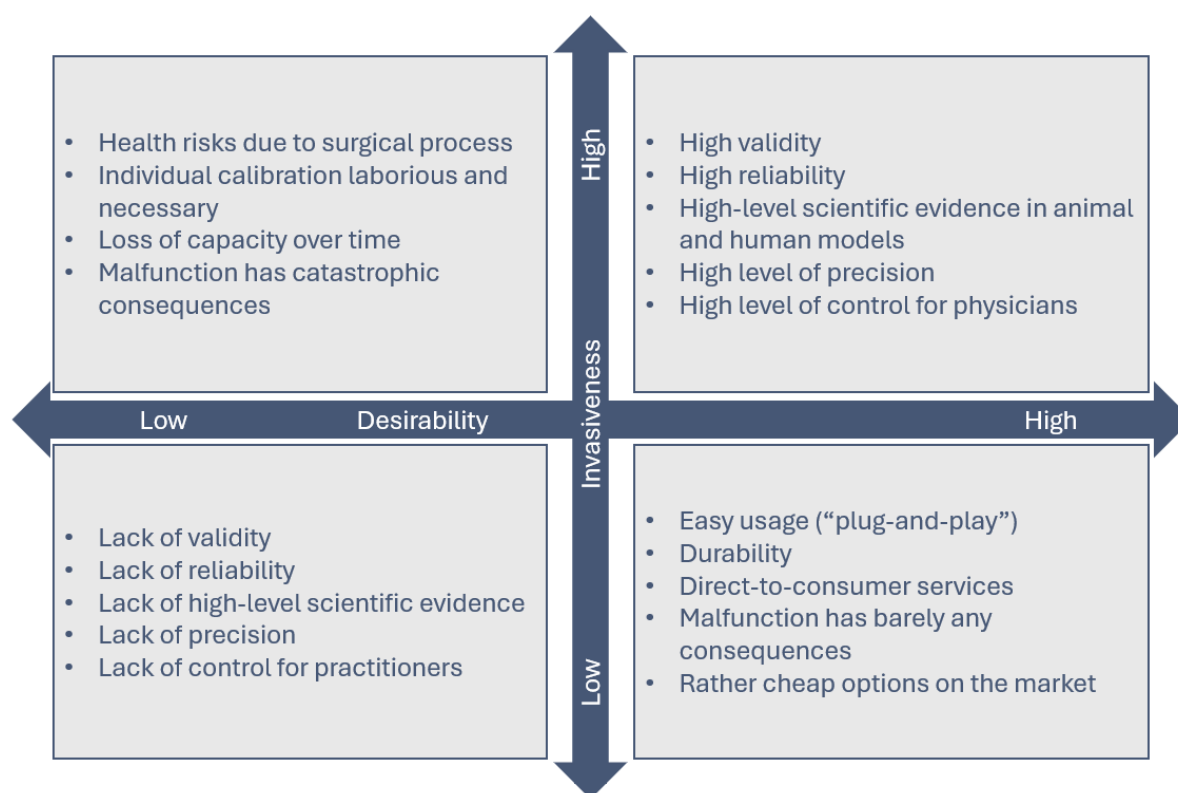
The high degree of desirability of promises made by NT regarding a privileged interaction with one's own brain blurs critical thinking. This is crucial regarding the decision making that should be based on more specific properties of these specific technologies. As we reviewed above, a distinction between invasive and non-invasive technologies can be made and is useful, since their properties and capabilities differ considerably. In public communication about NT these differences are often blurred and favour a specific mechanism we call here transfer of reputation across invasive and non-invasive NT. The comparison of the typical properties of invasive and non-invasive NT reveals a complementary pattern of desirable and undesirable properties of both types of NT. In the following, we present in Figure 1 the transfer of reputation occurring between invasive and non-invasive NT, and how the perception and judgement of laypersons and specialists can be influenced by their coexistence. Transfer of reputation, as its name reveals, describes a confusion between properties of different groups of technologies, which typically leads to a blend containing only positive characteristics (Desirable Properties, Figure 1) and concomitant neglect of negative characteristics (Undesirable Properties, Figure 1). The focus on the blend of positive characteristics is potentiated by an optimistic tune frequently seen in public communication regarding NT. In a positively framed context, desirable properties of NT receive substantial attention, while undesirable properties remain mostly unattended. Moreover, failure of these technologies is easily forgotten or rephrased as a success. One example was that of the exoskeleton worn by a paraplegic patient, who was in charge of starting the World Cup in Football 2014. Although the exoskeleton employed was not much different from several other models available at that time and although several aspects of the demonstration of the prototype did not work as planned, the public memory of the event is that of a huge breakthrough and a complete success.<sup>3</sup>

Another example is given by the adoption of vocabulary to resignify events. Kober et al. (2023) investigated the public communication on NF. One of the outcomes of that study was the identification of reactions to specific events, such as the publication of critical reviews. One such event was observed in the years 2016 and 2017 in response to high profile criticism of the low level of scientific evidence about most NF uses on the market. Kober et al. observed the appropriation of a specific concept -'evidence-based practice'- in the Twitter communication about NF (Kober et al., 2023). Interestingly, in public communication the label 'evidence-based practice' was used improperly to rebrand old and poorly controlled studies as 'evidence-based practice'. Such appropriation of vocabulary has been observed in public communication on different topics such as terrorist attacks (Garcia & Rimé, 2019) and reflects more a cultural adaptation to specific events than necessarily a change in scientific practice.

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<sup>3</sup> See: <https://www.livescience.com/46317-world-cup-paralyzed-man-exoskeleton.html>.

Figure 1 – Transfer of reputation between invasive and non-invasive neurotechnologies



### 3.6. Findings from a neuropsychological perspective

NT are an indispensable tool in the field of rehabilitation and medicine. They allow disabled people to participate in everyday life and regain autonomy over their actions. But also the healthy population can profit from NT in the domain of cognitive augmentation. However, while the application fields are already intensely discussed, research on possible side-effects and the scope of benefits lags behind. There are several concerns in this field that need to be discussed. One of which is the big discrepancy between the consumer market and application fields and what is already scientifically underpinned. Further, due to the inherent persuasiveness of NT, users may be tricked into believing in technologies that do not work the way promised and hence run the risk of being manipulated. Promoting NT literacy is an important step to educate users, manufacturers and practitioners to enable a safe usage.

## 4. Social implications of neurotechnologies

Up to now the predominant societal domain of application for NT is in healthcare. Many of the arguments brought forward by the NRF (Andersen, 2023; Goering et al., 2021; Ienca & Andorno, 2017; Yuste, 2017; Yuste et al., 2021) and others are about the (potential) benefits of NT to support the management of different mental health conditions. Overall, NT are anticipated to support a number of conditions, such as Parkinson's for stopping tremors, stroke rehabilitation, Alzheimer's, OCD and addiction. For those suffering with PTSD NT are anticipated to enable affected people to narrate difficult memories. This could pose, according to the NRF, issues for people's sense of identity and formation of a moral conviction as traumatic memories play a part in developing one's sense of morality. Furthermore, through the processing of traumatic incidents, it may be difficult to determine what patients want to do with these. Similarly, in the treatment of depression, the Foundation identifies issues related to the concern of 'identity'. It sees the possible disruption of people's sense of identity and agency as highly problematic as it can destabilise people's sense of self and personal responsibility. As such, it has implications for legal and moral subjectivities too as it is not clear to distinguish between conscious intent from the self and intent supported or influenced by a NT. As general areas of application, the Foundation posit the ability to share images, thoughts and words between people through the use non-invasive BCIs as a possible use case. Similarly, the ability to translate thoughts to text is mentioned. Here, the NRF problematises 'mental privacy' as an area of concern since neural data is made visible to others.

In this section we turn to the societal implications of NT. This means we are less concerned with a psychological perspective on a person's sense of self and identity, legal considerations about human rights or ethical implications for dignity and more interested in the ways in which NT may transform social roles, relations, practices, norms and values across a whole spectrum of social domains. To do this, we present our analysis of how NT are anticipated to be used in other social domains than healthcare. This demonstrates that NT are not only considered (problematic) *tools* for the medical profession, but visions of their potential application extend beyond health. As such, they have socio-political and socio-cultural implications for how we live as a society. To do so, we focus on three domains: Education, Work and Entertainment.

- **Education:** The education sector is susceptible to many technological transformations (Jarke & Breiter, 2019). The possible development and use of NT in educational settings raise fundamental questions on the purpose and meaning of education, how learning is understood and what competencies future students need to be equipped with (Macgilchrist et al., 2024; Rahm, 2023a).
- **Work:** The potential negative and positive implications for workers and businesses when it comes to the development of NT require to be carefully assessed. Due to labour's centrality in many peoples' lives, the particular and unique risks that arise in workplaces (Moradi & Levy, 2020) and the ever-increasing blurring of boundaries between the workplace and the private sphere (Gregg, 2011), we assess the implications of NT in workplaces.
- **Entertainment:** While risks and opportunities may be underestimated in the domain of entertainment, this domain also has implications in how technologies come to be 'normalised' and introduced in people's lives.

To analyse the social implications of NT, this section is structured as follows. First, we demonstrate how the introduction of data-driven technologies in education, work and entertainment have raised challenges and harms for different affected actors. We then proceed to analyse for each of these domains how the NRF anticipates the possible uses of NT, how users and use contexts are imagined and what they articulate as potentially problematic. The anticipations of the NRF are then compared to what other scholars have presented as potential uses, imagined as users and use contexts and problematised. The analysis is based on a literature review of relevant state-of-the-art publications.

Analysing these domains allows us to consider a range of technology-induced transformations and societal implications (which a mere examination of the health domain would not warrant). We close with a discussion on the differences and similarities between the domains, and also the gaps that we have identified between what the NRF has brought forward and what the wider academic community considers relevant.

## 4.1. The power of narratives shaping technology and policy development

A sociological engagement with NT allows us to assess the discourses, narratives and imaginaries that surround NT and their implementation across different settings. This 'talking artificial intelligence (AI) into being' (Bareis & Katzenbach, 2022) is based on the assumption that the design of digital technologies is not merely a process of technical development but also embedded in wider socio-political, economic and cultural practices. For example, the study on the policy discourses of AI and their shaping of resource allocation, infrastructure and organisational projects demonstrates the key roles of tech development, politics and discourse in contributing to what the authors deem the 'hype of AI'. This may facilitate to the de-prioritisation of sober risk assessments and potentials, but also risks positioning the rise of AI as an inevitable pathway in tech development. A recent commentary by STS scholar Lucy Suchman criticises the unquestioning positioning of AI as ubiquitous and prevalent. Policy and academic literature have placed much focus on AI's controversies, instead of problematising AI in itself (Suchman, 2023). Both of these studies take issue with the use of hype in influencing and shaping what our societal understandings of what a technology and its capacities are. In a similar vein, Neuropsychologists coined the term 'neuro-enchantment' to describe an empirically founded phenomenon in which an overpromise of NT capabilities leads to people firmly believe in its potentials – albeit scientifically unfounded (Ali et al., 2014).

- In sum these studies demonstrate that narratives, discourses and imaginaries about the potential effects of technologies co-construct 'regimes of anticipation' (Adams et al., 2009) in which policy makers feel challenged to respond through policy development and regulation. The issues and challenges arising with the development of NT bear resemblances with the rise of artificial intelligence. Not least because NT often apply AI systems for data analysis, but also for their purported capabilities in inferring traits, emotional states and behaviours of individuals.

Returning to the role of narratives, we build on existing literature utilising the concept of socio-technical imaginaries. In the last three decades we have seen the study of the 'imaginaries', especially in technology development. According to Rahm, these allow us to analyse how problems and their solutions are understood and their resulting implications (Rahm, 2023b). Jasanoff and Kim define them as 'collectively held, institutionally stabilised and publicly performed visions of desirable futures [...] attainable through, and supportive of, advances in science and technology' (Jasanoff et al., 2015). The focus here lies within the collective views and how they are upheld institutionally.

Taking the rise of AI as impetus to study the use of NT across different setting, we briefly cover the ambivalent social implications of data-driven technologies. Harms and potentials may resonate across different domains, but how users or affected people are imagined varies across. The (potential) social implications of NT hence need to be considered vis-à-vis different sociotechnical imaginaries across different social domains. Social implications of NT mirror existing concerns about the use of data-driven technologies in different social domains. In our literature study, we specifically focus on the domains of education, work and entertainment. We assume that NT potentially accelerate and add to the existing, well researched ambivalences of data-driven technologies. Here are some of the issues that have been uncovered so far:

- **EDUCATION:** The push towards introducing AI and other data-driven systems in educational settings often comes with the promise of being able to cater to different pupils' needs. The development of these technologies, however, is criticised to produce a limited view of what learning and education is (Selwyn, 2022). The drive towards 'learnification' makes learning about acquiring and mastering skills (Knox et al., 2020). This is criticised to constrain a society-wide discussion on the purpose and value of education. Through the introduction of these technologies, responsibilities for learning and achieving success are delegated onto the individual learner instead of supporting social relationships as part of the learning process (Macgilchrist et al., 2024).
- **WORK:** The use of data-driven systems poses a plethora of issues for workers. It is already evident that these technologies increase the ability for worker surveillance and produce new possibilities on how workers could be measured and judged against (Ajunwa et al., 2017; Manokha, 2020). Often, AI-based technologies are introduced to support worker wellbeing. Literature on the introduction of wellness-based literature criticises that wellbeing is framed around productivity (Hull & Pasquale, 2018) and thus gives a limited scope for how wellbeing can be discussed in a workplace (Tirabeni, 2023).
- **ENTERTAINMENT:** The push towards datafication, the ubiquitous collection and use of data, is also an issue for entertainment. As Internet of Things (IoT) and other sensing devices are deployed in increasing entertainment functions, user data including their behaviour is collected (Hallur et al., 2021).

It is therefore important to explore and analyse the underlying societal assumptions that necessitate and are necessitated by the introduction of such NT. In this section we analyse how different scientific studies conceive of and construct the social problems and users of NT in different societal domains. Subsequently we assess the social implications this may have for different social actors.

## 4.2. Conceptual approach

In this section, we explain sociological concepts that are important to our analysis of the 'social implications' NT. To this end, we draw on the following concepts to elucidate the framing:

### 4.2.1. What is a social problem? How do technologies co-construct social problems?

In order for a social phenomenon to be understood as a social problem, it ought to be collectively defined as such and be in congruence with a normative understanding held by a group of people (Spector & Kitsuse, 2001). This hinges on various actors and their positions in society to construct a social problem. Technology development plays a role in co-constructing social problems as it often relies on problematisations to justify its approach. Following this, parallels can be drawn with how disability is conceived.

### 4.2.2. Social model of disability

The social model of disability challenges common framings of disability as a medical problem or to lie within the individual (Beckett & Campbell, 2015; Goering, 2015). Instead, it holds society to account for creating conditions that are disabling. Recent advances in AI development are criticised to build on a legacy of ableist technology making that problematise disability in need of a technological fix. The concept of 'technoableism' was introduced to describe a 'rhetoric of disability' that at once talks about empowering disabled people through technologies while at the same time reinforcing ableist tropes about what body-minds are good to have and who counts as worth' (Shew, 2020). Since NT are focused on enhancing or augmenting human capabilities or supporting medical conditions, it is crucial to assess how these contribute to a conception and problematisation of humans as imperfect.

### 4.2.3. Sphere transgression: How does big tech produce power and reinforce inequalities?

Considering the political economy of technological production, the concept of 'sphere transgression' reveals how the big players in the technology industry position themselves as experts in multiple domains (Taylor et al., 2023). This then shows that technology produced for one specific purpose is marketed and adopted in another domains (Sharon & Gellert, 2023). A case in point would be a software created for business purposes becomes deployed in school settings. In this argument, a strong democratic society is reliant upon the separation of distinct societal spheres. If one company or societal actor is able to hold power in multiple spheres, this damages societal cohesion and democracy at large.

## 4.3. Methodology

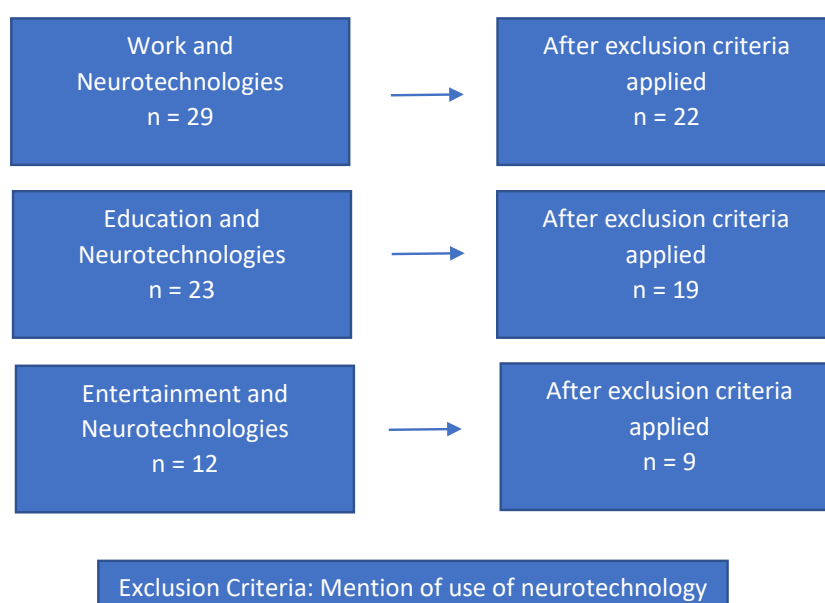
### 4.3.1. Approach

This is a desk-based study that analyses literature from both the NRF as well as further scientific literature from in the fields of AI ethics, science and technology studies and sociology. In reading and assessing the literature the following questions were leading the review:

### 4.3.2. Data collection

We used Google Scholar to find relevant literature and applied a snowball sampling technique to the literature study. We identified relevant literature from the papers. The keywords included: neuroergonomics; physiological computing; affective computing; neurointervention; brain at work; NT labour/employment; neuropedagogy; neuroeducation; neurodidactics; neurolearning. We omitted any papers that discussed implications of NT on a purely philosophical or technical level. Saturation was reached in all domains.

Figure 2 – Data collection process



### 4.3.3. Data analysis

Once the corpus of relevant literature was established, we analysed the papers thematically with the following questions:

- **Promises of NT:** What kind of 'social problem' is meant to be solved by what type of NT? What is the promise and 'use case' of NT in the social domain?
- **Imagination of different actors:** How are different social actors imagined to utilise NT and who is and is not envisaged as 'relevant' social actor?
- **Problematization of NT:** How do authors problematize the use of NT in the social domain?

In the following paragraphs, we present the results of our literature study. To aid comparison, we also present an overview on how the papers authored by the NRF present possible scenarios for use in the domains mentioned. Each domain reference is marked respectively as ED (education), W (work), and E (entertainment) and listed as separate Tables 3, 4 and 5 in the Annex.

## 4.4. Education

### 4.4.1. The Neurorights Foundation's view

In education, the NRF considers the ability to measure pupil's levels of concentration as a potential benefit of NT. This measurement could be conducted by the use of a headset and is meant to contribute to the improvement of learning for individual children. The NRF discusses a prominent example from a Chinese school and problematizes misinterpretation and/or missing consent from pupils as a concern.

### 4.4.2. Neurotechnologies in Education: Discussion in the Literature

#### Promises of Neurotechnologies

In the literature, we have topologized three different types of NT that are identified in line with their purported affordances: skills-enhancing NT, NT for inferring the mental state of pupils and NT for the assessment of cognitive needs. Social problems around the need for skills-enhancing NT are framed around an educational crisis with poor educational outcomes [ED 3; 10; 16; 17, see Table 3 in the Annex]. NT and the associated deeper level of knowledge around learners' brains are presented to give teachers deeper understandings of brains [ED 16; 19]. Skills such as linguistic expression, mathematical reasoning and decision-making should be supported by neurotechnological manipulation of abstract concepts and mental images [ED 4; 5; 14; 15]. Through the advances of digital technologies, NT are necessitated to play an important role in ensuring that countries remain competitive by supporting future skills associated with new technologies. Students' attention levels are positioned to be measured in real-time to give teachers and parents (instant) feedback [ED 2; 3; 10; 12; 14]. In addition, NT can play a role in assessing the cognitive needs of learners to then allow for better interventions by teachers [ED 9; 19]. These include factoring in mental and biological variabilities, dis-/ability, neurodivergence including ADHD [ED 19]. This extends to policy-making where a deeper understanding of students' brains and associated interventions can be quantified to support more targeted policies and investment [ED 9].

#### Imaginations of users and educational settings

The literature focusses heavily on teachers' competencies. The need for NT is justified by presenting the argument that teachers' lack of up-to-date knowledge about learners' brains [ED 16]. This causes the risk of missing out on opportunities for more targeted learning interventions of individual students. Students as well as teachers are also conceived of as needing to 'keep up' with the technological development to be best prepared for a future that necessitates proficiency with

digital technologies. The use of NT is purported to support the development of a 'modern, competitive personality [ED 2]. The imaginations of users also reveal how the use context is reconfigured through these technologies. In the discussion of NT, learning is conceived of as a cognitive process, instead of a social process. A common thread is the focus on making learning more 'targeted' and 'efficient'. In that case, the aspects that facilitate learning are students' ability, disability and variables that are mental or biological [ED 2]. When it comes to the inference of emotional states, some literature cites the promise of obtaining 'objective' information about pupil's emotions through NT rendering students' own accounts of how they feel as unreliable. Students needs can be assessed 'correctly'. These should then contribute to better learning outcomes, which should be better predicted through the availability of data.

#### 4.4.3. Problematisation within the literature

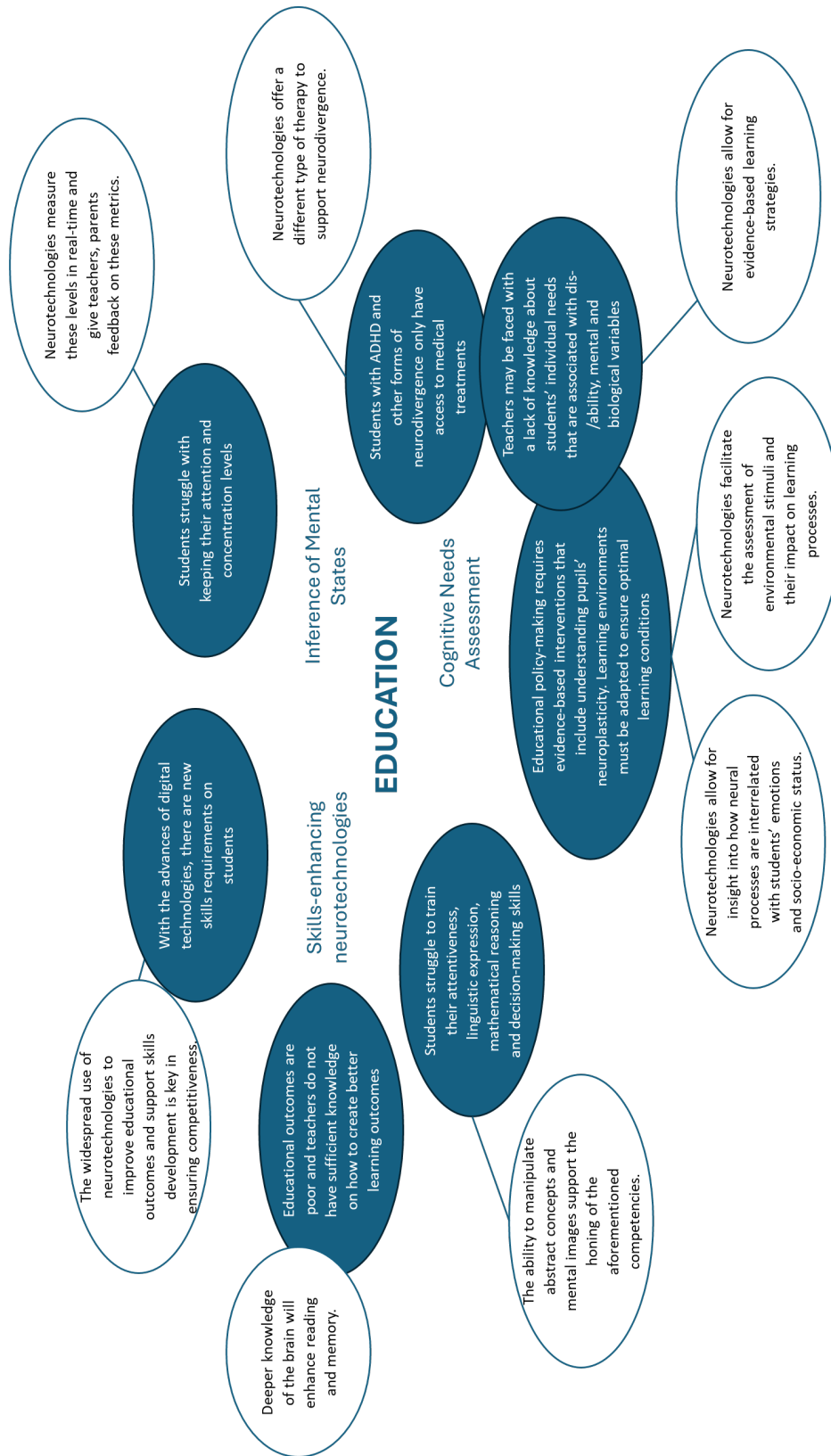
The **education literature** addresses a range of concerns that pertain to the availability and use of neural data. On the one hand, this is addressed as a **cybersecurity concern**, where the robustness of systems is questioned. On the other hand, the possibility of the data being used for unintended purposes such as for possible commercial means is warned against. The literature raises the issue of consent and decision-making, where this will have to be delegated to parents or legal guardians of pupils.

Aside from issues around data, researchers warn against the **possibility of manipulation** [ED 1; 15]. Since children's brains are developing, it is not clear how they respond to NT: side effects, harms and other unintended consequences – especially those that are long-term – are not clearly researched [ED 4]. This brings uncertainty on the impact of NT on the typical maturation of the brain.

Researchers also warn against the possibility of NT being introduced in educational settings under **false promises** [ED 1; 15]. There is unclarity on how these technologies improve educational outcomes. This ties in with the outputs of NT: there is a possibility that the data generated by these technologies is unreliable due to system changes or changes in student needs. In addition, teachers, parents and students may lack the competencies to interpret the data correctly or as intended leading to problems such as **stigmatisation** [ED 2; 12]. What is considered as normal brain functioning could change with the rise of NT. This could also lead to an increase of pressure to use NT [ED 4].

Similarly, the literature takes issues with **teachers' competencies** – teachers may not know enough about technology or learners' brains to effectively use NT to facilitate learning [ED 10]. Teachers will need to be trained. This ties in with the need for pedagogical materials to be adapted to support NT. Another aspect mentioned is the importance of teachers' attitudes towards NT as these would impact the successful adoption in classrooms.

Figure 3 – Overview of how NT are anticipated to be used in the domain of education



Description: Dark blue bubbles represent how educational problems are framed and to which NT promise to be a solution (white bubbles).

## 4.5. Work

### 4.5.1. The Neurorights Foundation's view

Within the domain of work, a number of possible use cases are mentioned. Recruitment procedures could, in the future, use brain data analysis to determine a good fit for an organization. This is asserted as highly problematic and the Foundation refers to possible misinterpretation as well as race and gender bias as an area of concern. While not speaking of a possible use case, the possible use of NT to surveil workers in addition to other digitized practices in which workers are monitored is also mentioned. The inability to consent for workers stemming from power disparities needs to be considered in employment settings. The ability to get words to text through the use of NT is a promise made by a few products already on the market such as the Facebook Reality Labs EMG Wristband and Emotiv's headsets measuring brain data.

### 4.5.2. Neurotechnologies at work: Discussion in the literature

#### Promises of Neurotechnologies

Here, we group three NT according to the promises made around their technical capacities: those that centre around enhancing wellbeing, those that promise to measure cognitive load and those that seek to surveil emotions and/ or assess personality traits. High stress levels and lack of concentration are associated with low productivity. Fatigue can lead to higher accident or failure rates. The promise to measure these states in real-time is made [W 4; 8; 15; 21, see Table 4 in the Annex]. Through the use of an app, interventions to improve sleep or concentration such as mediation exercises are suggested [W 1; 7] to workers and they are given scores [W 6]. In the field of neuroergonomics, much focus has been to measure workers' cognitive loads to design jobs that are supportive of cognitive functions and to prevent over- and understimulation [W 3; 6; 11; 16; 18]. NT are posited to be able to measure cognitive load in real-time and correctly to prevent accidents [W 3; 21]. These are marketed towards safety-critical roles in industries such as aviation and transport [W 11]. As far as emotion recognition is concerned, NT are positioned to give a 'true' and 'objective' assessment of a job candidate or a correct interpretation of a worker's motivational states throughout the day [W 1; 2; 10; 11; 12; 17].

#### Imaginations of users and workplace settings

In **work** settings, NT are promised to allow and support the optimisation of processes. Due to the possibility of constant measurements of brain states, workers' shortcomings such as lack of attention, the human error rate or risks due to fatigue can be mitigated [W 3; 21]. Workers are imagined as being prone to error and NT promise to fill this possible limitation. Workers are also imagined to be 'deceitful' in recruitment scenarios where NT promise to give a 'correct' assessment on a person's characteristics, their leadership skills, resilience and traits such as callousness [W 3]. The literature does not directly address workers, but makes a case for 'neuroergonomics' as a possible consideration in human resource management (HRM), where the best possible work environments for supporting brain processes is a desired outcome from the use of NT [W 1; 7]. Here, the focus lies on workers' wellbeing as key in increasing productivity. The indicators for wellbeing are limited to stress, fatigue and attention levels. However, stress is not necessarily something bad for wellbeing. Safety-critical role such as air traffic controllers or truck drivers are positioned to benefit the most of NT as they can indicate when a workers' attention level is critically low to conduct the work safely [W 3; 21].

### 4.5.3. Problematisation within the literature

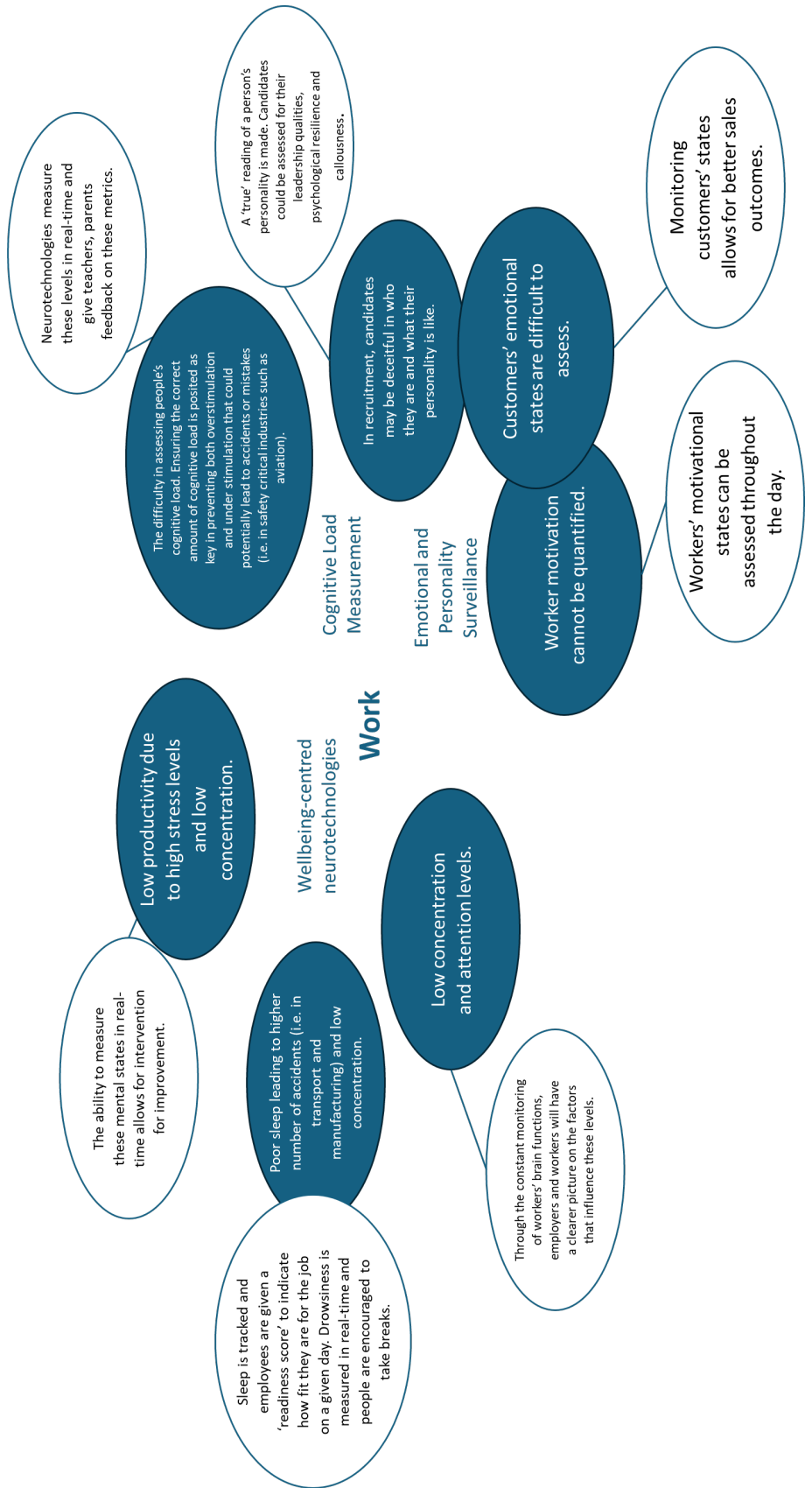
The **work literature** problematises a range of different issues where synergies can be drawn with other domains. Similarly, to concerns in education, the **unknown long-term effects** on workers' brains such as brain damages, bodily integrity, shifts in users' integrity are challenged [W 1]. This may defeat the intended purpose of introducing NT to increase health and safety in workplaces.

The heavy use of data in workplace settings including and as part of **wider monitoring of workers** is addressed as a key issue in workplaces. This ties in with the potential misuse of data and the risk of it being used in other settings such as to access housing, loans, insurance and more [W 1; 7; 10; 12; 19]. The use of NT and its data can lead to many **misuses**. This is part of similar concerns around privacy, accuracy and lack of explainability. There is also a potential for the data to be monetised by organisations selling it to third-parties.

Different studies also cite the **uncertainty about the performance and capabilities of NT** as an important issue to consider in workplaces. NT may not be able to adapt to different situations where they are used leading to inaccuracies. The tools are positioned as unreliable where their efficacy is unclear to assess [W 1; 10; 13; 16].

Due to the power relations that exist in workplaces, workers may also struggle to freely and informedly **consent** to the use of NT [W 4; 20]. In addition, the literature cites **increasing social pressures and performance standards** as a problem when NT are introduced. As some people may be more prone to experiencing stress (i.e. arousal) workers may lose out on opportunities due to their neural make-up [W 7]. This adds another level of discrimination and is exacerbated by other factors to do with brain data and its resulting metrics. Due to socialisation in education settings, workers from more affluent backgrounds could have an advantage over others as they may have learned to use these technologies from a younger age [W 4; 20].

Figure 4 – Overview of how NT are anticipated to be used in the domain of work



Description: Dark blue bubbles represent how problems at work are framed and to which NT promise to be a solution (white bubbles).

## 4.6. Entertainment

### 4.6.1. The Neurorights Foundation's view

Based on our literature review of the foundation's papers, discussion of NT in entertainment is not addressed.

### 4.6.2. Neurotechnologies in entertainment: Discussion in the literature

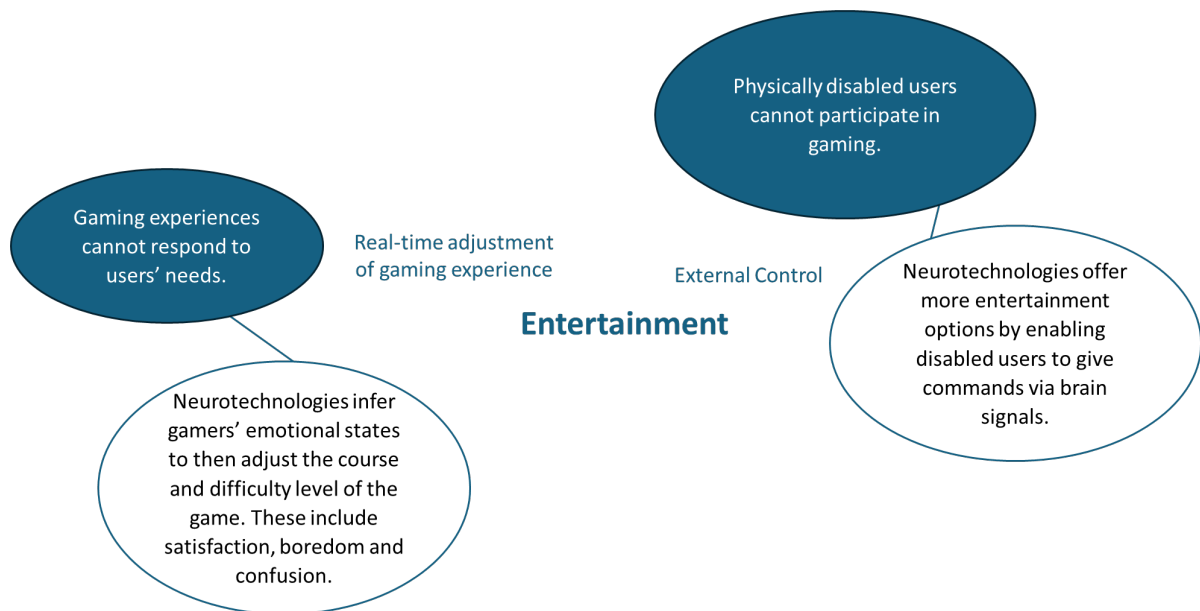
#### Promises of Neurotechnologies

The discussion of NT in gaming, art and other forms of **entertainment** frames users' emotions around metrics for successful games such as confusion, boredom or satisfaction [E 5; 6; 8; 9, see Table 5 in the Annex]. There is an enthusiasm about the ability to respond to users' cognitive states in real-time and adjust difficulty levels of games [E 5] for example or to use brain data to make art [E 3; 6]. The possibility of controlling games via brain inputs may also open up gaming to a wider set of gamers, who may have physical disabilities that bar them from participating in certain games [E 1; 3; 5; 7; 8; 9]. The enhancement of human creativity is featured in the discussion of NT and entertainment.

### 4.6.3. Problematisation

In the domain of **entertainment**, researchers are also raising the concern of **optimistic advertising** [E 3] deceiving what the technologies are actually capable of. Similarly, issues of safety, **cybersecurity**, accuracy and data gathering are also mentioned [E 3; 8; 9]. Researchers warn of the application of medical devices in non-medical settings [E 3].

Figure 5 – Overview of how NT are anticipated to be used in the domain of entertainment



Description: Dark blue bubbles represent how educational problems are framed and to which NT promise to be a solution (white bubbles).

## 4.7. Comparison of our insights from education, work and entertainment

In this section we compare how NT and their aims are differently conceived depending on their social domains.

### 4.7.1. Promises and the aims of neuroenhancement

Notable are the differences between the *aims of neuroenhancements* in education (better educational outcomes) vs. work (more productivity) vs. entertainment (to counter boredom). While NT in education build on the policy goal to improve education, e.g. by supporting tailored learning, the use of these devices in work settings primarily aims at reducing accidents in safety critical roles. In entertainment, the aim is to provide more user-centred gaming experiences. Focus on measuring and inferring mental states such as attention and fatigue levels is placed on students and workers. This potentially reconfigures what we societally value as education (here reduced to the enhancement of learning) and well-being at work (here reduced to cognitive processes).

### 4.7.2. User imaginations and contexts: Transforming social relations

When brain data is made measurable and accessible, it has implications on how we relate to one another. The possible transformation of the *relationship* between teachers and pupils vs. the relationship between workers and employers is associated with newly established metrics made available by NT. The literature does not necessarily clarify who and how people should get access to data, and to what benefit. It is not clear, how possible organisational embeddedness includes and excludes certain actor groups. Oftentimes, however, workers, educators or students are not central parts of the discussion.

This brings us to reflecting on the potential competences that are required to introduce NT and raises a normative question on what constitutes as 'successful' and 'good' or 'ethical' uses of these technologies. As mentioned before, teachers' lack of skills of these technologies are positioned as contributing to an 'unsuccessful' introduction. As with any technology, it is contested what and who constitutes the 'intended purpose' of NT and how NT may be reappropriated by social actors for (different) their own purposes or in an attempt to resist their use altogether? In addition, evidence suggests that NT can be easily manipulated and their data falsified through not using the sensors correctly.

Emotions and skills are also differently negotiated in the anticipated uses of NT in the three domains that we analysed. Creativity, for instance, is often undervalued in discussions within education and work contexts, yet prominently featured in discourses surrounding entertainment, indicating a gap in understanding its broader implications. Additionally, there is a tendency in some of the literature to oversimplify work environments, focusing solely on productivity metrics and overlooking the nuanced interplay of emotions. NT make judgements on different emotional and mental states. Furthermore, the interpretation of brain data poses challenges, as emotions such as arousal (stress) may have dual effects, both supportive and potentially detrimental, depending on the context.

### 4.7.3. Problematisations of neurotechnologies

As we have demonstrated, the literature rightly raises the issues of cybersecurity when it comes to the governance, storage and transfer of brain data. It is imperative to assess who has a stake in brain data and the potential effects on social relationships. To illustrate: Classroom dynamics may change drastically if brain data of all students are available on a screen for all to view. Considering different potential actors implicated in the use of NT, it is challenging to assess the potentials and risks of NT. Therefore, the possibility for manipulation or 'neuro-enchancement' is given.

Through the introduction of NT, new societal norms are established. The optimisation of the self is taking primacy over other organisational and institutional goals. It begs questioning how a society's notion of disability is co-constructed through these technologies. The social model of disability sheds light on the emergence of new norms of cognitive abilities and how this then creates a conception of humans that requires 'fixing'. In addition, the promised assessment of people's correct mental states and characteristics rests on an assumption that identities and personalities are 'stable' and 'fixed'. It ignores the complexity of human dynamics and emotions. At the same time, the development of NT produces an understanding of certain emotions and mental states as 'desirable' and 'unacceptable' in different societal domains. This then shifts responsibility for managing these mental states onto the individual. Responsibility of performance is an individual pursuit.

Policy makers are also encouraged to question the potential of Big Tech companies to hold an ever-growing grip on power over a range of societal domains and the implications this has for social cohesion and democracy more generally. NT raise how we as a society want to relate to one another, what our idea of good education and good work is, and who can access these technologies to people's benefit.

## 4.8. Findings from a sociological perspective

In light of this study, we summarise four critical points for engagement when it comes to NT and their role in and for society.

### 4.8.1. Neurotechnologies represent human brains as fact instead of humans as socially embedded and evolving beings

NT operate on a reductive approach, where emotions and mental states are singled out from the larger social contexts. This is in stark contrast to sociological research into emotions as socially embedded that is as being produced in and responsive to social contexts<sup>4</sup>. In the sociotechnical imaginaries around NT that we have reviewed, the brain becomes 'fact' before all else including personal accounts and interpretations within a social setting. In light of these insights, attention must be paid to problematising conventional notions, such as 'attention levels', and considering a more comprehensive range of emotional states, including confusion, boredom, and satisfaction, across various domains.

Overall, the inference of people's personality traits rests on an assumption that identities are stable and fixed instead of evolving and changing as part of the continuous transformation and negotiation of social relations. In a similar vein, the assessment of peoples' mental states works reductively. Complex social contexts and situations are reduced to cognitive states and the brain becomes the source of seemingly factful and objective knowledge. To add another layer, only certain emotions are made measurable and therefore articulable. This is dependent on the social domains where NT are expected to be deployed: While the NT in the entertainment sector are intended to measure boredom and satisfaction, those in the domains of work and education measure attention levels and fatigue. As these technologies tend to serve a simplified understanding of social settings, the predominant discourse around NT endangers a conception of people being embedded in and constituted by socio-technical settings. For example, the social disability model demonstrates how humans may be constituted *as* disabled by technologies.

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<sup>4</sup> On the social embeddedness of emotions see Scherke (2024). Scherke presents different ways in which emotions are produced through collective experiences, how emotions enable collective action and how social contexts also prescribes 'feeling rules'. See also: Hochschild (1979).

## 4.8.2. Neurotechnologies reconfigure social domains and the relations between social actors

The capturing, processing and subsequent use of brain data and associated metrics by different social actors reconfigure the ways we relate to ourselves and to one another. Across the social domains that we have analysed we found anticipations about how NT may generate knowledge about bodies and brains that are privileged over people's own embodied experience of their emotions, feelings and well-being. Like with other socio-technical innovations, there is a danger that new norms about socially expected and accepted 'cognitive performances' develop that lead to the medicalisation and pathologizing of neurodiverse individuals and groups of people.

All the while, NT redefine what is conceived of as a social problem (that requires a technical fix). For example, sociotechnical imaginaries around the adoption of NT in education define a key problem to be solved as one of attention and focus levels. Teachers become problematised as being incompetent about what brains do.

In addition, humans are embedded in existing (and often times unequal) power structures across social domains. For example, employees have less say about how working conditions are configured than employers. While in many countries, laws regulate and protect the interest of workers, this is not the case everywhere and for every field of work (e.g. gig workers). While it is yet unclear who will be able to access brain data and potentially manipulate cognitive processes, research on comparable data-driven technologies has shown, how technologies exacerbate and contribute to the unequal distribution of power (Eubanks, 2018).

## 4.8.3. Sociotechnical imaginaries and anticipation about neurotechnologies' potential shape

In our assessment of sociotechnical imaginaries around NT, we have pointed to the dominant discourses accompanying the possible deployment of NT in work, education and entertainment. Through this, new regimes of anticipation are conjured whereby actors prepare themselves for an 'anticipated' future, which is then enacted. This demonstrates that sociotechnical imaginaries do not stay at the level of discourse level, but rather that accompanying anticipations determine how resources are allocated, what and who receives funding for what kind of 'techno-solutions' and what kinds of solutions to *regulate* NT are sought (e.g. the proposed neurorights). While our study has taken academic publications as our object of study, it is clear that discourses are dominantly driven by market actors that then stake a claim in various social domains. The concept of *sphere transgression* shows how this leads to and reinforces power imbalances on a socio-political levels as it allows dominant and resource-rich companies to determine a different understanding of various social domains and social roles therein (e.g. the 'new learner' or the 'new worker'). Subsequently, these dominant actors are then able to set the agenda on what society perceives of as social problems that are in need of the neurotechnical 'fix'.

## 4.8.4. Research gaps

The literature review demonstrates a clear empirical gap on the organisational and everyday embeddedness of NT. It is paramount to assess how different actors negotiate the use of these technologies. Those affected by NT are not at the core of the debate. Further research should centre domain experts and the lived experiences of those affected in the development of NT.

## 5. On neurorights/-technologies – an ethical perspective

From an ethical perspective, opportunities, risks and unintended consequences for society and individuals must be considered with regard to NT. At the normative level, the philosophical and ethical foundations on which the representatives of the NRF base their proposal of neurorights on, must be examined for their plausibility and derivations. For example: The texts of the NRF are dominated by a materialistic focus on the human self, the origin of which is pinpointed in the brain. While the latter finds broad academic approval, there is an underlying danger of 'objectification' and reduction of the human being to brain data. On the pure basis of such materialism, for example, the special status of human dignity, which is a central European value, would be difficult to argue and could unintentionally lead to a weakening of the foundations of fundamental rights. This would be particularly worrying with regard to highly vulnerable people (e.g. coma patients, people with cognitive disabilities).

With regard to technological designs, the problem is addressed that concrete technologies offer a broad spectrum of possibilities, but that a form of technology assessment is necessary for these. With regard to the experiments being carried out by the company Neuralink, for example, the risks for individuals must be considered as well as the effects that the mere existence of such technologies could have on society as a whole and the unintended consequences (e.g. pressure to adapt to meet new performance levels achievable only through invasive NT). However, the opportunities offered by NT should also be given due consideration.

To assess the proposals made to policy makers by the NRF, the philosophical-ethical<sup>5</sup> basis of the normative concerns conceptualized as 'neurorights' will be analysed, as described above.<sup>6</sup> The point of orientation for these considerations are the foundations in the history of ideas as stated by the NRF as well as the human rights and European core values. This part of the ethical assessment is focused on the selection of fundamental concepts in the history of ideas made by representatives of the NRF and the question whether this selection has led to shortcomings or gaps in view of the landscape of European values.

This step is necessary to be able to weigh up the legal level at which neurorights can be sensibly implemented, if at all. This becomes particularly clear in light of the fact that it is argued to see neurorights as a junction of moral and legal rights (Ienca, 2021a, p. 44). This suggests that the formulated neurorights are not only of a moral nature, but that they have an inherent claim to implementation within concrete secular legislation. However, there is no moral obligation for positivisation, i.e. the implementation of moral rights into legal rights, as morality in itself is sufficient in its claim to validity (Kirchschläger, 2019, p. 28). From an ethical perspective, the suggestion of the simultaneity of moral and legal rights appears to arise, firstly, from the way in which the proposed neurorights are presented and imagined. However, if one recognises that not every moral right *eo ipso* realises a claim to positivisation and if one takes the moral nature of neurorights seriously, one must ask within which moral system the neurorights are proposed, what they are intended to

<sup>5</sup> Philosophical-ethical refers to the focus on the philosophical foundation in the history of ideas, that are relevant for the ethical derivations. In section 5.3 we provide considerations from a socio-ethical point of view, which give insights from a more practical point of view.

<sup>6</sup> The term 'neurorights' was coined by Ienca and Andorno (2017), whose article was linked on the website of the NRF until at least September 2023. However, for unknown reasons, the article cannot be found in the publications section of the homepage as of April 2024. In (2021b) Ienca argues in favour of neurorights in "Common Human Rights Challenges raised by different Applications of Neurotechnologies in the Biomedical Field", further substantiating the foundations and necessity of neurorights. The initial article of Ienca and Andorno is referenced by the following publications, which are still linked on the website of the NRF: Álamos et al. (2022); Goering et al. (2021); Yuste and Quadra-Salcedo (2023) as well as in the report authored by Genser et al. (2024), which bears the NRF logo, but is not available on the NRF website as of 27 April 2024.

achieve there and under which conditions and to what extent they are to be implemented as legal rights within this moral system. As will be seen in the following section, the foundations chosen to propose new neurorights are based on the moral foundations of what has been consolidated in European intellectual history as 'human rights'. The debate on the extent to which human rights themselves are moral or legal rights touches on the transition from natural law to positive law, in which human rights are recognised in legal frameworks at both national and international level (Nickel, 2019). This must be considered in the context of the proposed neurorights.

However, if neurorights within this system are understood as moral obligations with the importance of establishing new rights, the question arises as to whether legal implementation should be located at the highest level of the moral system or whether a subsidiary level is more appropriate.

## 5.1. 'Fundamental concepts' from the history of ideas

Argumentations to establish new neurorights are repeatedly based on considerations on the history of ideas and derive fundamental concepts from it. Therefore, this part will focus on the fundamental concepts that serve as a base to the proposed neurorights. It will be an analysis of the concepts themselves, their derivations, and the plausibility of the neurorights proposed on their basis. Those who argue in favour of neurorights repeatedly refer to: (1) *Freedom of thought and conscience*, (2) *Mental integrity* and (3) *Privacy* and trace the neurorights conceptually back to these. (Ienca, 2021a, p. 44) The concept of *personal identity* is also taken up (Ienca, 2021a, pp. 53–54).

Researchers in favour of new neurorights repeatedly refer to the importance of (1) freedom of thought and conscience. This occurs either in a direct examination of the concept of freedom of thought, as in Ienca (2021a), Ligthart et al. (2022) and Hertz (2023b), or indirectly in the context of the examination of areas of concern identified by researchers, whose articles are linked on the NRFs website. Even if the examination of the areas of concern ((a) identity and agency, (b) privacy, (c) bias, and (d) enhancement (Goering et al., 2021))<sup>7</sup> must take place on a different level in terms of content, (a) identity and agency, for example, is inextricably linked to the concept of freedom of thought and conscience in the history of ideas. Ienca and Andorno (2017, p. 24) even argue that freedom of thought is an antecedent for all other freedoms. Ienca takes up this assertion again in a report for the Committee on Bioethics (DH-BIO) of the Council of Europe (Ienca, 2021a, p. 47). While this approach is understandable, as Bublitz, for example, also argues that freedom of speech can only follow immanently from freedom of thought (J. C. Bublitz, 2014, p. 4), this emphasis harbours the potential to reduce people and what constitutes their freedom, identity, and actions to a freedom that is related to the function of the brain. To exaggerate: Where there is no thinking, there is no freedom of thought and conscience. Those who are unable to produce a basic brain function (comatose people, infants, dementia patients, people with cognitive impairments, etc.) would thus also be deprived of their right to other freedoms. Basically, focusing on freedom of thought as an antecedent for other freedoms in combination with a materialistic world view harbours the danger of reducing people and their freedoms to biological functions, rather than focusing on human dignity as an overarching and inviolable fundament. While it must be recognised that having freedom is not the same as exercising freedom, the latter should not become the criterion for the former, as it would not do justice to the complexity and dignity of the human existence. At this point, it must be noted that a freedom does not *eo ipso* constitute a legal entitlement, nor does the loss of such a freedom automatically represent a loss of rights; nevertheless, the intertwining of freedom and rights must be particularly emphasised, especially in the context of human rights, as the protection of freedom in particular was conceptually relevant for the pioneers of human rights (Bielefeldt, 2023; Funke, 2023; Willoweit, 2023). If neurorights were incorporated at a subsidiary legal level, the danger of functionalisation and objectification of the human being could be mitigated by

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<sup>7</sup> Similar but with other designations: Yuste (2017).

the primacy of the concept of dignity. As an unconditional aspect of the human being, dignity is a stable, inviolable foundation that transcends ability, origin, gender, wealth, etc., and constitutes rights that protect the most elementary ways of being human. Therefore, it seems favourable to base freedom and the right to specific freedoms on human dignity rather than ability/capability.

At least two neurorights, the right to free will and the right to personal identity, are directly or indirectly founded in the freedom of thought and conscience. The right to free will constitutively presupposes a form of freedom of thought since any kind of restrictions on thought itself would limit the formation of a will at its root.

With regard to the right to personal identity, proponents of neurorights refer to the tradition of John Locke, according to which a person is an intelligent being that possesses both *reason* and the *ability to reflect, recognising itself as a self*, as the same thinking being *at different times and in different places* (lenca, 2021a, p. 54). lenca and Andorno (2017) elaborate on this idea to the effect that interventions in one of these elements could negatively affect the continuity and coherence of personal identity. NT could cause such continuity and coherence problems via brain stimulation, in addition to drugs, hypnosis and other external influences (lenca & Andorno, 2017, pp. 21–22). Interventions of this kind in thinking would contradict the right to freedom of thought and conscience insofar as it is a manipulation of individual thinking that is outside the individual's sphere of influence and causes changes in the individual. This also coincides with the perspective of the *Special Rapporteur on freedom of religion or belief*, who mentions such modifications (Shaheed, 2021, 32–34) and manipulations (Shaheed, 2021, 35–39) as potential violations of freedom of thought. In principle, the human mind is protected from manipulation by psychoactive substances and other manipulations under Article 18 of the ICCPR. This treaty has been signed by all EU member states and also appears to be indisputable within the EU institutions, as they were still in favour of consolidating the ICCPR and ICESCR into a joint document in 2017 (Apap, 2018). The protection of freedom of thought, conscience and religion is an absolute right that cannot be weighed against other rights (Lighthart et al., 2022, pp. 2–3; Shaheed, 2021, 25). The fact that the Special Rapporteur explicitly addresses these potential violations in the report on freedom of thought seems to weaken the position that an additional right to personal identity would be needed to protect against such interference.

Personal identity also has references to mental integrity (2), which has been claimed as a separate right in one of the earliest mentions of the neurorights (lenca & Andorno, 2017), but later lenca categorises it as a foundation in the history of ideas (lenca, 2021a). In terms of content, mental integrity is naturally closely linked to freedom of thought. In the debates, the distinction is sometimes made that freedom of thought is intended to protect against the intrusion (and extraction) of the human cognitive sphere, whereas mental integrity is intended to protect against harm (lenca, 2021a, p. 50). Schauer (2020) addresses this aspect of protection against harm in his considerations regarding the freedom of thought, but in this context, he sees the prevention of harm as something that should go hand in hand with the freedom of thought. The above-mentioned report of the Special Rapporteur also includes the prevention of harm to the cognitive sphere in the considerations regarding freedom of thought. Other scholars regard mental integrity as the counterpart to bodily integrity and argue on this basis that a right to mental integrity can be thought of as analogous to the right to bodily integrity and that this is even more fundamental than the aforementioned right to mental integrity (Craig, 2016). Harmful interventions via NT, whether intentional by malicious actors or due to technical malfunctions, can be thought of as a radical violation of mental integrity. Lavazza and Giorgi (2023) emphasise in this context that a special feature of NT is that (malicious) manipulation of individuals could occur without their knowledge, which distinguishes the dangers of NT from those of psychoactive substances. Recently, however, Tesink et al. (2024) argued that with the help of a potential extension of the mind through NT, even an extended protection of mental integrity could be possible. It should be noted that the latter assume that '[...] mental states that make up the human mind—including beliefs, desires and

memories—are not only realised by our brains but can also be realised by physical processes and artefacts located outside the brain and indeed beyond the body' (Tesink et al., 2024, p. 3). These considerations are to be classified as speculative, but should be mentioned here because, as mentioned above, the thinkers in favour of neurorights also hold a materialistic approach whose climax can be found in the quote presented (Ienca, 2021a, p. 26).

Based on the concept of (3) privacy, the NRF calls for a right to mental privacy. In texts close to the NRF, privacy is recognised as an area of concern, just like identity (Goering et al., 2021). Thoughts about privacy in the context of neurorights play a key role in the NRF's line of argument. Where freedom of thought and mental integrity focus on the integrity of the inner level, the main aspect of mental privacy is that data read out using NT is sufficiently protected or that the individual is protected from this happening at all. A particularly problematic aspect, Yuste argues, is that '[...] neurodata (i.e., the recording of the activity of the nervous system) can be generated subconsciously and often involuntarily' (Yuste, 2023, p. 2870). In addition, the decoding of brain activity has already been successful in several areas using non-invasive NT. These include images, emotions and, in combination with AI, hearing spoken words (Yuste, 2023). In a recent report, the NRF was able to demonstrate that the majority of companies distributing consumer products do not handle neural data with the special care required by its sensitivity (Genser et al., 2024). With regard to the protection of consumer privacy and transparency, the findings of the aforementioned report are cause for concern, necessitating further investigation on how the right to privacy could be enforced and what it encompasses in regard of NT. Looking at the history of what privacy means, it is evident that since the first mention in the essay 'The Right to Privacy' by Warren and Brandeis (1890), who saw this right as a '*right to be left alone*' in the face of the incipient tabloid press, constant updating and expansion was necessary. From the very beginning, the concept of privacy has had an inherent protective function against new technologies and their negative effects on human life. What Warren and Brandeis saw as the spread of cameras expanded to include the possibility of making mobile sound recordings, digital technologies such as the internet and, finally, the emerging NT. The academic (and legal) discourse followed the technological development and developed a wide variety of theories as to what exactly the right to privacy and, its intellectual child, the right to data protection encompassed (Ivanova, 2021, p. 148). In view of NT, representatives of the NRF focus on brain data, its extraction, analysis, and the potential misuse of this data (Genser et al., 2024; Yuste, 2023). Although, as described above, a materialist view of the world runs through the arguments in favour of neurorights, Ienca and Andorno already distinguish that privacy is primarily aimed at brain data, whereas the above-mentioned mental integrity is intended to protect against interference in the cognitive sphere (Ienca & Andorno, 2017). If one takes the materialist perspective to its logical conclusion, it could be argued that mental integrity could be reduced to privacy, as the protection of brain data would also have to include the malicious alteration of the same. The distinction made between privacy and mental integrity is therefore not a distinction on the merits, but a distinction in the goal. This distinction can be useful for understanding, but in principle the regression remains possible, so that the separation of privacy and mental integrity would require further argumentative support. Lavazza (2018) argues for a synopsis of privacy and mental integrity, albeit with mental integrity taking precedence. In addition to the privacy dimension, self-determination could also be included in mental integrity, which is why, in contrast to the NRF, he argues in favour of the creation of only one new right. According to Hertz, this conceptual approach is in line with the perspectives of legal scholars (Hertz, 2023b, p. 5). However, it should be emphasised that viewing privacy as a simple matter of protecting data, be it brain data, neural data, or any other data, falls short of the broad dimension the already established right to privacy should encompass. As Warren and Brandeis already understood, it is not only about taking and distributing data, in their case pictures, but also about the unjust intrusion into the personal sphere of a human being. With regard to NT, it is of the utmost importance to keep this dimension of privacy in mind rather than reducing privacy issues to a matter of data collection, processing, handling, storage, etc. However, all these issues

regarding data must be dealt with and considered, but always with the human being as a whole in mind.

In the course of analysing the foundations of freedom of thought, mental integrity and privacy in the history of ideas, it became particularly clear that these concepts still form the argumentative basis for the protection of human life in the face of diverse technical challenges. Based on what was conceptually useful in the past for shaping specific rights, updated considerations can still be derived today. In this respect, these concepts also provide the NRF with an appropriate and stable foundation for the demand for new neurorights. In addition, the importance of the rights set out in the neurorights as being worthy of protection can be recognised, although, as we have seen, these are by no means necessary, but merely possible derivations that lead to the aforementioned rights. Furthermore, it was seen that the protection paradigms laid down in these fundamental concepts are certainly applicable to new technologies such as NT, even if they were not originally conceived with these in mind. Furthermore, the foundations in the history of ideas are not only a conceptual basis, but have themselves been translated into rights, which will be considered in more detail in the following section.

## 5.2. Human rights as a fundamental framework

As described above there are already various existing rights and treaties about the fundamental concepts the NRF is referring to. Among these, Article 18 of the International Covenant on Civil and Political Rights (ICCPR) serves as a foundational element, safeguarding individuals from manipulations through psychoactive substances and other forms of mental interference. The unanimous endorsement of the ICCPR by EU member states, and the bloc's advocacy for integrating the ICCPR with the International Covenant on Economic, Social and Cultural Rights (ICESCR) into a single document, underscores the EU's commitment to human rights protections (Apap, 2018), including those relevant to NT. Moreover, freedom of thought is guaranteed by Article 9 of the European Convention on Human Rights (ECHR). In view of the area of NT it is indeed beneficiary to also look at the closely to freedom of thought related aspects of mental integrity and privacy. As Ienca puts it: 'If freedom of thought protects the human brain and mind from undue external interference and privacy rights protect personal information (including mental information) from external intrusion, other normative principles protect the human brain and mind from harm' (Ienca, 2021a, p. 50).

The right to mental integrity finds legal backing in several instruments, such as Article 3 of the Charter of Fundamental Rights of the European Union (CFR) and Article 8 of the European Convention on Human Rights (ECHR), all of which affirm the necessity of respecting physical and mental integrity. Furthermore, the European Charter of Fundamental Rights explicitly recognizes the right to mental integrity, reflecting a broader understanding of human dignity that encompasses both physical and psychological dimensions (Tesink et al., 2024, p. 2). This perspective is reinforced by similar provisions in the Convention on the Rights of Persons with Disabilities (Article 17), which acknowledges the critical importance of protecting both bodily and psychological integrity.

The legal framework provided by Article 17 of the ICCPR and Article 8 of the ECHR are the core elements to the rights to privacy. Additionally, the understanding of Article 17 was updated through CCPR General Comment No. 16 to explicitly encompass information gained or processed through digital means. (Office of the High Commissioner for Human Rights, 1988, 10)

It seems that the core aspects of what '*neurorights*' are supposed to achieve have already been regulated several times, including at European level. Nevertheless, one might argue, that it could be beneficiary to have different rights protecting various nuances of the same overarching topos. However, this brings immanent problems with it. As Clément (2018) argues that rights inflation, as

it is called, leads to a shift in addressing grievances, which could hinder their resolving. Clément refers to Philip Alston, a legal scholar, who warned of an inflation of rights as early as 1984: 'Such a proliferation of new rights would be much more likely to contribute to a serious devaluation of the human rights currency than to enrich significantly the overall coverage provided by existing rights' (Alston, 1984). This is also reflected by Ienca when he argues that neurorights could be seen as an evolutionary interpretation of already existing rights (Ienca, 2021b, p. 9). Regarding the right to mental privacy Susser and Cabrera (2023) argue against the necessity of a right to mental privacy in the context of NT. They contend that the disruptive potential of NT does not differ from that of other high-impact technologies and that the data collected through NT are no different. Susser and Cabrera make a plausible case comparing brain data to genetic data emphasizing their similarities in uniqueness, intimacy and uncertainty about future inferences, arguing that the data produced and processed through NT is not something *sui generis*, making special neurorights necessary (Susser & Cabrera, 2023, pp. 2–3).

Following these arguments an implementation of neurorights as new human rights does not seem fit. However, what about local regulations? As neurorights as proposed by the NRF are implemented in the Chilean Constitution it seems relevant to take a look if there might be philosophical objections to this specific case as well. In 2021 Chile approved a constitutional amendment to protect brain data as well as a law establishing the rights to personal identity, free will and mental privacy as advocated by the NRF.<sup>8</sup> However, this led to a scholarly analysis, which problems may arise in the context of disability law as well as human rights. Fins (2022) conducted such an analysis on basis of the Works of Martha Nussbaum and Amartya Sen, arguing that any neurorights regulation has to fulfil several criteria such as a balance between positive and negative rights, future orientation, specificity and avoidance of generalization as well as harmonizing new neurorights with established laws and norms in the international human rights and disability law. Fins concludes that

'[...] Chile's nascent constitutional venture into neurorights fails to satisfy these criteria. While there yet may be a role for a more capacious and bivalent articulation of neurorights that accounts for capabilities and precedent, the current Chilean neurorights reforms are vague and premature. As such they should undergo additional scholarly scrutiny and should not be adopted by other jurisdictions' (Fins, 2022, p. 8).

### 5.3. Neurotechnology: Irresistible but irrevocable

After focusing specifically on neurorights, this section will be dealing with a brief ethical reflection of NT, especially from a socio-ethical point of view. Specifically, with regard to a normative-ethical reflection on these technologies, it seems obvious to draw on ethical frameworks and principles from the fields of medical, bioethics and technology ethics. For example, the traditional principles of Beauchamp and Childress (2019) (autonomy, nonmaleficence, beneficence, justice) can serve as important reference points for an ethical discussion. In view of the massive entanglement of humans and machines (and therefore also with AI) in NT, it also seems sensible to consider principles discussed in the field of technology ethics. Floridi (2023), for example, takes up the four bioethical principles, expands them by one principle and reflects on them against the background of AI. Such a more systematic ethical reflection of – especially specific<sup>9</sup> – NT seems essential in view of the subject matter. However, we have also deliberately opted for a socio-ethical perspective because, in view of current discussions in the field of medical and bioethics, it can introduce new approaches that we consider relevant in the context of NT and thus open up a more holistic view of the need for ethical reflection on NT.

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<sup>8</sup> <https://neurorightsfoundation.org/chile>

<sup>9</sup> Specific because specific NT can also pose specific and different ethical challenges, which should be discussed in a correspondingly differentiated manner.

It is obvious that not all ethically relevant aspects can be addressed, not to mention adequately discussed, within the scope of this study, so limitations are clearly inevitable. In this context it has to be emphasized that there is the need for a more intensive examination of the issue in further projects. On the one hand, it will critically outline the extent to which they can exert an irresistible attraction on individuals and society as a whole due to their potential benefits. On the other hand, the problems that could arise from the use and spread of NT, which could irrevocably change society and individuals within it, will be addressed in particular. Of course, it must be borne in mind that although the hype surrounding NT has affected research,<sup>10</sup> the market and society alike, there are important differences between these areas: NT research is usually carried out under strict ethical conditions and is accompanied and monitored by qualified third parties, which is why in context of already existing regulation individuals generally should not have to expect deception or malpractice in this context. NT are fundamentally very ambivalent in our eyes. On the one hand, they could help a large number of people with diseases (e.g. Parkinson's, epilepsy, etc.) by effectively alleviating the symptoms of the disease. Other very positive application contexts arise, for example, with regard to prosthetics (Raspopovic, 2020) and new possibilities in connection with rehabilitation.<sup>11</sup> In general, these technologies could be used to respond very specifically to individual clinical conditions and the needs of those affected. NT would thus be able to make a considerable contribution to the individual and the common good. On the other hand, however, there are also challenges and even risks and dangers. These begin with 'collateral damage' during treatment: For example, when current pulses continuously emitted by deep brain stimulation not only hit the target area, but also affect other areas of the brain and can thus lead to known and/or unknown – possibly irreparable – consequences (such as the development of addiction symptoms or personality changes) (Gilbert et al., 2019). Applications in the field of BCI also appear to be particularly risky and worthy of discussion – although new opportunities for people with physical disabilities may also arise here – or if these technologies are to be used to treat mental illnesses.

Taking a socio-ethical perspective means, in particular, addressing questions of justice, solidarity, equality, the rule of law and participation (Koska & Filipović, 2017). This perspective also appears to be particularly relevant in the context of NT and against the background of the neurorights under discussion. It is not without reason that the foundations of the history of ideas discussed above are the starting points for discourses on the creation of new rights or their adoption and actualisation. Freedom of thought and conscience, mental integrity and privacy are closely linked to the aspect of justice with regard to the individual, as they indicate which interventions and restrictions on the individual are at least considered unjust. The basis set in this way necessarily applies not only to isolated individuals, but to all individuals within a social structure, which in turn leads to aspects such as solidarity, participation and equality coming to light in a significant way. Furthermore, as part of the change in perspective from the individual to the community, it is important to consider which facets of justice require more attention as a result. In short, just because something is just for the individual does not mean that it is generally just for the community and vice versa.

In addition, a further wealth of relevant ethical questions arises, particularly with regard to the social implications of NT: For example, questions relating to social justice and, in particular, questions in the area of equal opportunities and participation appear to be central. These dimensions become clearer, for example, with regard to the domains of education and labour from the section on sociological perspectives and require specific discussions.<sup>12</sup> While, for example, evidence-based, safe and effective NT to combat diseases raises the question of fair access to these technologies and thus addresses the aspect of participatory justice, the question also arises as to what NT means for individual groups against this background. What do NT mean, especially when they are available as

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<sup>10</sup> See section 3.5.

<sup>11</sup> It goes without saying that the corresponding limitations of the technology must always be taken into account here.

<sup>12</sup> See section 4.

consumer goods for 'self-optimisation' for particularly vulnerable groups such as children, the poor and the sick? And in view of the socio-ethical principle of sustainability (Vogt, 2009), it is particularly important to consider future generations and aspects of intergenerational justice. These questions already illustrate the broad need for ethical reflection that goes hand in hand with NT and which expands any research ethics questions and, due to the technology-related obvious questions from the field of medical and bioethics. Selected contexts are briefly discussed below to emphasise the need for reflection outlined above.

### 5.3.1. NT between the individual and society

Democratic societies are characterised by a tense relationship between the individual and the common good. The concept of human dignity, human rights and the Charter of Fundamental Rights emphasise the central status of the individual. It is therefore the individual, the person endowed with dignity and thus with freedom and autonomy – every individual – who is the central and ultimate yardstick for all issues relating to the organisation of our society – including technological issues (Heimbach-Steins, 2022). Nevertheless, we know that people do not live in a void, but in concrete social contexts, that they are social beings. This social nature of human beings is often described as one of their central characteristics (Vester, 2009, pp. 25–43). Living as a human being therefore necessarily means being part of a society and interacting, communicating, and working together with other people on an almost daily basis. Together we build social structures and institutions, pursue work or hobbies, and try to lead a good life. Without interaction and cooperation between individuals, our societies today would be inconceivable and would not function. This also addresses the responsibility for shaping society as a whole, which affects all individuals as part of such a society. This results in a field of tension between individual and social interests. And these different positions require appropriate reflection and balancing processes that take account of individual freedom as well as issues of social justice. NT could and will influence both spheres, the individual one as well as the societal one. Individuals are the potential carriers of NT, but the changes in the individual give rise to new social challenges, which is why the relationship between NT and society also requires special attention.

### 5.3.2. NT and human agency

We have mentioned the aspects of justice, individual wellbeing and the common good here for a reason. The point is to emphasise that human actions are embedded in specific social contexts and that autonomy and freedom must also be considered against this background. It is precisely against this background that the influence of NT must be reflected upon. While reference is often made to the positive aspects of the various invasive and non-invasive NT or while relevant sections of the population believe in them (Giattino et al., 2019; van Elk, 2019), consequences beyond the physical and psychological dimensions are often ignored. From an ethical perspective, interventions of this kind also raise the question of what this means for human agency. Human agency cannot be described in detail here either, which is why we will limit ourselves to the core content. Agency is closely linked to intentional actions and intentionality (Anscombe, 1957; Davidson, 1963). '[...] [A] being has the capacity to exercise agency just in case it has the capacity to act intentionally, and the exercise of agency consists in the performance of intentional actions and, in many cases, in the performance of unintentional actions (that derive from the performance of intentional actions' (Schlosser, 2024). The latter reference to unintentional actions refers to the fact that intentional actions lead to events that imply unintentional actions. For example, if you switch on the light because you have heard something in your home, thereby alerting a burglar. Switching on the light was the intentional action that resulted in the unintentional action of 'alerting a burglar' (Schlosser, 2024). In this context, the concept of sense of agency becomes particularly important, as it encompasses the direct knowledge of our actions, which is also related to the judgement of our actions. Sense of agency describes the perception that we actually do something in the course of our actions and control them (Legaspi et al., 2024). It describes the sense of having ownership about

actions. This in turn has particular significance for an individual's self-perception and self-image. Interference with the sense of agency has the highest disruptive potential in that it would cause the individuals to doubt themselves. In this aspect in particular, NT should be viewed with special caution.

### 5.3.3. NT as a consumer product: The risk of social pressure

From an ethical point of view, in addition to the question of whether NT are non-invasive or invasive, it is also relevant whether they are used in the context of research or whether they are consumer goods. In this section, we are focussing in particular on consumer products, as neurotech in the context of research is ostensibly subject to very strict regulations anyway and is studied in a closed setting. However, as consumer goods, they affect a large number of people, and the central question is whether people can adequately assess the potential impact of the use of such technology on themselves and society. There is also a risk that social pressure (both direct and indirect) in the face of various aspects such as pressure to perform, promises or hopes placed in the technology may encourage the increasingly unreflected use of non-invasive or even invasive NT. They also join the enhancement debate as consumer goods. People have been trying to improve and optimise themselves for many years and, from an ethical point of view, there are good reasons both for (e.g. increase social performance, increase the chance of individual happiness in life) and against (e.g. possible pressure to conform towards the use of enhancement, open questions in connection with equity of access) the possibility of enhancement (Schöne-Seifert, 2007). However, the digital upgrading of the central nervous system represents a relatively new quality in the enhancement debate. The umbrella term neuroenhancement refers to different areas of medical-technical intervention in the central nervous system. A distinction is usually made here between emotional, cognitive, moral, sensory and motor enhancement. However, more intensive – both individual and social – ethical analyses are required to be able to properly classify this complex issue (Fenner, 2019).

### 5.3.4. NT are never value-free: About the intentions and values of the producers

Digitalisation is not a natural disaster that is sweeping over us, but a man-made transformation (Grunwald, 2019a). Technological innovations – which today mostly take place in multinational corporations, large companies or young innovative start-ups – are now influencing the lives of many people with an unprecedented intensity. Many modern technologies – think of particularly efficient smartphones and generative AI systems such as ChatGPT – are already accessible to the masses today, a fact that could not have been foreseen a few decades ago. And a circumstance with massive transformative potential with regard to the human-machine relationship in the most diverse areas of life (Kirchschläger, 2022). NT are part of this process and are (and will presumably become even more intensively so in the future) part of this digital transformation. There is no doubt that these new technologies present many opportunities, but also significant challenges. Technologies are never value-free (Grunwald, 2019a) and are associated with power and the exercise of power – perhaps not even visible to many at first glance (Gremsl, p. 46). Behind technological innovations are the interests and values of developers and producers. And these interests and values are implicitly and/or explicitly part of the respective technologies. Adopting the perspective of an *advocatus diaboli* and, in doing so, taking into account the thoroughly positive and appreciable intentions and values of the producers of such tools, we consider the question of what effects such advanced NT could have on individuals and society in the future to be essential. So, at first glance, the question arises as to how these interests and values, which are consciously or unconsciously part of the specific technological systems, could affect the users. This raises questions of freedom of action, for example, but also generally with regard to the vulnerability of people. In view of increasing attacks on digital infrastructure in the sense of cyber warfare, recurring hacker attacks on private individuals and companies and thus the overall vulnerability of digital infrastructure in the 21st century, we would also like to address the aspect of misuse of such technologies. An increasing

fusion of man and machine would presumably also transfer this vulnerability to humans and lead to new dangers.<sup>13</sup> These aspects are particularly important when considering high-risk technologies and their potential impact on individuals and society, as such complex technologies always involve a certain amount of power. However, the various stakeholders (politicians, companies, consumers, etc.) must not forget that power always comes with dependencies and pressures, but also with responsibilities. In view of the subversive potential of new technologies, in-depth research efforts are needed, particularly with regard to these power relations and questions of responsibility.

### 5.3.5. NT and the image of man

Finally, we would like to point out what we consider to be another central perspective that is being discussed intensively in the transhumanism debate but should be discussed even more intensively in the broader digitalisation debate: the anthropological perspective. The technology ethicist Armin Grunwald emphasises that behind the ethical question of digital transformation lies the question of who the human being is. Who does a person want to be in the face of a highly technologized world and how can a person live freedom, responsibility and creativity against this backdrop (Grunwald, 2019a, 2019b, 2021). Grunwald therefore focuses question of the image of man in increasingly technologized societies. This is because the image of the man - a wide variety of concepts are known in this regard - is affected by the increasing degree of digitalisation. Technological developments in the field of NT are particularly disruptive in this context. The image of a 'human in need of optimization' is often sketched out, which without the synthesis between man and machine - especially in view of developments in the AI sector - threatens to drift further and further behind. A - especially in transhumanist debates - human x.0 (Loh, 2023) is needed to meet these challenges. Although it should be pointed out that the diverse positive potential of various NT is decidedly recognized here, in our view these technologies are the reverse tip of an iceberg that lies beneath the water's surface: it seems to us that no more massive entanglement of humans and technology is possible than influencing the central nervous system; the potential - individual and social - consequences (both in the medium and long term) are not foreseeable. In view of the implications, which can only be sketched out to some extent, this topic should not be an innovation process driven by corporate interests but requires broad scientific (especially from the humanities) and social and political discourse and debate.

## 5.4. Findings from an ethical perspective

On the basis of these analyses, caution and intensive consideration of the implications of implementing neurorights must be advised. The basic protective intentions of neurorights are derived from the concepts of the history of ideas, but implementation at the level of human rights is not expedient from a philosophical and ethical perspective as there is a risk of rights inflation and dilation of existing human rights. Implementation at a subordinate legal level, for example as a supplement to protective norms in the area of healthcare, could be a preferable way of preserving the positive protective intentions without 'overshooting the mark'.

A comprehensive ethical assessment of NT is a complex endeavour and requires in-depth studies from different perspectives and different ethical approaches (e.g. meta-ethical, normative; individual-ethical, socio-ethical). In this short section, we have only been able to discuss selected ethical challenges, primarily from a socio-ethical perspective. However, in view of the potential scope of these technologies, it is advisable to carry out as broad an ethical analysis as possible. In addition to the aspects mentioned above, this also concerns questions such as what concepts of a good and successful life might look like in the face of such technologies, what such technologies

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<sup>13</sup> We deliberately do not list any specific dangers here, as we are unable to assess them in concrete terms and they might appear to come from science fiction novels or films. Nevertheless, we would like to point out that creative and innovative examples from pop culture in particular have repeatedly influenced the development of technology.

mean for identity and personality and, in particular, the dimension of long-term consequences of the impact of NT on the individual and society.

In any case, regulation that is appropriate to the issue (and thus to the complexity of the topic in particular) seems just as essential as the need to take measures to raise awareness of the social and ethical dimensions of NT among the general public in the long term.

## 6. Neurorights: – A legal perspective

### 6.1. Introduction

As explained in section 3, reports on NT include both scientific studies and promises for the future as well as advertising claims for self-improvement products. For this reason, so-called 'neurorights' have been called for since 2017. While its content had already been addressed, at least in part, by Bublitz's *'My Mind is Mine!? Cognitive Liberty as a Legal Concept'* in 2013<sup>14</sup> since 2019, the NRF has been the main proponent, with the aim of establishing neurorights as human rights or further interpreting the human rights framework. The NRF aims at the legal level, while moral neurorights are not the focus of its demands, for further details refer to section 5. The website of the NRF contains numerous documents relating to neurorights. The neurorights demanded there include – with changes over the years and with variations in number (3-5) and designation – 'the right to mental privacy', 'the right to personal identity', 'the right to free will', 'the right to equal access to mental augmentation' and 'the right to protection from algorithmic bias', as shown in Table 7.

In this section, the proposals of the NRF will be analysed from a legal perspective, closely following the proposed texts, and an attempt will be made to place them within the existing human rights framework and the structure of the EU's legal system (EU primary and secondary law). In particular the NRF's 'right to mental privacy', will be at the centre of the analysis, as the title of the report explicitly focusses on 'mental privacy'. From this, following the precautionary principle as envisaged in COM/2000/0001<sup>15</sup> a first statement on the urgency and usefulness of implementing the proposed neurorights will be derived.

At the beginning of the analysis, a brief description of the NRF will shed light on who is so intensively committed to neurorights.

### 6.2. The Neurorights Foundation

#### 6.2.1. Neurorights Foundation

According to its website, the base for the NRF dates back to 2017, when a three days long 'Morningside Group - Columbia Workshop' was held in which a 'Neurorights Framework' was developed. This later gave rise to the 'Neurorights Initiative' funded by Columbia University. This initiative was subsequently merged into the NRF.<sup>16</sup> Currently, as of April 2024, the board of directors consists of Rafael Yuste<sup>17</sup>, Jared Genser, Jamie Daves and Sean Pauzauskie.

#### 6.2.2. Documents 2017-2023 provided on the Neurorights Foundation website related to neurorights

The following list of publications refers to documents listed on the NRF website.<sup>18</sup> The analysis of the texts published on the NRF website began in autumn 2023. It is important to note that the key

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<sup>14</sup> The importance of this topic was already known beforehand, but the rights were not yet labelled as 'neurorights'. E.g.: J.-C. Bublitz (2013) For this reason the focus is on the neurorights of the NRF.

<sup>15</sup> Communication from the Commission on the precautionary principle (COM/2000/0001 final).

<sup>16</sup> <https://neurorightsfoundation.org/mission>

<sup>17</sup> MD P.h.D Rafael Yuste, Chairman and Co-Founder of the NRF, is Professor of Biological Sciences at Columbia University and directs its Center for Neurotechnology; more details: <https://neurorightsfoundation.org/people>.

<sup>18</sup> It should be noted that there are also numerous other publications that are not discussed in this analysis.

publication by Ienca and Andorno (Ienca & Andorno, 2017), which was also available on the NRF website in September 2023, can no longer be found there.

This publication ('Towards new human rights in the age of neuroscience and neurotechnology') from 2017 is the first one, in which neurorights were addressed and called for and was written by Ienca and Andorno (Ienca & Andorno, 2017). In the same year Yuste identified concerns related to NT in the publication 'Four ethical priorities for neurotechnologies and AI' (Yuste, 2017).

In 2021, the rights proposed by Ienca and Andorno in 2017 were summarised by Goering et al in 'Recommendations for Responsible Development and Application of Neurotechnologies' (Goering et al., 2021) and by Yuste, Genser and Hermann in 'It's time for Neuro-Rights. New human rights for the age of neurotechnology' (Yuste et al., 2021).

In 2022, 'Protecting the mind' (López-Silva & Valera, 2022) was published, in which chapter 13 ('Neuro Rights: A human rights solution to ethical issues of neurotechnologies') (Baselga-Garriga et al., 2022) again calls for neurorights. The article 'International Human Rights Protection Gaps in the Age of Neurotechnology' by Genser, Hermann and Yuste was also published in 2022 (Genser et al., 2022). In 'Horizon Report for The Law Society. Neurotechnology, law and the legal profession' McCay summarises the required neurorights (McCay, 2022).

In 2023, in 'Neuro-Rights and New Charts of Digital Rights: A Dialogue Beyond the Limits of the Law', Yuste and Quadra-Salcedo again vehemently call for neurorights (Yuste & Quadra-Salcedo, 2023).

In April 2024 the report 'Safeguarding Brain Data: Assessing the Privacy Practices of Consumer Neurotechnology Companies' by Genser, Damianos, Yuste was published. This report includes the five neurorights but no longer calls for them as new human rights (Genser et al., 2024).

The 'mission' of the NRF also contains the requested neurorights.<sup>19</sup>

## 6.3. Neurorights

The NRF provides several publications on neurorights on its website. The proposed neurorights according to the NRF website are: 'the right to mental privacy', 'the right to personal identity', 'the right to free will', 'the right to equal access to mental augmentation' and 'the right to protection from algorithmic bias'.<sup>20</sup> The number of proposed neurorights varies (3-5), as does the wording and the description.

### 6.3.1. Number of proposed neurorights

Table 6 in the annex lists the relevant documents concerning neurorights, the year of publication and the authors. For a quick overview, the number of proposed neurorights, which will be discussed in the following section, is shown. The amount of proposed neurorights (3-5) varies from one document to another, please refer to Table 6. The analysis is current as of April 2024.

### 6.3.2. Wording

Currently as of April 2024, the contributions of the NRF do not contain any formulated legal text. The content of the so-called neurorights can only be derived from the headings as shown in Table 7 and from the descriptions.

<sup>19</sup> <https://neurorightsfoundation.org/mission>

<sup>20</sup> <https://neurorightsfoundation.org/mission>

This makes it impossible to analyse and interpret the wording of the required neurorights. The desired content can therefore more or less be derived from the descriptions, which will be discussed in the next section.

### 6.3.3. Description of each proposed neuroright

As already mentioned in the subsection 6.3.2, the required neurorights consist only of headings. Even though no formulation has taken place yet, this section attempts to determine the required neurorights from the existing descriptions and demands. After considering the rights in different documents, the analysis for each document is presented in the tables (Table 8, Table 9, Table 10, Table 11, Table 12 and Table 13) as original wording. An attempt is then made to identify the similarities and differences within the same proposed rights.

#### Right to mental privacy

The demand for a 'right to mental privacy' has remained unbroken since 2017, see Table 8. In 2021, Yuste/Genser/Herrmann added the explanatory half-sentence '[...] or the ability to keep thoughts protected against disclosure'. (Yuste et al., 2021, p. 160) A new explanation was also added in April 2024 '[...] or the ability to keep mental activity protected against disclosure' (Genser et al., 2024, p. 14). The relevance of this right is said to arise from the fact that data subjects are not aware of the processing, storage and deletion of their 'brainwaves' (lenca & Andorno, 2017, p. 14). It is criticised that current data protection rules are aimed at the external information of data subjects, whereas the data relevant to the use of NT should be directly related to one's inner life (lenca & Andorno, 2017, p. 14). The possibility of an opt-out or an opt-in is also discussed (Goering et al., 2021). As far as we know, the specific object of protection of this right remains unclear; 'the individual's neural processing' (lenca & Andorno, 2017, p. 14) is mentioned, since it is not so easy to distinguish the information from the source in the case of 'brain data' (lenca & Andorno, 2017, p. 15), but also 'conscious thinking and the subconscious' (Yuste & Quadra-Salcedo, 2023, p. 23).

#### Right to personal identity

The 'right to mental (Genser et al., 2022, p. 4; Yuste & Quadra-Salcedo, 2023, p. 23)/personal (Baselga-Garriga et al., 2022, p. 159; McCay, 2022, p. 22; Neurorights Foundation) identity/integrity (Goering et al., 2021; lenca & Andorno, 2017, p. 17; Yuste et al., 2021, p. 160) /agency (Yuste, 2017, p. 162) /"sense of self" (Genser et al., 2022, p. 4) is not mentioned quite as clearly as 'mental privacy' in the documents analysed here, see Table 9. Again, Yuste/Genser/Herrmann 2021 add an explanation: '[...] or the ability to control both one's physical and mental integrity' (Yuste et al., 2021, p. 160) a new clarification was added by Genser/Damianos/Yuste in April 2024: '[...] or the ability to control one's mental integrity and sense of self' (Genser et al., 2024, p. 14)

As far as we understand, it is intended to protect the psychological dimension of the individual. Actions that are considered threatening include access to or manipulation of neural signals, actions without informed consent, and actions that 'result in physical and/or psychological harm.' (lenca & Andorno, 2017, p. 18) The protection of self-determination, including through informed consent, is cited as a normative goal (Yuste, 2017, p. 162). Informed consent also includes the ability to choose whether and to whom this information is made available and to whom it is shared (Baselga-Garriga et al., 2022, p. 159). According to Yuste and de la Quadra-Salcedo, since NT can alter personality (Yuste & Quadra-Salcedo, 2023, p. 23), this right should ensure the preservation of human consciousness.<sup>21</sup>

In a nutshell: Human decisions should not be made or manipulated by external technology (Baselga-Garriga et al., 2022, p. 160).

<sup>21</sup> <https://neurorightsfoundation.org/mission>

## Right to free will

It was not until 2021 that Yuste/Genser/Herrmann formulated the 'right to agency, or the freedom of thought and free will to choose one's own actions' (Yuste et al., 2021, p. 160), this formulation was taken up in April 2024 (Genser et al., 2024, p. 14), which is subsequently referred to as the 'right to (mental) (Genser et al., 2022, p. 4) agency or "free will"' (Yuste & Quadra-Salcedo, 2023, p. 23) or simply 'the right to free will' (Baselga-Garriga et al., 2022, p. 160; McCay, 2022, p. 22; Neurorights Foundation); a precursor could be the 'cognitive freedom' mentioned by Ienca/Andorno in 2017 (Ienca & Andorno, 2017, p. 10) or the 'right to mental freedom' postulated by Goering et al (Goering et al., 2021), see Table 10. The right demanded here, which is summarised as a concordant component under the heading 'right to free will', is associated with the expectation that individuals will be guaranteed control over their decisions.<sup>22</sup> Behind this is the fear that NT in relation to mental improvement might not be accessible to everyone (Baselga-Garriga et al., 2022, p. 160; Neurorights Foundation), but also that this could lead to a compulsion to improve oneself mentally.

## Right to equal access to mental augmentation

Finally, the demand for protection against or fair access to enhancement technologies follows a similar line. 'Augmentation' is already mentioned by Yuste in 2017 (Yuste, 2017, p. 162), and concretised by Yuste/Genser/Herrmann in 2021, taken up in April 2024 by Genser/Damianos/Yuste (Genser et al., 2024, p. 14), in a respectful right as follows: 'the right to fair access to mental augmentation, or the ability to ensure that the benefits of improvements to sensory and mental capacity through NT are distributed justly in the population' (Yuste et al., 2021, p. 160), see Table 11. The stated aim in 2017 is to define areas in which 'mental augmentation' is absolutely prohibited (Yuste, 2017, p. 162). While the initial focus was on the protection of vulnerable people (Yuste, 2017, p. 162), the descriptions from 2022 onwards clearly shift the focus to equal and fair access to mental augmentation (Baselga-Garriga et al., 2022, p. 160; Yuste & Quadra-Salcedo, 2023, p. 24). In our view, the more recent statements on augmentation are based on the assumption that NT can be used by everyone, and that the predominantly positive effects of NT lead to an imbalance between people who use NT and those who do not (or cannot) use it (Baselga-Garriga et al., 2022, p. 160; Neurorights Foundation; Yuste & Quadra-Salcedo, 2023, p. 24).

## Right to protection from algorithmic bias

'Bias' (see Table 12) was already mentioned by Yuste in 2017 (Yuste, 2017, p. 162), but was not formulated with a corresponding competence goal until 2021 by Yuste/Genser/Herrmann, namely as: 'the right to protection from algorithmic bias, or the ability to ensure that technologies do not insert prejudices' (Yuste et al., 2021, p. 160), this formulation was taken up in April 2024 (Genser et al., 2024, p. 14); this term is subsequently uniformly referred to as the 'right to protection from algorithmic bias'. This is based on the recognition that algorithms can also reflect bias in NT. The proposed right is intended to prevent the privileging of individual groups (Baselga-Garriga et al., 2022, p. 160; Neurorights Foundation; Yuste, 2017, p. 162; Yuste & Quadra-Salcedo, 2023, p. 24). According to Baselga-Garriga, Rodriguez and Yuste, this could be prevented, for example, by including all groups in the process (Baselga-Garriga et al., 2022, p. 160; Yuste, 2017, p. 162).

### 6.3.4. Impact

Even if, as the review of the documents makes clear, neurorights currently have little concrete legal content from a jurisprudential perspective, their political impact is impressive.

<sup>22</sup> <https://neurorightsfoundation.org/mission>

In 2019, the OECD published a working paper on NT (OECD, 2019). The paper already addressed the protection of fundamental rights, referring to Ienca & Andorno, 2017 (OECD, 2019, p. 30). Concrete neurorights or a reference to the NRF are not discernible.

In 2022, the European Parliament made a request to the Commission in relation to the AI Act:

'[...] to consider an initiative on neurorights with the aim to guard the human brain against interference, manipulation and control by AI-powered neurotechnology; encourages the Commission to champion a neurorights agenda at the UN level in order to include neurorights in the Universal Declaration of Human Rights, concretely as regards the rights to identity, free will, mental privacy, equal access to brain augmentation advances and protection from algorithmic bias.' (European Parliament, 2022, No 247)

These rights are the same as those of the NRF. The current version as published in March 2024 does not mention NT any more.<sup>23</sup>

In 2023, UNESCO published a paper entitled '*The Risks and Challenges of Neurotechnologies for Human Rights*', which outlines the risks and opportunities of NT for human rights. Although the NRF is not explicitly mentioned in the text, it can be found in footnote 32 (UNESCO, 2023, p. 50) of the document and is referred to in the text as the 'Neuro-Rights Initiative'. The five neurorights demanded by the NRF are also listed here. References to literature with Yuste as (co-)author (Goering et al., 2021; Yuste, 2017; Yuste et al., 2021) are also included in this paper.

While the '*León Declaration*' only refers to the NRF in connection with one study (Spanish presidency, 2023), the declaration is listed on the NRF homepage on the 'News' subpage.<sup>24</sup> This declaration only contains a general statement that further steps will be taken in relation to NT, but does not yet define any neurorights.

In 2021, Chile became the first country in the world to adapt its constitution with specific reference to brain activity. The following paragraph was added to Article 19 '*Constitución Política de la República*':

'El desarrollo científico y tecnológico estará al servicio de las personas y se llevará a cabo con respeto a la vida y a la integridad física y psíquica. La ley regulará los requisitos, condiciones y restricciones para su utilización en las personas, debiendo resguardar especialmente la actividad cerebral, así como la información proveniente de ella' (Modifica la carta fundamental, para establecer el desarrollo científico y tecnológico al servicio de las personas, 2021/CVE 2031873).

To summarise, this means that scientific and technological development should in general be at the service of humanity and protect life and physical and mental integrity. In particular, brain activity and information that can be derived from brain activity should be protected.

Most recently, the Brazilian state of Rio Grande do Sul included neurorights in its constitution in December 2023 (Altera o parágrafo único do artigo 235 da Constituição do Estado do Rio Grande do Sul (SEI 14506-0100/23-7), 2023/PEC 298 2023). The 'Justificativa' contain both 'neurotecnologia' and 'neurodireitos' (PEC 298/2023).

Overall, therefore, it is clear that high-level institutions, organisations and some countries have taken up the issue of neurorights and have already proposed that they be enshrined at UN level within the framework of the Universal Declaration of Human Rights.

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<sup>23</sup> Proposal for a Regulation of the European Parliament and of the Council laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) and amending certain union legislative acts/ P9\_TA(2024)0138

<sup>24</sup> <https://neurorightsfoundation.org/news>

### 6.3.5. Quality of law

The NRF and all publications analysed in connection with the NRF, except the report of April 2024, refer to the proposed neurorights as human rights; the new report published in April 2024 contains a new statement: 'Advocates of neurorights are not calling for the creation of new rights, but rather the further interpretation of existing human rights law to guide the development of national legal and regulatory frameworks.' (Genser et al., 2024, p. 14). UNESCO also mentions fundamental rights. This classification shows that a categorisation at the highest level is intended, while a secondary law does not always seem to be considered.

The rights referred to throughout as 'rights' leave open the question of their actual quality. It is unclear whether they are meant to be subjective rights that can be claimed by those affected, or rather state objectives, i.e. guidelines for state bodies. To clarify the significance of the distinction, we will briefly discuss what we consider to be the key characteristics in the given context.

The declarations of UNESCO, as one of the 17 legally independent specialised agencies of the UN, have a global impact. Initiatives placed by interested member states (currently 194)<sup>25</sup>, often also by NGOs – in this case possibly by the NRF – usually form the starting point. In some cases, preparatory work is also carried out by the UNESCO Secretariats (Oberleitner, 2022). Recommendations or international conventions to be ratified by the member states are proposed to the Member States by the UNESCO General Conference in accordance with Article IV of the UNESCO Constitution. Recommendations are adopted by a simple majority vote and agreements by a two-thirds majority. According to Article VIII, the Member States are obliged to submit a report to the General Conference on the measures taken on the basis of the recommendations or agreements.<sup>26</sup>

The European Convention on Human Rights (ECHR)<sup>27</sup> from 1950 is an agreement imposing international legal obligation. All signatory states are obliged to guarantee the rights granted therein. If an ECHR right is violated, domestic legal action is the first option, after which the person concerned can apply to the European Court of Human Rights (ECtHR) (Article 35 ECHR).<sup>28</sup> The judgements of the ECtHR are binding on the states concerned (Article 46 ECHR). If the NRF neurorights were to be enshrined in the ECHR, the Council of Europe would have to take action.

Since 2009 (Treaty of Lisbon),<sup>29</sup> the Charter of Fundamental Rights of the European Union<sup>30</sup> is legally binding and part of primary law (Article 6 Treaty on European Union). The national courts are responsible for enforcing the law, indirectly through references to the ECJ for preliminary rulings.<sup>31</sup>

National objectives<sup>32</sup> must be distinguished from the subjective rights of the ECHR and the CFR. National objectives have the same constitutional status as simple constitutional provisions, but cannot be enforced by the parties concerned. They are addressed to the state and serve as a guide as to which objective should be pursued in legislation and administration. When interpreting the law, the courts – in Austria especially the Constitutional Court – must also take into account the national objectives (Bertel, 2015).

<sup>25</sup> <https://www.unesco.org/en/countries>

<sup>26</sup> Constitution of the United Nations Educational, Scientific and Cultural Organization

<sup>27</sup> European Convention on Human Rights

<sup>28</sup> <https://www.echr.coe.int/how-the-court-works>

<sup>29</sup> Treaty of Lisbon Amending the treaty on European Union and the treaty establishing the European community

<sup>30</sup> Charter of Fundamental Rights of the European Union

<sup>31</sup> [https://commission.europa.eu/aid-development-cooperation-fundamental-rights/your-rights-eu/how-report-breach-your-rights\\_en](https://commission.europa.eu/aid-development-cooperation-fundamental-rights/your-rights-eu/how-report-breach-your-rights_en)

<sup>32</sup> National objectives exist for example in Austria, France, Germany.

Under secondary legislation, regulations create uniform law while directives aim at a harmonised legal framework, which must then be implemented by the member states at national level (Article 288 Consolidated Version of the Treaty on the Functioning of the European Union).

The level at which the required neurorights should be meaningfully implemented is currently completely unclear. Even the term 'human rights' gives little indication of this level. In this case, the ECHR, but also the UN, would be a possible starting point. UNESCO, as a sub-organisation of the UN, has taken a first step, albeit more in terms of legal policy, within a publication (UNESCO, 2023).

### 6.3.6. Allocation of neurorights to existing human and fundamental rights

In this section, the proposed neurorights are linked to already existing rights.<sup>33</sup> It should be noted again that the actual scope of the proposed rights is not totally clear and the following explanations refer to the titles and the descriptions given above. After focussing on the level of human and fundamental rights, we extend the scope of the analysis to an initial interrogation of the NT in the area of secondary legislation.

By way of introduction, we remind that the EU is committed to the precautionary principle as formulated by the Commission in the Communication COM/2000/0001<sup>34</sup>. Thus, in cases of scientific uncertainty about potential risks of NT, the EU decision-makers will have to find an adequate political way how to deal with opportunities and risks of NT. According to the before mentioned Communication, the general principles that must be observed are: proportionality, non-discrimination, consistency, examination of the benefits and costs of action or lack of action and examination of scientific developments.

Important from a legal perspective in this context: 'Recourse to the precautionary principle does not necessarily mean adopting final instruments designed to produce legal effects, which are subject to judicial review' (Communication from the Commission on the precautionary principle (COM/2000/0001 final), p. 19); there is a wide range of possible actions available to decision-makers e.g. namely to fund a research programme or to inform the public about the possible adverse effects of a product or procedure may themselves be inspired by the precautionary principle.

Bearing in mind that conceptual framework, we start analysing the proposed NRF neurorights within EU legislation.

#### Primary law

The 'right to mental privacy' is similar to the right to privacy, which is comprehensively protected by human rights and fundamental rights, but is limited to the 'mental' sphere. In Europe, privacy is a recognised, guaranteed and adjudicated value. Article 8 ECHR guarantees respect for private and family life; Article 7 and Article 8 of the CFR guarantee privacy as a highly protected, legally enforceable right in the EU; for further details: section 6.4.

What remains unclear is the 'right to mental identity', which is obviously not intended to regulate the recognisability of persons in virtual/digital environments (e.g. in the eIDAS Regulation<sup>35</sup>, but rather the characteristics of personality. This issue, which is still unresolved in philosophy (Precht, 2007) and psychology, is not well suited to be given a normative character.

<sup>33</sup> First results were discussed and published on IRIS24: Berger et al. (2024)

<sup>34</sup> Communication from the Commission on the precautionary principle (COM/2000/0001 final)

<sup>35</sup> Regulation (EU) No 910/2014 of the European Parliament and of the Council of 23 July 2014 on electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC

Importantly, Article 3 CFR, titled 'Right to the integrity of the person', explicitly safeguards an individual's 'physical and mental integrity'.

However, 'free will', which is linked to the same disciplines, is legally defined. Section I of the ECHR is entitled 'Rights and Freedoms' and, in addition to the 'right to life' (Article 2), the 'prohibition of torture' (Article 3) and the 'prohibition of slavery and forced labour' (Article 4), it explicitly lists the 'right to liberty and security' (Article 5), the 'right to respect for private and family life' (Article 8), 'freedom of thought, conscience and religion' (Article 9)<sup>36</sup>, 'freedom of expression' (Article 10) and 'freedom of assembly and association' (Article 11). Within the CFR, the whole of Title II (Articles 6-19) is devoted to the above-mentioned freedoms. In addition to the comprehensive protection of human dignity in Title I of the CFR (Articles 1-5; explicitly Article 1), specific freedoms of the will are also recognised, e.g. in the form of freedom of thought, which is particularly relevant in the context of NT (Article 10 CFR 'Freedom of thought, conscience and religion'). 'Freedom of expression' is also comprehensively protected by fundamental rights in addition to the human rights guarantee (Article 11 CFR).

The two rights requiring 'equal access' to NT and protection against algorithmic bias can be categorised as prohibitions of discrimination (Article 14 ECHR, Title III, Articles 20 - 26 CFR).

Importantly, human rights and fundamental rights must be applied in a way that does not violate the essence of any right (Article 52 CFR). Consequently, the process involves a nuanced balancing of interests in individual cases, which has led to a significant body of case law from the courts. It is crucial to recognize that, regarding these emerging neurorights, established case law has yet to be developed. This lack of precedent introduces a high degree of uncertainty.

## Secondary law

In addition to primary law, EU secondary law must also be observed. The existing EU legal framework is consolidating the (digital) single market, based on European Values as stated in Article 2 TEU<sup>37</sup> and in the CFR. Core pillars of the single market are fair competition<sup>38</sup>, a high level of consumer protection<sup>39</sup>, and product safety rules<sup>40</sup>, complemented by standardisation<sup>41</sup> and market surveillance<sup>42</sup>. This legal framework is supplemented by the digital strategy, which – based on the

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<sup>36</sup> Reflecting this Article: Hertz (2023a, 2023b)

<sup>37</sup> Treaty on European Union

<sup>38</sup> Directive 2005/29/EC of the European Parliament and of the Council of 11 May 2005 concerning unfair business-to-consumer commercial practices in the internal market and amending Council Directive 84/450/EEC, Directives 97/7/EC, 98/27/EC and 2002/65/EC of the European Parliament and of the Council and Regulation (EC) No 2006/2004 of the European Parliament and of the Council ('Unfair Commercial Practices Directive')

<sup>39</sup> Directive 2011/83/EU of the European Parliament and of the Council of 25 October 2011 on consumer rights, amending Council Directive 93/13/EEC and Directive 1999/44/EC of the European Parliament and of the Council and repealing Council Directive 85/577/EEC and Directive 97/7/EC of the European Parliament and of the Council Text with EEA relevance

<sup>40</sup> Regulation (EU) 2023/988 of the European Parliament and of the Council of 10 May 2023 on general product safety, amending Regulation (EU) No 1025/2012 of the European Parliament and of the Council and Directive (EU) 2020/1828 of the European Parliament and the Council, and repealing Directive 2001/95/EC of the European Parliament and of the Council and Council Directive 87/357/EEC

<sup>41</sup> Regulation (EU) No 1025/2012 of the European Parliament and of the Council of 25 October 2012 on European standardisation, amending Council Directives 89/686/EEC and 93/15/EEC and Directives 94/9/EC, 94/25/EC, 95/16/EC, 97/23/EC, 98/34/EC, 2004/22/EC, 2007/23/EC, 2009/23/EC and 2009/105/EC of the European Parliament and of the Council and repealing Council Decision 87/95/EEC and Decision No 1673/2006/EC of the European Parliament and of the Council Text with EEA relevance

<sup>42</sup> Regulation (EU) 2019/1020 of the European Parliament and of the Council of 20 June 2019 on market surveillance and compliance of products and amending Directive 2004/42/EC and Regulations (EC) No 765/2008 and (EU) No 305/2011

GDPR and in line with the CRF – in current legal acts (e.g. AI Act<sup>43</sup> provides strong protection while enabling broad data usage; focussing on ICT products, cybersecurity plays a vital role in the legal regulation of the digital realm.<sup>44</sup>

The EU has opted for a – highly punitive – risk-based approach to product safety, which regularly starts with risk assessments and provides for increased measures depending on the study of the expected risk. This process is included in the General Product Safety Regulation (EU) 2023/988, but also forms the basis of the MDR (Regulation (EU) 2017/745)<sup>45</sup> and, quite remarkably, the GDPR (Regulation (EU) 2016/679)<sup>46</sup>. As far as can be foreseen, it will also determine the European approach to AI.

In the area of healthcare products and services the EU already has a highly differentiated legal framework for cross-border healthcare services<sup>47</sup> including strict authorisation and ongoing monitoring of medical devices.<sup>48</sup>

Neuro-devices with a medical purpose are strictly regulated by the MDR, that sets rules on placing, making available and putting into service medical devices for human use and their accessories on the EU market. The MDR poses stringent procedures for conformity assessment to ensure that unsafe or non-compliant devices do not end up on the market and also includes post-market surveillance. Thus, neuro-implants (such as DBS and BCI) and, for example, TMS and tES are highly regulated as medical devices under the MDR as long as they are used for medical purposes, see section 3.

Annex XVI MDR lists groups of products without an intended medical purpose referred to in Article 1(2) and extends the scope of the MDR specifically to 'Equipment intended for brain stimulation that apply electrical currents or magnetic or electromagnetic fields that penetrate the cranium to modify neuronal activity in the brain.'<sup>49</sup> This category includes, for example, tES when this NT is used for non-medical purposes, see section 3.

Still some neuro-devices remain outside the scope of the MDR (Freise, 2024; Ienca et al., 2022; Steindl, 2024). Here the above mentioned general legal framework comes into play. Since neuro-devices are always designed as some hardware (chip, EEG-headband etc.) with software (for converting brain signals into processable data), they are in any case 'goods with digital elements'

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<sup>43</sup> Proposal for a Regulation of the European Parliament and of the Council laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) and amending certain union legislative acts

<sup>44</sup> Regulation (EU) 2019/881 of the European Parliament and of the Council of 17 April 2019 on ENISA (the European Union Agency for Cybersecurity) and on information and communications technology cybersecurity certification and repealing Regulation (EU) No 526/2013 (Cybersecurity Act) (Text with EEA relevance)

<sup>45</sup> Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC

<sup>46</sup> Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)

<sup>47</sup> Directive 2011/24/EU of the European Parliament and of the Council of 9 March 2011 on the application of patients' rights in cross-border healthcare

<sup>48</sup> Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC

<sup>49</sup> Annex XVI (6) Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC

within the meaning of Article 2(5) Directive (EU) 2019/771.<sup>50</sup> This definition is included in both the Competition Directive<sup>51</sup> and Consumer Rights Directive,<sup>52</sup> thus bridging the gap between consumer and competition law and creating a solid foundation for trustworthy markets for all types of goods in the EU. Moreover, whenever NT is a product –

'means any item, whether or not it is interconnected to other items, supplied or made available, whether for consideration or not, including in the context of providing a service, which is intended for consumers or is likely, under reasonably foreseeable conditions, to be used by consumers even if not intended for them' (Article 3(1) General Product Safety Regulation)

– it falls under the General Product Safety Regulation that specifies minimum product safety requirements; in the digital space, additionally the Cybersecurity Package and the GDPR are applicable. It is summarized in a nutshell:

Table 1 – NT and law

NT	Law
MDR-NT	"medical device" means any instrument, apparatus, appliance, software, implant, reagent, material or other article intended by the manufacturer to be used, alone or in combination, for human beings for one or more of the following specific medical purposes: diagnosis, prevention, monitoring, prediction, prognosis, treatment or alleviation of disease, [...], an injury or disability, [...] <sup>53</sup>
Annex XVI-NT for non medical use	'Equipment intended for brain stimulation that apply electrical currents or magnetic or electromagnetic fields that penetrate the cranium to modify neuronal activity in the brain.' <sup>54</sup>
NT - not included in MDR	No medical use, not Annex XVI, but still 'goods with digital elements', 'products', 'personal data' and 'ICT-products'.

Thus from a legal perspective we distinguish between three types of NT goods

- highly protected MDR-NT products
- Annex XVI products without medical use and
- products that are neither covered by the MDR nor by Annex XVI but must nevertheless fulfil the general requirements under competition, consumer and product safety law.

<sup>50</sup> Directive (EU) 2019/771 of the European Parliament and of the Council 20 May 2019 on certain aspects concerning contracts for the sale of goods, amending Regulation (EU) 2017/2394 and Directive 2009/22/EC, and repealing Directive 1999/44/EC

<sup>51</sup> Directive (EU) 2024/825 of the European Parliament and of the Council of 28 February 2024 amending Directives 2005/29/EC and 2011/83/EU as regards empowering consumers for the green transition through better protection against unfair practices and through better information

<sup>52</sup> Directive (EU) 2019/2161 of the European Parliament and of the Council of 27 November 2019 amending Council Directive 93/13/EEC and Directives 98/6/EC, 2005/29/EC and 2011/83/EU of the European Parliament and of the Council as regards the better enforcement and modernisation of Union consumer protection rules

<sup>53</sup> Article 2 (1) Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC

<sup>54</sup> Annex XVI (6) Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC

Preview: From 12 January 2025: Regulation (EU) 2021/2282<sup>55</sup> will be in force, introducing common rules and methods for joint health technology assessment (HTA), including joint clinical assessments and the establishment of national HTA bodies coordinated by the Member States Coordination Group on HTA. Article 15 Directive (EU) 2011/24 established the Health Technology Assessment Network, which could be a good starting point for addressing NT in cooperation with the Member State Coordination Group on HTA.

European universities are also already working on NT, in particular the European University of Brain Technology – NeurotechEU.<sup>56</sup>

Together they could ensure responsible research in NT and initiate and support codes of conduct and harmonised standards.

With the focus on brain data caused by the use of NT the GDPR has created a uniform law for the processing of personal data. Personal data includes information on/about an individual and is generally to be interpreted broadly. Brain activity data or data about neuronal processes in a human brain, in individual cases, may be categorised as highly protected data under Article 9 GDPR.

## Summary

Answering the question. If the proposed neurorights should actually be enshrined as human or fundamental rights or at the constitutional level, we clearly state, that we urgently recommend not to open the highest level of the law to technological specificities. As an example, we refer to the upcoming AI Act, which regulates an equally impressive and powerful technology under secondary law without amending fundamental rights.

## 6.4. Mental privacy

Due to the specific task of this report – since mental privacy is mentioned specifically in the title – an in-depth analysis shall be added.

Mental privacy can be included in the area of privacy, although the exact scope of this specific right to privacy remains unclear from a legal perspective. Privacy has been established as a recognised value in the EU. Respect for private and family life is enshrined in Article 8 ECHR. In the CFR, Article 7 and Article 8 must be respected with regard to privacy. While Article 7 CFR, 'Respect for private and family life', grants everyone the subjective right to respect for their private and family life, their home and their communications, Article 8, 'Protection of personal data', explicitly guarantees everyone the right to the protection of personal data.

At the level of secondary legislation, the GDPR addresses 'the protection of natural persons with regard to the processing of personal data'. In order for the GDPR to apply, the scope of application must be open in terms of territory, material and persons.<sup>57</sup> If the GDPR is applicable, the principles of Article 5 GDPR and the lawfulness reasons of Article 6 GDPR and, under certain circumstances, Article 9 GDPR.

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<sup>55</sup> Regulation (EU) 2021/2282 of the European Parliament and of the Council of 15 December 2021 on health technology assessment and amending Directive 2011/24/EU

<sup>56</sup> <https://education.ec.europa.eu/sites/default/files/document-library-docs/european-universities-factsheet-neurotech-eu.pdf>

<sup>57</sup> Article 2, Article 3 Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)

Article 9(1) GDPR lists the categories of 'specific categories of personal data' and prohibits their processing in principle, unless an exception applies pursuant to Article 9(2). The category of Article 9 GDPR includes, among others and relevant in this context, health data.

The definition of the term is derived from Article 4(15) GDPR. The definition has two elements. 1) 'personal data related to the physical or mental health of a natural person', and 2) 'reveal information about his or her health status'.

If the data collected by NT relate to the natural person from whom the data originate, the GDPR must be taken into account. If there is a clear link to health, the data must be classified as health data according to Article 9 GDPR in conjunction with Article 4(15) GDPR. The classification 'brain data' is not always so clear, especially with regard to enhancement products. These data do not always relate to physical or mental health or provide information about the state of health.

According to Borges, it is not the category of data that should be the focus of the classification under the special category according to Article 9 GDPR, but rather the specific processing of the data. This is based on the fact that the risk to the rights of data subjects does not arise from the category per se, but from the processing. The focus should therefore be on the processing operations. (Borges, 2023)

Brain data is therefore currently not always covered by the special category of Article 9 GDPR. It may therefore be worth considering adding 'brain data' to the category of specially protected data under Article 9 GDPR as a new category; to answer this question, in-depth investigation and discussion is needed.

The processing of data by and with NT can certainly lead to interference and harm. With NT, brain data is still coming out, but at the same time, data can also be brought into the brain and thus can lead to manipulation. Manipulation must be understood in a broad sense. In this context, it is essential mentioning that the draft of the AI Act includes cognitive behavioural manipulation in a very broad way within the prohibited practices of Article 5(1) (a) AI Act. In the most recent version Article 5(1) (a) states as following:

The following AI practices shall be prohibited: (a) the placing on the market, the putting into service or the use of an AI system that deploys subliminal techniques beyond a person's consciousness or purposefully manipulative or deceptive techniques, with the objective, or the effect of, materially distorting the behaviour of a person or a group of persons by appreciably impairing their ability to make an informed decision, thereby causing a person to take a decision that that person would not have otherwise taken in a manner that causes or is likely to cause that person, another person or group of persons significant harm'.<sup>58</sup>

It is worth mentioning that the AI Act not only near AI systems but also AI-related technologies as high risk systems according to Article 8(1) AI Act.

Again, a closer examination of the potential and risk of manipulation through NT and the associated legal implications on the level of secondary law is beyond the scope of this study and requires further discussions.

## 6.5. Findings from a legal perspective

**The texts of the NRF are not rights in the technical sense** The proposed neurorights are not formulated precisely enough to be designated as 'rights'; they describe issues on which the NRF believes there is need for action. We have attempted to derive plausible meanings from the texts by

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<sup>58</sup> Proposal for a Regulation of the European Parliament and of the Council laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) and amending certain union legislative acts/ P9\_TA(2024)0138

analysing them over time, using both headings and descriptions. Nevertheless, our findings are merely interpretations that could be rejected by the NRF.

**Implementation of neurorights at the level of human and fundamental rights** Our analysis of the texts identified five rights and assessed the necessity and sensibility of embedding them at the level of human and fundamental rights, these are: 'the right to mental privacy', 'the right to personal identity', 'the right to free will', 'the right to equal access to mental augmentation' and 'the right to protection from algorithmic bias'. It became evident that the existing framework of human and fundamental rights provides a well-established and effective protective shield. For instance, 'the right to mental integrity' is already explicitly protected under Article 3 CFR as the 'right to physical and mental integrity'. Amending this with a separate 'right to mental integrity' would necessitate differentiation, assuming the legislator did not introduce this right frivolously; it must signify something different from the right already enshrined in Article 3. However, this raises new questions: Is the understanding developed under Article 3 transferable to the new right? Where are the limits? Would further aspects of integrity also need explicit regulation? What is the novelty? Ultimately, legal uncertainty at the highest level of law would be a definite consequence.

**Potential damage to the corpus of human and fundamental rights** For example, 'mental privacy' is mentioned. Privacy is protected as a human and fundamental right at the European level under Article 7 ECHR and Article 7 CFR. The ECtHR recently was able to include climate issues on the basis of Article 7 ECHR and demand active protection measures from the state. Regulating 'mental privacy' separately raises the question of how the new right relates to established rights and whether other forms of privacy should be separately regulated. Such regulation would have an overall restrictive effect and would not enhance protection.

**Action in secondary law needed** The result of our analysis led to a brief review of secondary law, revealing that the EU's body of norms, with strong consumer protection, fair competition, high product safety standards, and thorough digital integration, is well-prepared to address recognized issues associated with NT. For instance, medical devices and certain NT devices are already highly regulated under the MDR. Other NT devices not covered by the MDR must fulfil the general high level of protection. Still, adaptations could be considered, such as explicitly incorporating neuro data in Article 9 GDPR or an NT Act, comparable to the AI Act. In both instances, the focus is solely on regulating impactful technologies.

**Fostering law enforcement by enhancing scientific and public knowledge** The next logical step is to intensify law enforcement efforts. To this end, the EU should actively participate in narrating the story of NT, which involves encouraging sciences and education, as well as stringent oversight of their commercial communication. This comprehensive approach ensures that the public receives accurate and balanced information, which is crucial for effective regulation and the responsible development of NT. One of the main problems identified with NT is our insufficient knowledge, which predominantly promotes success stories used commercially for advertising, leading to described 'neuro-enchantment' and 'neuromyth' as described in section 3.5. Consumer law, competition law, and product safety law are well-suited to counteract false or exaggerated claims; they just need to be utilized. Moreover, there is a societal need to tell people the true story about NT – clarifying what we know and do not know, where the opportunities, dangers and risks lie. This means actively promoting NT research, publishing failures as well as successes, communicating results in an understandable form not only through science but also through public administration, integrating it into education, and strictly controlling commercial representations.

## 7. Synthesis in use cases

A broad variety of NT devices are available on the market, offering a multitude of functionalities with different goals and promises. We want to elaborate within four different use cases possible scenarios and their threats and benefits.

From the perspective of neuropsychology, NT have a heterogenous profile. Some are medical products while other ones are mere entertainment products. The general public as well as a considerable proportion of the specialists themselves cannot technically distinguish between their properties and specifications. Moreover, the requirements to obtain a seal of a technical product depend on physical and technical specifications, such as prevention of burns, occurrence of electric shocks, sharp corners, etc. and do not include sufficiently specific norms regarding the expectations, one can realistically derive from the use of those devices. Among the entertainment devices, origin, quality, stability and reproducibility of signal is only superficially regulated, so that signals that do not originate in the brain can easily and misleadingly be interpreted as brain signals. NT have the propensity to re-configure how we relate to ourselves and each other. The deployment of these technologies extends beyond the realm of health to social domains such as education and work. Therefore, they hold relevance for fundamental questions about society. To summarise the sociological considerations, we raise issues around the opacity of technology development, the inability for different societal actors to assess the benefits and risks of these technologies, and the ability of powerful actors to assert power in various societal domains through sphere transgression. We also problematise the drive towards self-optimisation that creates different norms on what is constituted as 'normal'.

From an ethical perspective it is necessary to think about the disruptive potential of NT as well as the consequences for individuals and society. This includes potential changes in regard to agency as well as the risk of pressuring vulnerable groups into using NT. Especially since society should support and care for these individuals rather than shifting the responsibility onto them to adapt via technology. If NT is used for personal enhancement, it must remain beneficial and not compromise diverse cognitive abilities for hyperperformance. This technology should not reinforce societal pressures or promote an image of humans as inherently deficient and in need of improvement.

From a legal perspective we can stress, that the EU builds on a very strong and broadly established legal framework, including both, human and fundamental rights on the level of primary law and strong provision in the secondary law. Following the main topic of the study, we focus on the level of primary law, in particular the CFR, to see whether the proposed NRF neurorights could provide added value. It should be noted that according to Article 52 CFR the application of fundamental rights is not a question of 'one or the other', but must always balance conflicting interests while respecting the essence of all rights and freedoms. Thus, by cumulating rights the protective shield gets strengthened. These preliminary remarks frame the following legal analysis of concrete use cases.

The use cases deal in two cases on health and in two cases on invasive NT – as defined in section 3.

### 7.1. Use case 1: Invasive NT for patients with quadriplegia

This use case addresses the very recent implantation of a Neuralink device in a quadriplegia patient (PRIME study). Press coverage was enthusiastic about the promises of the new technology developed by Neuralink. However, these promises were ambiguous and went far beyond the improvement of health of neurologic patients, which is the actual objective of the current study.

Articles published by the magazine Nature<sup>59</sup> express concerns about the lack of transparency and the apparent rush of the American FDA to approve the study. Moreover, specialists mentioned in these articles also question the extent to which the present study will produce substantial new results, since the known version of Neuralink chip only contains technological innovation already available in other chip implant systems. Moreover, the study advertisement fails to inform the location of the brain chip implant and the outcome measured addressed. As informed in the Nature article, the trial is not registered at [ClinicalTrials.gov](https://www.clinicaltrials.gov), an online repository curated by the US National Institutes of Health. Since many universities require that researchers register a trial and its protocol in a public repository of this type before study participants are enrolled, one may conclude that the motivation of Neuralink to publish the results in a peer-review scientific journal is not necessarily given.

**Context/keywords:**

Unreliable study design of NT benefits for different populations; research; Neuro-enchantment, Neuromyths

### 7.1.1. Use case 1: Neuropsychology

Lack of transparency of clinical studies is highly problematic because a hasty endorsement of studies without proper documentation of the features of invasive technologies such as brain chips is still publicly seen as sound scientific work done according to the rules state-of-art procedures. This results in NT being marketed to support different means: the rehabilitation of a disease as well as the enhancement of human capabilities beyond medical means.

Ambiguity about the long-term efficacy of the medical device: Impressive decoding successes on short-term are highly probable, a comparable degree of success on the long-term (5 years follow-up period in the PRISMA study) is highly improbable, for many of the sensors become inoperable due to tissue scarring and cicatrisation. Hasty decisions on such studies in the future may negatively affect the overall quality of evidence about efficacy and risks involved in the use of new highly invasive NT.

Benefits: Invasive NT offer direct stimulation of neuron assemblies, record brain activation artifact-free and effects from stimulation can be reversible. Symptoms of disease can be effectively diminished, which increases quality of life of patients.

### 7.1.2. Use case 1: Sociology

Here we highlight the two issues that should be considered.

Opacity: The opacity of the study prohibits civil society as well as policy makers to assess the benefits and dangers of NT. This then risks exacerbating inflated beliefs in the abilities of NT leading to a higher propensity for manipulation or so-called 'neuro-enchantment'. Investment into NT for societal domains such as Education or Work may be based on insufficient data about the efficacy of these technologies.

Sphere Transgression: While Neuralink conducted a study on quadriplegia patients, there have already been conversations about the possibility of embedding the technology for different uses and in different societal domains. Decision-makers are advised to be attuned to the possibility of 'sphere transgression' where technologies developed for a specific use are deployed in non-intended societal domains. This has implications for democracy as powerful companies may be able to set the agenda across different societal domains.

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<sup>59</sup> <https://www.nature.com/articles/d41586-024-00304-4> and <https://www.nature.com/articles/d41586-024-00550-6>

### 7.1.3. Use case 1: Ethics

#### Pre-deployment

A lack of transparency is already the first problem in the context of Neuralink: In the context of interventions in physical and mental integrity, the individual must at least have a conceptual understanding of the intervention, its risks, and implications. In addition, the individual must be able to trust that the intervention/research will be monitored and accompanied by expert, independent third parties who are committed to human rights and medical ethics with regard to its methods, implementation and the expected results and complications. Particularly in view of the fact that unintended consequences for the subject concerned are impossible to foresee without expert knowledge and cannot be factored into the individual decision.

#### Post-deployment

Therapy vs. enhancement: Even in the case of optimal success, there is a risk that the pressure on patients to submit to this operation will subsequently increase. If improvements beyond the common human capacity can be achieved, there is pressure within society to adapt in order not to lose touch with the new normal.

Agency: As actuation through a BCI like this could be classified as a form of disembodied agency, it is necessary to think about the consequences of such agency before broad implementation, as it is possible that BCI-mediated agency could lead to misattributions in the sense of agency.

### 7.1.4. Use case 1: Law

Use case 1 pinpoints NT in research; Neuralink is an example how non-transparent research may lead to 'neuro-enchantment' and 'neuromyths'.

In general: false factual assertions violate European law in many ways; in detail the issue causes several more distinct questions.

While Article 13 CFR enshrines that scientific research shall be free of constraint and that academic freedom shall be respected, Article 6 CFR comprehensively provides the 'right to liberty and security of person'. Article 3(1), the right to the integrity of the person, explicitly guarantees, that 'everyone has the right to respect for his or her physical and mental integrity'; para 2 (a) states, that in the fields of medicine and biology, particularly 'the free and informed consent of the person concerned, according to the procedures laid down by law' has to be respected. Article 3 broadly addresses 'fields of medicine and biology', making no strict distinction between medical and health usage on one side and others like improvement on the other side. Without any doubt, in all cases free and informed consent is based on true information.

Reflecting the freedom of science, it should be stressed, that beside the protection of freedom of the sciences.

European research is characterised by a commitment to European values reflected in responsible research.<sup>60</sup> Following Art 10 PSID (EU) 2019/1024<sup>61</sup>, this means that data should be generated and

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<sup>60</sup> <https://www.consilium.europa.eu/de/policies/european-research-area/>  
[https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe\\_en](https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en)

<sup>61</sup> Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information

managed according to the 'FAIR' criteria<sup>62</sup> (findable, accessible, interoperable, re-usable) and are made openly accessible.<sup>63</sup>

In general, Article 38 CFR, consumer protection, and Title XVI TFEU grant a high level of consumer protection that provides the basis for the above-mentioned secondary competition, consumer protection and product safety law which also clearly states that the advertising of products in the EU must be based on true facts.<sup>64</sup>

To sum up: In view of the existing legal framework, which consists of primary and secondary EU law, non-transparent research leading to 'neuromyths' and 'neuro-enchantment' are frowned upon.

While on the level of primary law the issues are well met, there is room for improvement; outside the law e.g. a code of conduct for responsible research in NT, comparable to nanotechnologies or AI, could be considered.

What could be the benefit in use case 1 if the 5 NRF neurorights would be implemented into the CRF?

- 'the right to mental privacy': As the CFR already protects privacy in Articles 7 and 8, there would be no benefit in implementing this right.
- 'the right to personal identity': Article 3(1) CFR refers to the physical and mental integrity of a person. In trial studies further conditions (Article 3(2) CFR) must be respected.
- 'the right to free will': Article 3(2) CFR requires for a free and informed consent from the person concerned. It is important that all relevant information is provided, otherwise the person concerned may be able to give a free and informed consent.
- 'the right to equal access to mental augmentation': Discrimination is not allowed in relation to Article 20 – Article 26 CFR.
- 'the right to protection from algorithmic bias': Protection against algorithmic bias is already covered by Article 21 CFR.

In summary there is no benefit from the NRF neurorights in the constellation of use case 1.

## 7.2. Use case 2: Non-invasive NT for a healthy population

This use case addresses an imaginary application scenario of a non-invasive device used by a healthy population.

Easy to set-up consumer-grade EEG-headband which can record brain activation (as well as health data e.g. migraine) and stimulates specific brain areas to increase attention and focus through application of small doses of electric current for a better work/learn performance.

Users get alarm whenever focus level drops and can decide whether they want stimulation to increase their level of focus. Information on focus and stimulation is given on a smartphone via an App.

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<sup>62</sup> <https://www.go-fair.org/fair-principles/>

<sup>63</sup> Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information

<sup>64</sup> Directive 2006/114/EC of the European Parliament and of the Council of 12 December 2006 concerning misleading and comparative advertising

Different implications for work (adults) and learn (minors/students) environments will be considered. Examples of this could be products from Emotiv<sup>65</sup> or Muse<sup>66</sup>.

**Context/keywords:**

Institutional introduction of NT to improve learning and working.

### 7.2.1. Use case 2: Neuropsychology

EEG data can easily be manipulated (e.g. pressing on electrodes) and recordings in live environments make the data very prone to artifacts. It is possible that users develop psychological stress due to the implied pressure to achieve.

**Work environment:** When performance monitoring needs to be upheld at a specific level throughout the working time the danger of burnout arises. Further, work environment can become tensed between colleagues and superiors. If such devices will be supplied by the management/work place, they should not get access to this data, thereby avoiding exploitation. High standards and rules for work and safety risks may be necessary.

**School/education:** It is likely that not every parent supports the idea of such NT devices being used by their children. Hence some children might get disadvantaged in the school environment. Also, as children will compare performances some children with worse attention will be teased or sidelined. If teachers have the possibility to see the data (e.g. through lights on the device indicating the attentiveness status, as seen in controversial Chinese school experiments)<sup>67</sup> some children might be more privileged, and others get bad grades. This is especially problematic due to the unreliability of consumer-grade devices.

**Benefits:** The devices can be beneficial in high-productivity jobs with health risks (assembly line work, jobs with long driving routes and danger of microsleep etc.) where attention is crucial and drifting off mentally can lead to (even life threatening) accidents. There have already been attempts to figure out associated EEG patterns.<sup>68</sup> Users can actively learn about their attentiveness patterns and be more about their individual productivity levels. They will be motivated to take breaks when needed. Also, it may be the case that undiagnosed attention deficits (such as ADHD) can be found in users.

### 7.2.2. Use case 2: Sociology

**Freedom of Choice:** To ensure that these technologies are used to everyone's best benefit, it is crucial that student and worker voice is prioritised in the deployment, use and assessment phases of these technologies. As our literature study has demonstrated, these stakeholders are rarely discussed. Previous studies on workplace technologies and educational technologies have shown how these could quickly be misused by power-holders as a management tool.

**Reductive Logic:** NT also produce a conception of learning and working that is limited to cognitive processes. Performance is narrowly defined as levels of concentration, attention and fatigue. It is also a reductive conception of what constitutes as work. Social learning, relationship building, overcoming challenges individually and collectively are not factored in to contribute to the success of educational institutions or workplaces. On the other hand, greater awareness of cognitive processes can encourage students and workers to be mindful of their physical states.

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<sup>65</sup> <https://www.emotiv.com/>

<sup>66</sup> <https://choosemuse.com/>

<sup>67</sup> <https://www.scmp.com/tech/start-ups/article/3005448/brainwave-tracking-start-china-schoolchildren-controversy-working>

<sup>68</sup> <https://core.ac.uk/download/pdf/301313572.pdf#page=5>

**Blurring of boundaries between working time and outside of it:** When it comes to the monitoring of sleep of workers, this also challenges workers' privacy outside of the workplace as sleep is monitored outside of working time. Even if these technologies are offered on a voluntary basis, social pressure may restrict free decision-making of pupils or workers.

### 7.2.3. Use case 2: Ethics

**Functionalization of people:** Due to the sheer possibility of compensating for the 'weakness' of the loss of concentration, the danger emerges that people will adapt to the pressure out of their own accord or out of the need to meet the increased general level of concentration. This could, from a corporate point of view, strengthen tendencies to reduce human beings to their workforce alone as well as the inept pressure within the individuals to be always focused. Especially in the context of the education of children, who are especially vulnerable as they depend on responsible adults to provide safe and appropriate environments, the idea to apply even small doses of electric currents to a developing brain over an extended period of time, has to be seen highly critically.

**Monolithisation:** Thinking further about the application of this technology to people with learning disabilities, while everything mentioned above of course also applies, it might also lead to an unjust monolithisation of how to 'help' people with concentration issues to work all together. Aside from various dependency issues (on the device itself, Datacentres, corporations for continuous updates etc) this could promote uniform working expectation based on some form of standard work done by a person with NT-Aid rather than promoting work environments where all people, regardless of their individual capabilities are encouraged and challenged to do their best. This could reverse the endeavours to create inclusive workspaces.

### 7.2.4. Use case 2: Law

From a legal perspective, this use cases illustrates that the use of NT can be crucial even when the NT is non-invasive and non-medical. The situation pinpointed here is a power of imbalance (work, school) where there is a specific need for protection. Moreover, beside mere data storage (local? cloud?), stimulation is possible.

As the devices do not only record brain activities, but also store data on the state of health, e.g. in case of a migraine, there is a serious encroachment on privacy within the meaning of Article 8 ECHR and Article 7 and Article 8 CFR.

**Variant work:** Article 27 CFR grants, that workers or their representatives must be guaranteed information and consultation on important issues which includes, in our opinion, the use of NT e.g. to enhance work performance.

In general, every employee has the right to fair and just working conditions. These are further defined in Article 31(1) CFR as 'conditions which respect his or her health, safety and dignity'<sup>69</sup>. It is therefore clear that dignity is also a key asset in the working environment.

Additionally, Title X TFEU referring to the European Social Charter signed at Turin on 18 October 1961 and in the 1989 Community Charter of the Fundamental Social Rights of Workers also establishes fair and appropriate working conditions.

Moreover, in working environments, the use of neuro-devices will not be voluntary in many cases. Free consent might not be possible, which is also relevant when it comes to data protection issues according to Article 8 CFR.

**Variant education:** Children are highly protected under Article 24 CFR granting that 'children shall have the right to such protection and care as is necessary for their well-being'. Despite education is

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<sup>69</sup> Treaty on the Functioning of the European Union

not within the direct scope of the EU, but lays within the competences of the member states, Title XII TFEU focusses on 'quality education by encouraging cooperation between Member States and, if necessary, by supporting and supplementing their action'.<sup>70</sup> Therefore, the usage of neuro-devices in educational requires specific consideration, taking into account the need to protect minors and to enable an environment that allows learners to enhance wisdom, knowledge and skills. Again, as under working conditions in educational environments the use of neuro-devices will not be voluntary in many cases. Free consent might not be possible, which is also relevant when it comes to data protection issues according to Article 8 CFR. Above all, as Article 24(2) explicitly states, 'In all actions relating to children, whether taken by public authorities or private institutions, the child's best interests must be a primary consideration'.

What could be the benefit in use case 2 if the 5 NRF neurorights would be implemented into the CRF?

- 'the right to mental privacy': see use case 1
- 'the right to personal identity': According to Article 3(1) CFR 'Everyone has the right to respect for his or her physical and mental integrity'.
- 'the right to free will': As there should be a choice as to whether the person wants to use the neuro-device or not, Article 31 CFR for working conditions and Article 24 CFR for children can be mentioned according to use case 2.
- 'the right to equal access to mental augmentation': see use case 1.
- 'the right to protection from algorithmic bias': see use case 1

In summary there is no benefit from the NRF neurorights in the constellation of use case 2.

### 7.3. Use case 3: Invasive NT for healthy population

This use case addresses an imaginary application scenario of an invasive device used by a healthy population.

Implantable BCI system enabling users to mentally connect with AR smart glasses. This allows users to show visualizations of brain activity on real-life via the AR smart-glasses. It can continually show cognitive performance values throughout the (work)day and can be controlled via brain activation. One can also trigger stimulation application with activation pattern recognition. Since implantable devices are less prone for artifacts it can be used in highly dynamic situations, e.g. showing focus level during sports and enabling the release of a stimulating electrical pulse during a marathon to push motor activation etc. The devices record data, which is then transmitted. Since most NT companies are situated in the US, the data is transmitted there.

Different implications for entertainment and self-enhancement will be considered.

#### **Context/keywords:**

Personal use of NT for entertainment and self-improvement

#### 7.3.1. Use case 3: Neuropsychology

**Danger:** The usage of AR smart glasses in daily life can pose dangers in for example traffic (shared attention, multisensory processing), possibility of threat to personality, pressure for idealisation, two-tier society? Such a technology would be highly expensive (especially when eyesight adaptations are needed), maybe is not compatible when there is a neurological disease (or anything related) so

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<sup>70</sup> Article 165 Treaty on the Functioning of the European Union

those who are already separated are separated even more because they are not 'suitable' for new technology

**Discrimination:** Some users get eye strain and sickness problems due to disorientation during the usage of AR. This could limit them in the usage of such devices. Depending on whether such technologies might be used on a daily basis at work there is the possibility of being disadvantaged.

**Benefit:** This sort of technology can be compared to smart watches. Here heart activity, sleep quality etc. can be tracked to improve performance in sports, improve sleep and learn more about the own body. The same could be achieved on a neuronal and cognitive base. Such a device could enable us to figure out when we are most productive, what we can do to increase focus and attention. It could also be used to monitor changes in case of abnormalities that need to be checked medically.

### 7.3.2. Use case 3: Sociology

**Optimisation:** The voluntary use of NT builds on the practice of the quantified self-movement where technologies are used to support aspirations towards self-improvement and optimisation. It is important that users are given sufficient information to weigh up benefits and risks of implanting a chip and training on how to interpret the data of these technologies.

**Stigmatisation:** As already touched upon, this technology may produce new or exacerbate existing social pressures and can develop a new understanding of what constitutes as normal.

**Socio-economic factors:** Those with the ability to access these technologies may have a competitive advantage in a number of settings such as work and education. This is problematic if conceptions of performance change due to the use of NT. On the other hand, those that have more access to economic resources are able to protect themselves more easily from privacy invasions.

### 7.3.3. Use case 3: Ethics

**Agency and dependency:** As in Use case 1 through the use of BCI systems the question of Agency immediately arises. In this context it is even more bothersome as technology like this would have to process its data through some kind of AI, which aside of the danger to induce forms of bias prone to the dataset or processing structure of the AI, could lead to even worse misattribution of agency up to a degree of unwilling agency or manipulation of agency. Furthermore, technology like this most likely requires constant connection to a data centre, amplifying dependency.

**Ubiquity:** Moreover, there is the danger that various spheres of life are influenced to a massive degree by this application. While this is also true for other technologies (e.g. smartphones), the potential problems regarding addicting product/app design and negative psychological effect through overuse are much more intensified as the option to 'get away from technology' is no longer present.

**Accessibility:** Additionally, if devices like this are effective (and legal), it has to be ensured, that they could be afforded by as many people as possible to prevent the further growth of economic divide.

### 7.3.4. Use case 3: Law

Use case 3 is characterized by invasive NT (transplant) but completely voluntary use; beyond that, there is no health-need, the user seeks only for entertainment and self-improvement.

Although the case highlights ethical concerns mostly, some thoughts from the legal side arise as well. The fundamental rights addressed here are again Article 3, building on free and informed consent, and Article 38 CFR granting a high level of consumer protection. Based on that protective framework, here we want to address the freedom of the human. This includes the personal freedom to decide if and how to use enhancement strategies, but also the freedom to conduct a business,

e.g. in the field of entertainment and well-being. After all, based on factual, true information about the implications of NT goods, having passed the product safety control checks and within fair competition, such goods can be sold and used in the EU without any doubt. This is why we want to use the case to delve a little deeper into the information and data issue.

**Variant entertainment:** 'Unfair commercial practices shall be prohibited.'<sup>71</sup> This increases the protection of consumer, who must not be misled about the essential characteristics of products and its risks.<sup>72</sup> The issue of data transfer should also be mentioned in this context. Most neuro-devices, especially those related to AI, are operated outside the EU. This means that the data generated by European citizens flows outside of the EU and cannot be used in the EU, while at the same time promoting the supremacy of individual companies. In view of the fact that people who play generate particularly interesting data, while paying for products, services and devices the *European Homo Ludens* not only directly enriches value chains outside Europe but additionally gives a deep (but hidden) insight into the functioning of NT.

**Variant self-improvement:** Here, from a legal perspective we want to issue equal access (Article 14 ECHR, Articles 20 – 26 CFR) and voluntariness as particularly relevant in this use case. On the one hand, access to this technology should be possible for everyone (assuming that it has mainly positive effects and that information about the technology is provided transparently). On the other hand, there should be no compulsion to improve oneself (e.g. in the case of power imbalances in working relationships).

What could be the benefit in use case 3 if the 5 NRF neurorights would be implemented into the CRF?

- 'the right to mental privacy': see use case 1
- 'the right to personal identity': 'Everyone has the right to respect for his or her physical and mental integrity' according to Article 3(1) CFR.
- 'the right to free will': Article 10 CFR 'Freedom of thought, conscience and religion' means the freedom of choice. Everyone is free to use neuro-devices or not. But there must be clear and accurate information, so that a free choice is possible.
- 'the right to equal access to mental augmentation': see use case 1
- 'the right to protection from algorithmic bias': see use case 1

In summary there is no benefit from the NRF neurorights in the constellation of use case 3.

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<sup>71</sup> Directive 2005/29/EC of the European Parliament and of the Council of 11 May 2005 concerning unfair business-to-consumer commercial practices in the internal market and amending Council Directive 84/450/EEC, Directives 97/7/EC, 98/27/EC and 2002/65/EC of the European Parliament and of the Council and Regulation (EC) No 2006/2004 of the European Parliament and of the Council ('Unfair Commercial Practices Directive')

<sup>72</sup> Article 6 Directive 2005/29/EC of the European Parliament and of the Council of 11 May 2005 concerning unfair business-to-consumer commercial practices in the internal market and amending Council Directive 84/450/EEC, Directives 97/7/EC, 98/27/EC and 2002/65/EC of the European Parliament and of the Council and Regulation (EC) No 2006/2004 of the European Parliament and of the Council ('Unfair Commercial Practices Directive')

## 7.4. Use case 4: Non-invasive NT for patients with Alzheimer's disease

This use case addresses an imaginary application scenario of a non-invasive device used by a clinical population, namely patients with Alzheimer's.

A tDCS stimulation device will be used to reduce symptoms/slow disease progression in Alzheimer's disease. Application of small doses of electric current on the scalp of the patients on a regular basis. The stimulation device can be worn throughout the day like a hat and stimulation protocols can work dynamically and individually without having to adjust parameters.

Examples of this could be products from flow<sup>73</sup> and NeuroMyst<sup>74</sup>.

### **Context/keywords:**

NT for managing Alzheimer's with dignity

### 7.4.1. Use case 4: Neuropsychology

Depending on the state of the patient, stimulation can be scary, especially when the tingling/burning sensation resulting from the electrical current impulse is felt and people with AD cannot grasp what is happening. They might feel threatened/frightened.

It is not clear whether long-term and regular tDCS application over months up to years can have negative implications. Most studies range about the time of 2 months. Also, individual brains differ greatly in terms of both functionality and morphology and this especially is the case in clinical patients with pathological neurology. So, if it is not fitted well for the individual the aim is completely missed and in the worst case the person can be harmed. Hence, exact location of relevant brain areas via neuroimaging methods (e.g. magnetic resonance imaging; MRI) would be necessary. Further, it is not clear whether regular stimulation of specific brain areas would lead to resource re-allocations, that lead to decrease of functionalities in other cognitive domains. due to stimulation could lead to decrease of functionalities in other domains.

**Benefit:** Previous research on this topic could show that tDCS can be a useful tool in the rehabilitation of dementia and Alzheimer's.<sup>75</sup> As intervention methods in this field are sparse, having a tool to help decreasing symptoms would be an achievement.

### 7.4.2. Use case 4: Sociology

**Re-constitution of care relations:** Research has shown that the introduction of technologies in care settings reconfigures the constitution of care relations. It is important to question who will also be involved in ensuring the technologies works as intended such as care staff or family.

**Creation of new forms of disability that require a 'fix':** Research from the field of Critical Disability Studies has also warned of the possibility of producing technologies that are not supporting the existing needs of those with a disability and misunderstanding what a technology ought to do. This could lead to ableist conceptions of a person who is seen as frail, or in need of a fix.

**Brain as a reliable source of information:** Different people react to NT differently. Therefore, some people may be excluded from the benefits of NT.

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<sup>73</sup> <https://www.flowneuroscience.com/de/produkt/headset/>

<sup>74</sup> <https://neuromyst.com/montage-guide/>

<sup>75</sup> See for a review: <https://www.frontiersin.org/journals/neurology/articles/10.3389/fneur.2021.798191/full>

### 7.4.3. Use case 4: Ethics

The use of NT to improve the lives of people with Alzheimer's disease is a great opportunity to improve the quality of life of vulnerable people. Ideally, targeted tDCS could increase the autonomy of people with dementia, thus enhancing a central value of medical ethical considerations. (Schmidhuber, 2020) Despite these opportunities, particular caution must be exercised in its use, dissemination and, above all, in the promises made. Since, in serious cases, third parties decide on the use of such a technology on a sick person, no false impression can/must be created by advertising or implicit promises of recovery. It must be prevented that relatives make decisions based on wishful thinking or suggested chances of recovery that are not justified by the medical indication and, in the worst case, are detrimental to the vulnerable person. Especially when there is a risk of unintentionally weakening or even damaging intact parts of the cognitive system.

Even in the best case, the question of distributive justice must be raised, as in use case 3.

### 7.4.4. Use case 4: Law

Use case 4 deals with the use of NT for medical purposes, specifically in the field of aging and control-loss. Without any doubt, NT can provide very useful support to enable humans to age in dignity. On the other hand, since specifically mental in vulnerable groups are mostly concerned by NT, new issues arise. In case of Alzheimer's disease in particular, the question of consent is central. Often, consent can no longer be given by the person concerned, but has to be given by an authorised representative. Human dignity (Article 1 CFR) must be respected in all cases. It is therefore necessary that all information is shared transparently so that the best possible decision can be made for the benefit of the person concerned. Again, all fundamental rights have to be considered as well.

With regard to elderly people, e.g. suffering from Alzheimer's disease, specifically Article 25 CFR must be observed, which states that '[t]he Union recognises and respects the rights of the elderly to lead a life of dignity and independence and to participate in social and cultural life.'

What could be the benefit in use case 4 if the 5 NRF neurorights would be implemented into the CRF?

- 'the right to mental privacy': see use case 1
- 'the right to personal identity': According to Article 3(1) CFR 'Everyone has the right to respect for his or her physical and mental integrity'.
- 'the right to free will': It is quite unclear, how the free will of a person with Alzheimer's disease can be respected. Any decision taken on behalf of a person with Alzheimer's disease must be based on the human dignity (Article 1 CFR).
- 'the right to equal access to mental augmentation': see use case 1; in this use case especially Article 25 CFR and Article 36 CFR should be considered in particular.
- 'the right to protection from algorithmic bias': see use case 1

In summary there is no benefit from the NRF neurorights in the constellation of use case 4.

## 8. Conclusions

We identified the following problems with the current use of NT and the kind of regulation proposed by the NRF.

- Transfer of reputation and neuro-enchantment
- Sociotechnical imaginary driven by neuro-enchantment and boundless optimism
- Neuro-essentialism, reification and functionalization
- High-level legislation with the proposition of new human rights

With all these characteristics combined, we conclude that the discussion on neurorights as put forward by the NRF is ill-posed and should be reframed to meet interests and rights of European citizens, reach the expectations of democratic European states and underlying European values.

The neurorights as proposed by the NRF more or less explicitly assume that an expansion of the use of NT in all its forms is desirable. One should be much more explicit about the situation in which NT are inadmissible and develop a more human-centred approach to risk management of NT, particularly when these are boosted by the transformative and transgressive power of AI.

### 8.1. Takeaways

#### 8.1.1. Neuropsychology

- **NT as a necessity:** From a medical perspective, NT are an indispensable tool for rehabilitation. They help regaining and sustaining the quality of life of clinical population when integrated into an effective treatment or rehabilitation program. NT
- **Close the gap between research and practice:** On the one hand, there is a lack of long-term studies, standardized double-blind controlled trials and specific research on side-effects. On the other hand, practitioners and manufacturers proclaim lots of promises about risk-freeness and positive long-term effects. To close this gap, more research concerning NT and their effects is necessary.
- **Work on NT literacy:** Users of NT become manipulable through the phenomenon of neuro-enchantment, the inherent persuasiveness of NT devices. Here, a fair communication of limitations and state-of-the-art knowledge should be given and the tone of advertisements should be more neutral.

#### 8.1.2. Sociology

- **Reductionism:** NT operate on a reductive approach towards emotions, mental states and personality traits. NT isolate these aspects from their larger social contexts. The brain is positioned as a source of objective knowledge. This thinking overlooks the complexity of social interactions, domains and the fluidity of identities.
- **Reconfiguration of social domains:** Through the use and processing of brain data, social domains and relationships with each other are transformed. Our research points to the risk of pathologizing individuals and stigmatisation.
- **The power of imaginaries and anticipations:** Discourses on NT in social domains shape our anticipations on our actions in the present. This influences resource allocation, funding decisions, and the type of solutions conceived as necessary. Resource-rich organisations may be able to set the agenda and determine the course of neurotechnological deployment in different social domains.
- **Research Agenda:** There is a clear empirical gap on the organisational and everyday embeddedness of NT. Further research should focus on the experience of experts in the domain and involve those in the development of NT.

### 8.1.3. Ethics

- **On NRFs proposed neurorights:** The proposed new rights are based on, but not necessarily derived from, historical ideas. Given that existing human rights frameworks cover fundamental aspects such as freedom of thought, (mental) integrity and privacy, the introduction of new rights risks diluting/inflating the impact and value of established human rights.
- **New form of agency:** Use of NT could lead to a 'disembodied form' of agency and could interfere with the formation of intentional action, requiring caution.
- **Responsibility for the vulnerable:** NT can improve the quality of life of people with illnesses, but it's crucial to avoid implicit pressure on vulnerable groups (e.g. children, dementia patients, neurodiverse) to use such technologies.
- **Distributive Justice** Since NT has the potential for self-optimisation, it must be managed to avoid societal pressures and unfair advantages based on wealth. Moreover, there is a risk that the enhancement of specific cognitive abilities could compromise other cognitive functions.

### 8.1.4. Law

- **Precautionary principle:** The EU's precautionary principle requires the EU to take action on the basis of risk analysis to avert, inter alia, the threats to human health.
- **Do not split human and fundamental rights:** The established human rights/fundamental rights should remain in their comprehensive definitions and not be broken down into smaller, more specific human rights/fundamental rights, as this risks creating gaps. Existing case law could also not be used in the case of new rights.
- **Medical Devices Regulation:** NT with medical purpose are already highly protected by the MDR; specific NT without medical purpose are also included in the Annex XVI MDR. However, some NT remain outside the scope of the MDR. These are not in a legal vacuum, but are covered by consumer protection law, competition law and product safety law.
- **Secondary law:** NT as a powerful technology should be enshrined in secondary law to fill existing gaps. Standardisation can also play a role in the regulation for NT.
- **Bridging the AI Act to NT:** Given its structured approach to handling the complexities of AI, the AI Act could indeed serve as a best practice model for regulating NT. Here's how the principles and frameworks of the AI Act could be adapted for NT:

Risk-Based Classification: Similar to AI, NT could be classified based on the risk they pose, with different levels of regulatory scrutiny for non-invasive versus invasive technologies, or consumer-use versus medical-use technologies.

Transparency and Information Requirements: Neuro-devices should be required to disclose information about their functioning, data usage, and potential effects on users' cognitive and psychological states, enabling users to make informed decisions.

Data Protection and Privacy: Provisions for data governance in the AI Act could be extended to include cognitive privacy protections, ensuring that neurodata is handled with the highest standards of privacy and security.

Ethical and Safety Standards: The establishment of ethical guidelines and safety standards for NT, especially for those classified as high-risk, would be crucial. This includes standards for informed consent and human oversight.

Prohibitive Measures: Like in Article 5 AI Act, drawing 'red lines' based on the agreed fundament of European values might be necessary, at least for certain types of neurotechnological applications

that pose significant ethical concerns, such as technologies capable of involuntary manipulation of thoughts or emotions.

- **Supporting law enforcement by improving scientific and public knowledge:** The EU should play an active role in the discussion about the story of NT. This could be done by encouraging sciences and education, so that false expectations cannot arise from advertising. The already existing law (consumer, competition and product safety law) is able to counteract false claims on NT devices.

## 9. Policy options

Following up on our findings, we have identified a number of policy options for the European Parliament to respond to possible ethical or societal threats posed by neurotechnological devices.

### 9.1. Policy option 1: Laissez-faire/non-interference

The field of neurotechnology is growing rapidly and a laissez-faire attitude without any regulations could lead to problems. As predicted in several studies, portable devices like the ones used for neurofeedback will become popular in the next few years, although there is insufficient research on their positive and negative effects. In addition, there is a clear publication bias in scientific literature, where statistically insignificant results are silenced while positive findings are often over-interpreted and overrepresented in the public discourse. Such positive advertising ('neuro-enchantment') can drive the market for neurotechnologies before there has been a critical assessment of potential side-effects that could harm mental and physical health. Another aspect of non-interference in consumer neurotech is the physiological data of European citizens, which could be harvested by non-European companies. Such data is critical for further research and development, but also for preserving privacy and security.

### 9.2. Policy option 2: Blanket prohibition of neurotechnologies in the EU

Prohibiting certain uses of neurotechnology could prevent possible negative side-effects or misuse. However, this would have drastic consequences on the neurotech domain and exclude European science and the European economy from international markets. Progress in neurotech is also needed as part of the treatment arsenal for clinical and vulnerable user groups. Policymakers need to consider in which domains and for which purposes neurotechnology offers significant gains and where potential bans could be necessary. Importantly, much more precise criteria to establish the borders between medical/therapeutical and enhancement neurotech applications must be developed by specialists, stakeholders, civil society and legislators.

### 9.3. Policy option 3: A set of orchestrated steps to change the state of play

The third option is to take a set of orchestrated steps to prevent the EU market from being freely dominated by non-European neurotech agents. These steps must be taken jointly and might not lead to the desired result if applied in isolation.

#### 1) Evaluating the risks of neurotechnology

Risk evaluation under the AI Act should go beyond the *technology-centred risk classification* of individual technologies. This could be done by adding *human-centred risk evaluation* that is not focused on the impact of single technologies as presently specified in the AI Act, but rather on the ecosystem of technologies as experienced by users in real life. This would help to 1) take better into account the specific needs of vulnerable groups (e.g. children, dementia patients, neurodiverse people) and 2) understand the impact of the whole ecosystem of available technologies, including interactions with single individuals, collectives and societies. Among other things, this would encompass the evaluation of risks associated with the effects of long-term usage. For example, for transcranial electrical stimulation (tES) research mostly recommends treatment lasting a few weeks, but consumer devices suggest regular treatment for over a year. Hence, the duration of neurotechnology usage could play a role in user safety and should be considered as part of risk

evaluation. Moreover, the combination of such neurotechnology with other AI-based systems could have a different impact to that determined by a single technology-centred risk evaluation system.

## 2) Public communication and neurotechnology literacy

Public communication on neurotechnologies should be tracked, and neurotechnology literacy should be improved not only among the general public but also practitioners and experts who often themselves amplify the effects of neuro-enchantment. Neurotech's public image is dominated by an overoptimistic attitude towards its positive aspects while neglecting negative ones. This is known to be a thriving factor for the development of neuro-enchantment and makes consumers vulnerable. This should be regulated by developing means to promote fair communication on limitations, risks and hype associated with neurotechnologies, including recommendations on daily exposure and safety instructions based on state-of-the-art knowledge ('open-label').

## 3) Neurotechnology and secondary legislation

Neurorights should no longer be formulated and claimed as human and fundamental rights. For example, as there is already a 'right to physical and mental integrity' in Article 3 of The Charter of Fundamental Rights of the European Union, a specific 'right to mental integrity' will raise questions as to how it differs and its limits. Thus, new human and fundamental rights may cause damage if broadly defined human and fundamental rights are split into specific new human/fundamental rights.

EU legislation already contains consumer, competition and general product safety laws, the Medical Device Regulation (MDR), the AI Act, and the General Data Protection Regulation (GDPR). Adaptations could be considered, such as the explicit inclusion of *neuro data* in Article 9 GDPR or the adaptation of the MDR, in particular Annex XVI(6) MDR, which only contains specific neurotechnologies. Neurotechnologies could also be explicitly included in the AI Act, as Article 8(1) already refers to AI-related technologies as high-risk technologies, which may entail specific AI-related neurotechnologies. As an example of best practice for a new technology regulation, the AI Act should be taken into account and could serve as a role model for a Neurotechnologies Act. Similar to AI, neurotechnologies could be classified based on the risk they pose, with different levels of regulatory scrutiny for non-invasive versus invasive technologies, or consumer-use versus medical-use technologies.

## 4) Funding neurotechnology research

Research studies investigating possible side-effects and neuropsychological, ethical, legal and societal implications should be supported and funded. Scientific literature differs concerning neurotechnology and the outcomes of associated treatments, with knowledge gaps related to efficacy and possible side-effects. There are hints in the literature that cognitive training in one domain could lead to decreases in another cognitive domain. This has also been shown in EEG (electroencephalography)-based neurofeedback training, but such side-effects are often missed as only a few researchers have the resources to include an extensive battery of tests in their studies. Neurotech devices are used for therapy, but are also increasingly used by lay persons without supervision and without taking into account individual aspects. Unfortunately, standardised double-blind controlled trials, long-term studies and their follow-up are rare in the field of neurofeedback training due to the associated costs.

Furthermore, technologies are never only just 'tools' (e.g. for medical purposes), but also have a socio-political and socio-cultural dimension. The everyday use of neurotechnology creates different conceptions of a social problem, a societal domain and their actors. By making certain mental states 'visible' and claiming to be a source of objective knowledge, neurotechnologies may enforce 'reductionism', including the risks of pathologising individuals and stigmatisation. This can

contribute to the medicalisation of neurodivergence and sets of behaviour seen as 'not normal'. All aspects mentioned above require coordinated research at EU level.

## 5) European neurodata space

As most neurotechnology providers are situated outside the EU, the data of European citizens will mostly be processed outside the EU, which is problematic insofar as non-EU countries have different data security policies. Therefore, EU-based providers of neurotechnology should be supported by implementing a solid legal basis for a European neurodata space. Its design could follow the example of the European Health Data Space (EHDS), the regulation for which is currently being adopted. For neurotechnologies, the aim of such a data space would be to prevent the loss of valuable information on both neurotechnologies and European citizens. A possible alternative is the European Open Science Cloud (EOSC) portal or EU Node. This goal could also be achieved by actively promoting the development and use of EU neurotechnologies in science, research and industry.

## 6) Standardisation of neurotechnology devices

It should be made clear whether 1) the existing general level of standardisation for neurotechnology devices is sufficient to guarantee reliable and valid usage, 2) existing standards should be adapted, or 3) new standards should be created. Consumer-grade devices are very prone to signal artifacts corrupting the signal and falsifying results. There is a consensus in the scientific community that neurotech devices often record more muscle artifacts than brain activation. Furthermore, artifacts and noise are often not properly filtered out and used for additional software applications, which makes the recorded data rather unreliable. This is especially relevant for the usage of consumer devices that promise the treatment of, for example, symptoms of depression or attention-deficit/hyperactivity disorder (ADHD).

## References

- Abdulkader, S. N., Atia, A., & Mostafa, M.-S.M. (2015). Brain computer interfacing: Applications and challenges. *Egyptian Informatics Journal*, 16(2), 213–230.  
<https://doi.org/10.1016/j.eij.2015.06.002>
- Adams, V., Murphy, M., & Clarke, A. E. (2009). Anticipation: Technoscience, life, affect, temporality. *Subjectivity*, 28(1), 246–265. <https://doi.org/10.1057/sub.2009.18>
- Ajunwa, I., Crawford, K., & Schultz, J. (2017). Limitless Worker Surveillance. *California Law Review*, 105(3), 735–776. <https://doi.org/10.15779/Z38BR8MF94>
- Álamos, M. F., Kausel, L., Baselga-Garriga, C., Ramos, P., Aboitiz, F., Uribe-Etxebarria, X., & Yuste, R. (2022). A Technocratic Oath. In P. López-Silva & L. Valera (Eds.), *Protecting the Mind: Challenges in Law, Neuroprotection, and Neurorights* (pp. 163–174). Springer International Publishing.  
[https://doi.org/10.1007/978-3-030-94032-4\\_14](https://doi.org/10.1007/978-3-030-94032-4_14)
- Ali, S. S., Lifshitz, M., & Raz, A. (2014). Empirical neuroenchantment: From reading minds to thinking critically. *Frontiers in Human Neuroscience*, 8. <https://doi.org/10.3389/fnhum.2014.00357>
- Allison, B. Z., & Neuper, C. (2010). Could Anyone Use a BCI? In D. S. Tan & A. Nijholt (Eds.), *Human-Computer Interaction Series. Brain-Computer Interfaces* (pp. 35–54). Springer London.  
[https://doi.org/10.1007/978-1-84996-272-8\\_3](https://doi.org/10.1007/978-1-84996-272-8_3)
- Almeida, M., & Diogo, R. (2019). Human enhancement: Genetic engineering and evolution. *Evolution, Medicine, and Public Health*, 2019(1), 183–189. <https://doi.org/10.1093/emph/eoz026>
- Alomar, S., King, N. K. K., Tam, J., Bari, A. A., Hamani, C., & Lozano, A. M. (2017). Speech and language adverse effects after thalamotomy and deep brain stimulation in patients with movement disorders: A meta-analysis. *Movement Disorders : Official Journal of the Movement Disorder Society*, 32(1), 53–63. <https://doi.org/10.1002/mds.26924>
- Alston, P. (1984). Conjuring Up New Human Rights: A Proposal For Quality Control. *American Journal of International Law*, 78(3), 607–621. <https://doi.org/10.2307/2202599>
- Andersen, R. (2023). *The Right to Not Have Your Mind Read: The Atlantic*.  
<https://www.theatlantic.com/technology/archive/2023/08/mind-reading-brain-data-interrogation-mri-machines/675059/>
- Angrisan, L., Arpaia, P., & Casinelli, D. (2017). Instrumentation and measurements for non-invasive EEG-based brain-computer interface. In *2017 IEEE International Workshop on Measurement and Networking (M&N)* (pp. 1–5). IEEE. <https://doi.org/10.1109/IWMN.2017.8078383>
- Anscombe, G. E. M. (1957). *Intention*. Harvard University Press.
- Antal, A., Luber, B., Brem, A.-K., Bikson, M., Brunoni, A. R., Cohen Kadosh, R., Dubljević, V., Fecteau, S., Ferreri, F., Flöel, A., Hallett, M., Hamilton, R. H., Herrmann, C. S., Lavidor, M., Loo, C., Lustenberger, C., Machado, S., Miniussi, C., Moliadze, V., . . . Paulus, W. (2022). Non-invasive brain stimulation and neuroenhancement. *Clinical Neurophysiology Practice*, 7, 146–165.  
<https://doi.org/10.1016/j.cnp.2022.05.002>
- Apap, J. (2018). *At a Glance: Indivisibility of human rights: Unifying the two Human Rights Covenants?* (PE 628.296). EPRS | European Parliamentary Research Service.  
[https://www.europarl.europa.eu/RegData/etudes/ATAG/2018/628296/EPRS\\_ATAG\(2018\)628296\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/ATAG/2018/628296/EPRS_ATAG(2018)628296_EN.pdf)
- Bareis, J., & Katzenbach, C. (2022). Talking AI into Being: The Narratives and Imaginaries of National AI Strategies and Their Performative Politics. *Science, Technology, & Human Values*, 47(5), 855–881.  
<https://doi.org/10.1177/01622439211030007>
- Baselga-Garriga, C., Rodriguez, P., & Yuste, R. (2022). Neuro Rights: A Human Rights Solution to Ethical Issues of Neurotechnologies. In P. López-Silva & L. Valera (Eds.), *Protecting the Mind: Challenges in Law, Neuroprotection, and Neurorights* (pp. 157–161). Springer International Publishing.  
[https://doi.org/10.1007/978-3-030-94032-4\\_13](https://doi.org/10.1007/978-3-030-94032-4_13)
- Baylis, F. (2013). "I Am Who I Am": On the Perceived Threats to Personal Identity from Deep Brain Stimulation. *Neuroethics*, 6(3), 513–526. <https://doi.org/10.1007/s12152-011-9137-1>
- Beauchamp, T. L., & Childress, J. F. (2019). *Principles of biomedical ethics* (8<sup>th</sup> ed.). Oxford University Press.

- Beckett, A. E., & Campbell, T. (2015). The social model of disability as an oppositional device. *Disability & Society*, 30(2), 270–283. <https://doi.org/10.1080/09687599.2014.999912>
- Berger, L., Zandonella, P., & Staudegger, E. (2024). Brauchen wir die NRF-Neurorechte? In J. Pfister, E. Schweighofer, F. Costatini, F. Schmautzer, & S. Eder (Eds.), *Sprachmodelle: Juristische Papageien oder mehr? Tagungsband des 27. Internationalen Rechtsinformatik Symposiums IRIS 2024 = Language models: legal parrots or more?: proceedings of the 27<sup>th</sup> International Legal Informatics Symposium IRIS 2024* (pp. 441–450). Editions Weblaw.
- Bernal, S. L., Celdrán, A. H., Pérez, G. M., Barros, M. T., & Balasubramaniam, S. (2022). Security in Brain-Computer Interfaces: State-of-the-art, opportunities, and future challenges. *ACM Computing Surveys*, 54(1), 1–35. <https://doi.org/10.1145/3427376>
- Bertel, M. (2015). Staatszielbestimmungen. Bedeutung und Funktion im österreichischen Verfassungsrecht. In Breitenlechner & Manolas (Eds.), *Sicherung von Stabilität und Nachhaltigkeit durch Recht* (p. 139).
- Bielefeldt, H. (2023). Freiheit als Anspruch: Eine menschenrechtliche Perspektive. In N. J. Saam & H. Bielefeldt (Eds.), *Sozialtheorie. Die Idee der Freiheit und ihre Semantiken: Zum Spannungsverhältnis von Freiheit und Sicherheit* (pp. 187–196). transcript.
- Borges, G. (2023). Der Mann mit der Brille und die DSGVO – Der Begriff des Gesundheitsdatums. *Rechtswissenschaft*, 14(2), 159–198. <https://doi.org/10.5771/1868-8098-2023-2-159>
- Breteler, M. H. M., Arns, M., Peters, S., Giepman, I., & Verhoeven, L. (2010). Improvements in spelling after QEEG-based neurofeedback in dyslexia: A randomized controlled treatment study. *Applied Psychophysiology and Biofeedback*, 35(1), 5–11. <https://doi.org/10.1007/s10484-009-9105-2>
- Bublitz, J. C. (2014). Freedom of Thought in the Age of Neuroscience. *Archiv Für Rechts- Und Sozialphilosophie*, 100(1), 1–25. <https://doi.org/10.25162/arsp-2014-0001>
- Bublitz, J.-C. (2013). My Mind Is Mine!? Cognitive Liberty as a Legal Concept. In E. Hildt & A. G. Franke (Eds.), *Trends in Augmentation of Human Performance. Cognitive Enhancement* (Vol. 1, pp. 233–264). Springer Netherlands. [https://doi.org/10.1007/978-94-007-6253-4\\_19](https://doi.org/10.1007/978-94-007-6253-4_19)
- Cagnan, H., Denison, T., McIntyre, C., & Brown, P. (2019). Emerging technologies for improved deep brain stimulation. *Nature Biotechnology*, 37(9), 1024–1033. <https://doi.org/10.1038/s41587-019-0244-6>
- Charter of Fundamental Rights of the European Union.
- Cinel, C., Valeriani, D., & Poli, R. (2019). Neurotechnologies for Human Cognitive Augmentation: Current State of the Art and Future Prospects. *Frontiers in Human Neuroscience*, 13, 13. <https://doi.org/10.3389/fnhum.2019.00013>
- Clément, D. (2018). Human rights or social justice? The problem of rights inflation. *The International Journal of Human Rights*, 22(2), 155–169. <https://doi.org/10.1080/13642987.2017.1349245>
- Communication from the Commission on the precautionary principle (COM/2000/0001 final). <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52000DC0001>
- Conitzer, V., Hadfield, G., & Vallor, S. (Eds.) (2019). *Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society*. ACM.
- Craig, J. N. (2016). Incarceration, Direct Brain Intervention, and the Right to Mental Integrity – a Reply to Thomas Douglas. *Neuroethics*, 9(2), 107–118. <https://doi.org/10.1007/s12152-016-9255-x>
- Davidson, D. (1963). Actions, Reasons, and Causes. *The Journal of Philosophy*, 60(23), 685. <https://doi.org/10.2307/2023177>
- deBettencourt, M. T., Cohen, J. D., Lee, R. F., Norman, K. A., & Turk-Browne, N. B. (2015). Closed-loop training of attention with real-time brain imaging. *Nature Neuroscience*, 18(3), 470–475. <https://doi.org/10.1038/nn.3940>
- Modifica la carta fundamental, para establecer el desarrollo científico y tecnológico al servicio de las personas, <https://www.diariooficial.interior.gob.cl/publicaciones/2021/10/25/43086-B/01/2031873.pdf> (2021 & rev. CVE 2031873).
- Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information.
- Directive (EU) 2019/2161 of the European Parliament and of the Council of 27 November 2019 amending Council Directive 93/13/EEC and Directives 98/6/EC, 2005/29/EC and 2011/83/EU of

- the European Parliament and of the Council as regards the better enforcement and modernisation of Union consumer protection rules.
- Directive (EU) 2019/771 of the European Parliament and of the Council 20 May 2019 on certain aspects concerning contracts for the sale of goods, amending Regulation (EU) 2017/2394 and Directive 2009/22/EC, and repealing Directive 1999/44/EC.
- Directive (EU) 2024/825 of the European Parliament and of the Council of 28 February 2024 amending Directives 2005/29/EC and 2011/83/EU as regards empowering consumers for the green transition through better protection against unfair practices and through better information.
- Directive 2005/29/EC of the European Parliament and of the Council of 11 May 2005 concerning unfair business-to-consumer commercial practices in the internal market and amending Council Directive 84/450/EEC, Directives 97/7/EC, 98/27/EC and 2002/65/EC of the European Parliament and of the Council and Regulation (EC) No 2006/2004 of the European Parliament and of the Council ('Unfair Commercial Practices Directive').
- Directive 2006/114/EC of the European Parliament and of the Council of 12 December 2006 concerning misleading and comparative advertising.
- Directive 2011/24/EU of the European Parliament and of the Council of 9 March 2011 on the application of patients' rights in cross-border healthcare.
- Directive 2011/83/EU of the European Parliament and of the Council of 25 October 2011 on consumer rights, amending Council Directive 93/13/EEC and Directive 1999/44/EC of the European Parliament and of the Council and repealing Council Directive 85/577/EEC and Directive 97/7/EC of the European Parliament and of the Council Text with EEA relevance.
- Drew, L. (2024). Elon Musk's Neuralink brain chip: What scientists think of first human trial. *Nature*. Advance online publication. <https://doi.org/10.1038/d41586-024-00304-4>
- Ehlen, F., Schoenecker, T., Kühn, A. A., & Klostermann, F. (2014). Differential effects of deep brain stimulation on verbal fluency. *Brain and Language*, 134, 23–33. <https://doi.org/10.1016/j.bandl.2014.04.002>
- Esper, C. D., Merola, A., Himes, L., Patel, N., Bezchlibnyk, Y. B., Falconer, D., Weiss, D., Luca, C., Cheeran, B., & Mari, Z. (2022). Necessity and feasibility of remote tele-programming of deep brain stimulation systems in Parkinson's disease. *Parkinsonism & Related Disorders*, 96, 38–42. <https://doi.org/10.1016/j.parkreldis.2022.01.017>
- Eubanks, V. (2018). *Automating inequality: How high-tech tools profile, police, and punish the poor* (First edition). St. Martin's Press.
- European Convention on Human Rights.
- European Parliament. (2022). *European Parliament resolution of 3 May 2022 on artificial intelligence in a digital age (2020/2266(INI))*. [https://www.europarl.europa.eu/doceo/document/TA-9-2022-0140\\_EN.html](https://www.europarl.europa.eu/doceo/document/TA-9-2022-0140_EN.html)
- Fenner, D. (2019). *Selbstoptimierung und Enhancement: Ein ethischer Grundriss*. UTB Philosophie: Vol. 5127. Narr Francke Attempto Verlag. <https://doi.org/5127>
- Fernández-Alvarez, J., Grassi, M., Colombo, D., Botella, C., Cipresso, P., Perna, G., & Riva, G. (2022). Efficacy of bio- and neurofeedback for depression: A meta-analysis. *Psychological Medicine*, 52(2), 201–216. <https://doi.org/10.1017/S0033291721004396>
- Fins, J. J. (2022). The Unintended Consequences of Chile's Neurorights Constitutional Reform: Moving beyond Negative Rights to Capabilities. *Neuroethics*, 15(3). <https://doi.org/10.1007/s12152-022-09504-z>
- Floridi, L. (2023). *The ethics of artificial intelligence: Principles, challenges, and opportunities*. Oxford University Press.
- Freise, J. (2024). Hirnstimulation: NIBS, THS und Optogenetik. *Medizinrecht*, 42(2), 90–96. <https://doi.org/10.1007/s00350-023-6669-4>
- Funke, A. (2023). Freiheit als konstitutives Prinzip der Rechtsordnung. In N. J. Saam & H. Bielefeldt (Eds.), *Sozialtheorie. Die Idee der Freiheit und ihre Semantiken: Zum Spannungsverhältnis von Freiheit und Sicherheit* (pp. 169–176). transcript.
- Ganzer, P. D., Colachis, S. C., Schwemmer, M. A., Friedenber, D. A., Dunlap, C. F., Swiftney, C. E., Jacobowitz, A. F., Weber, D. J., Bockbrader, M. A., & Sharma, G. (2020). Restoring the Sense of

- Touch Using a Sensorimotor Demultiplexing Neural Interface. *Cell*, 181(4), 763-773.e12. <https://doi.org/10.1016/j.cell.2020.03.054>
- Garcia, D., & Rimé, B. (2019). Collective Emotions and Social Resilience in the Digital Traces After a Terrorist Attack. *Psychological Science*, 30(4), 617–628. <https://doi.org/10.1177/0956797619831964>
- Genser, J., Damianos, S., & Yuste, R. (2024). *Safeguarding Brain Data: Assessing the Privacy Practices of Consumer Neurotechnology Companies*. [https://www.perseus-strategies.com/wp-content/uploads/2024/04/FINAL\\_Consumer\\_Neurotechnology\\_Report\\_Neurorights\\_Foundation\\_April-1.pdf](https://www.perseus-strategies.com/wp-content/uploads/2024/04/FINAL_Consumer_Neurotechnology_Report_Neurorights_Foundation_April-1.pdf)
- Genser, J., Herrmann, S., & Yuste, R. (2022). International Human Rights Protection Gaps in the Age of Neurotechnology.
- Giattino, C. M., Kwong, L., Rafetto, C., & Farahany, N. A. (2019). The Seductive Allure of Artificial Intelligence-Powered Neurotechnology. In V. Conitzer, G. Hadfield, & S. Vallor (Eds.), *Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society* (pp. 397–402). ACM. <https://doi.org/10.1145/3306618.3314269>
- Gilbert, F., Cook, M., O'Brien, T., & Illes, J. (2019). Embodiment and Estrangement: Results from a First-in-Human "Intelligent BCI" Trial. *Science and Engineering Ethics*, 25(1), 83–96. <https://doi.org/10.1007/s11948-017-0001-5>
- Gilbert, F., Goddard, E., Viaña, J. N. M., Carter, A., & Horne, M. (2017). I Miss Being Me: Phenomenological Effects of Deep Brain Stimulation. *AJOB Neuroscience*, 8(2), 96–109. <https://doi.org/10.1080/21507740.2017.1320319>
- Goering, S. (2015). Rethinking disability: The social model of disability and chronic disease. *Current Reviews in Musculoskeletal Medicine*, 8(2), 134–138. <https://doi.org/10.1007/s12178-015-9273-z>
- Goering, S., Klein, E., Specker Sullivan, L., Wexler, A., Agüera Y Arcas, B., Bi, G., Carmena, J. M., Fins, J. J., Friesen, P., Gallant, J., Huggins, J. E., Kellmeyer, P., Marblestone, A., Mitchell, C., Parens, E., Pham, M., Rubel, A., Sadato, N., Teicher, M., . . . Yuste, R. (2021). Recommendations for Responsible Development and Application of Neurotechnologies. *Neuroethics*, 14(3), 365–386. <https://doi.org/10.1007/s12152-021-09468-6>
- Gregg, M. (2011). *Work's intimacy*. Polity.
- Gremsl, T. Ethik 4.0? [Dissertation, Karl-Franzens-Universität Graz]. K10plus." -> "Gremsl, T. (2022). Ethik 4.0? Der „Faktor Mensch“ in der digitalen Transformation. Gesellschaft - Ethik - Religion: 21. Brill | Schöningh.
- Grunwald, A. (2019a). Digitalisierung als Prozess. Ethische Herausforderungen inmitten allmählicher Verschiebungen zwischen Mensch, Technik und Gesellschaft. *Zeitschrift Für Wirtschafts- Und Unternehmensethik*, 20(2), 121–145. <https://doi.org/10.5771/1439-880X-2019-2-121>
- Grunwald, A. (2019b). *Der unterlegene Mensch: Die Zukunft der Menschheit im Angesicht von Algorithmen, künstlicher Intelligenz und Robotern* (Originalausgabe, 1. Auflage). riva.
- Grunwald, A. (Ed.). (2021). *Wer bist du, Mensch? Transformationen menschlicher Selbstverständnisse im wissenschaftlich-technischen Fortschritt*. Herder.
- Guy, V., Soriani, M.-H., Bruno, M., Papadopoulou, T., Desnuelle, C., & Clerc, M. (2018). Brain computer interface with the P300 speller: Usability for disabled people with amyotrophic lateral sclerosis. *Annals of Physical and Rehabilitation Medicine*, 61(1), 5–11. <https://doi.org/10.1016/j.rehab.2017.09.004>
- Haller, S., Kopel, R., Jhooti, P., Haas, T., Scharnowski, F., Lovblad, K.-O., Scheffler, K., & van de Ville, D. (2013). Dynamic reconfiguration of human brain functional networks through neurofeedback. *NeuroImage*, 81, 243–252. <https://doi.org/10.1016/j.neuroimage.2013.05.019>
- Hallur, G. G., Prabhu, S., & Aslekar, A. (2021). Entertainment in Era of AI, Big Data & IoT. In S. Das & S. Gochhait (Eds.), *Digital Entertainment: The Next Evolution in Service Sector* (pp. 87–109). Springer Nature. [https://doi.org/10.1007/978-981-15-9724-4\\_5](https://doi.org/10.1007/978-981-15-9724-4_5)
- Hamilton-Bruce, M. A., Boundy, K. L., & Purdie, G. H. (1991). Interoperator variability in quantitative electroencephalography. *Clinical and Experimental Neurology*, 28, 219–224.
- Heimbach-Steins, M. (2022). Sozialprinzipien. In M. Heimbach-Steins, M. Becka, J. J. Frühbauer, & G. Kruip (Eds.), *Christliche Sozialethik: Grundlagen, Kontexte, Themen: ein Lehr- und Studienbuch* (pp. 170–186). Verlag Friedrich Pustet.

- Hertz, N. (2023a). „Neurorechte“ - Zeit für neue Menschenrechte? Eine Neubetrachtung des Menschenrechts auf Gedankenfreiheit. In *Freiburger Informationspapiere zum Völkerrecht und Öffentlichen Recht* (2/2023).
- Hertz, N. (2023b). Neurorights – Do we Need New Human Rights? A Reconsideration of the Right to Freedom of Thought. *Neuroethics*, 16(1). <https://doi.org/10.1007/s12152-022-09511-0>
- Hochschild, A. R. (1979). Emotion work, feeling rules, and social structure. *American Journal of Sociology*, 85(3), 551–575.
- Hull, G., & Pasquale, F. (2018). Toward a critical theory of corporate wellness. *BioSocieties*, 13(1), 190–212. <https://doi.org/10.1057/s41292-017-0064-1>
- Iamsakul, K., Pavlovic, A. V., Calderon, J. I., & Sanderson, L. M. (2017). Project HEAVEN: Preoperative Training in Virtual Reality. *Surgical Neurology International*, 8, 59. [https://doi.org/10.4103/sni.sni\\_371\\_16](https://doi.org/10.4103/sni.sni_371_16)
- Ienca, M. (2021a). *Common Human Rights Challenges raised by different Applications of Neurotechnologies in the Biomedical Field*. Committee on Bioethics of the Council of Europe. <https://rm.coe.int/report-final-en/1680a429f3>
- Ienca, M. (2021b). On Neurorights. *Frontiers in Human Neuroscience*, 15, 701258. <https://doi.org/10.3389/fnhum.2021.701258>
- Ienca, M., & Andorno, R. (2017). Towards new human rights in the age of neuroscience and neurotechnology. *Life Sciences, Society and Policy*, 13(1), 5. <https://doi.org/10.1186/s40504-017-0050-1>
- Ienca, M., Fins, J. J., Jox, R. J., Jotterand, F., Voienky, S., Andorno, R., Ball, T., Castelluccia, C., Chavarriga, R., Chneiweiss, H., Ferretti, A., Friedrich, O., Hurst, S., Merkel, G., Molnár-Gábor, F., Rickli, J.-M., Scheibner, J., Vayena, E., Yuste, R., & Kellmeyer, P. (2022). Towards a Governance Framework for Brain Data. *Neuroethics*, 15(2). <https://doi.org/10.1007/s12152-022-09498-8>
- Iuculano, T., & Cohen Kadosh, R. (2013). The mental cost of cognitive enhancement. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, 33(10), 4482–4486. <https://doi.org/10.1523/JNEUROSCI.4927-12.2013>
- Ivanova, Y. (2021). The Role of the EU Fundamental Right to Data Protection in an Algorithmic and Big Data World. In D. Hallinan, R. Leenes, & P. de Hert (Eds.), *Data Protection and Privacy: Data Protection and Artificial Intelligence* (pp. 145–186). Hart Publishing. <https://doi.org/10.5040/9781509941780.ch-006>
- Jarke, J., & Breiter, A. (2019). Editorial: the datafication of education. *1743-9884*, 44(1), 1–6. <https://doi.org/10.1080/17439884.2019.1573833>
- Jasanoff, S., Kim, S., & University of Chicago Press. (2015). *Dreamscapes of modernity: Sociotechnical imaginaries and the fabrication of power*. London. <http://www.degruyter.com/isbn/9780226276663>
- Jiang, L., Stocco, A., Losey, D. M., Abernethy, J. A., Prat, C. S., & Rao, R. P. N. (2019). Brainnet: A Multi-Person Brain-to-Brain Interface for Direct Collaboration Between Brains. *Scientific Reports*, 9(1), 6115. <https://doi.org/10.1038/s41598-019-41895-7>
- Kirchschläger, P. G. (2019). Menschenrechte, Demokratie und Religionen. *LIMINA - Grazer Theologische Perspektiven*, 2(1), 17–39. <https://doi.org/10.25364/17.2:2019.1.2>
- Kirchschläger, P. G. (2022). Ethische KI? Datenbasierte Systeme (DS) mit Ethik. *HMD Praxis Der Wirtschaftsinformatik*, 59(2), 482–494. <https://doi.org/10.1365/s40702-022-00843-2>
- Knox, J., Williamson, B., & Bayne, S. (2020). Machine behaviourism: future visions of 'learnification' and 'datafication' across humans and digital technologies. *1743-9884*, 45(1), 31–45. <https://doi.org/10.1080/17439884.2019.1623251>
- Kober, S. E., Buchrieser, F., & Wood, G. (2023). Neurofeedback on twitter: Evaluation of the scientific credibility and communication about the technique. *Heliyon*, 9(8), e18931. <https://doi.org/10.1016/j.heliyon.2023.e18931>
- Kober, S. E., Schweiger, D., Witte, M., Reichert, J. L., Grieshofer, P., Neuper, C., & Wood, G. (2015). Specific effects of EEG based neurofeedback training on memory functions in post-stroke victims. *Journal of Neuroengineering and Rehabilitation*, 12, 107. <https://doi.org/10.1186/s12984-015-0105-6>

- Koska, C., & Filipović, A. (2017). Gestaltungsfragen der Digitalität: Zu den sozialetischen Herausforderungen von künstlicher Intelligenz, Big Data und Virtualität. In R. Bergold, J. Sautermeister, & A. Schröder (Eds.), *Dem Wandel eine menschliche Gestalt geben: Sozialethische Perspektiven für die Gesellschaft von morgen: Festschrift zur Neueröffnung und zum 70-jährigen Bestehen des Katholisch-Sozialen Instituts* (pp. 173–191). Verlag Herder.
- Lavazza, A. (2018). Freedom of Thought and Mental Integrity: The Moral Requirements for Any Neural Prosthesis. *Frontiers in Neuroscience*, 12, 82. <https://doi.org/10.3389/fnins.2018.00082>
- Lavazza, A., & Giorgi, R. (2023). Philosophical foundation of the right to mental integrity in the age of neurotechnologies. *Neuroethics*, 16(1), 10. <https://doi.org/10.1007/s12152-023-09517-2>
- Legaspi, R., Xu, W., Konishi, T., Wada, S., Kobayashi, N., Naruse, Y., & Ishikawa, Y. (2024). The sense of agency in human–AI interactions. *Knowledge-Based Systems*, 286, 111298. <https://doi.org/10.1016/j.knsys.2023.111298>
- Li, Q., Ding, D., & Conti, M. (2015). Brain-Computer Interface applications: Security and privacy challenges. In *2015 IEEE Conference on Communications and Network Security (CNS)* (pp. 663–666). IEEE. <https://doi.org/10.1109/CNS.2015.7346884>
- Lighthart, S., Bublitz, C., Douglas, T., Forsberg, L., & Meynen, G. (2022). Rethinking the Right to Freedom of Thought: A Multidisciplinary Analysis. *Human Rights Law Review*, 22(4), Article ngac028, 1–14. <https://doi.org/10.1093/hrlr/ngac028>
- Littlefield, M. M. (2018). *Instrumental Intimacy: EEG Wearables and Neuroscientific Control*. John Hopkins University Press.
- Loh, J. (2023). *Trans- und Posthumanismus zur Einführung* (4<sup>th</sup> ed.). Junius. <http://epub.sub.uni-hamburg.de/epub/volltexte/einzelplatz/2020/112304/>
- López-Silva, P., & Valera, L. (Eds.). (2022). *Protecting the Mind: Challenges in Law, Neuroprotection, and Neurorights*. Springer International Publishing.
- Loriette, C., Ziane, C., & Ben Hamed, S. (2021). Neurofeedback for cognitive enhancement and intervention and brain plasticity. *Revue Neurologique*, 177(9), 1133–1144. <https://doi.org/10.1016/j.neurol.2021.08.004>
- Lozano, A. M., Lipsman, N., Bergman, H., Brown, P., Chabardes, S., Chang, J. W., Matthews, K., McIntyre, C. C., Schlaepfer, T. E., Schulder, M., Temel, Y., Volkmann, J., & Krauss, J. K. (2019). Deep brain stimulation: Current challenges and future directions. *Nature Reviews. Neurology*, 15(3), 148–160. <https://doi.org/10.1038/s41582-018-0128-2>
- Macgilchrist, F., Allert, H., Cerratto Pargman, T., & Jarke, J. (2024). Designing Postdigital Futures: Which Designs? Whose Futures? *Postdigital Science and Education*, 6(1), 13–24. <https://doi.org/10.1007/s42438-022-00389-y>
- Manahan-Vaughan, D. (Ed.). (2018). *Handbook of Behavioral Neuroscience: Volume 28. Handbook of In Vivo Neural Plasticity Techniques: A Systems Neuroscience Approach to the Neural Basis of Memory and Cognition*. Academic Press an imprint of Elsevier.
- Manokha, I. (2020). The Implications of Digital Employee Monitoring and People Analytics for Power Relations in the Workplace. *Surveillance & Society*, 18(4), 540–554. <https://doi.org/10.24908/ss.v18i4.13776>
- Markosian, C., Taruvai, V. S., & Mammis, A. (2020). Neuromodulatory hacking: A review of the technology and security risks of spinal cord stimulation. *Acta Neurochirurgica*, 162(12), 3213–3219. <https://doi.org/10.1007/s00701-020-04592-3>
- Martínez-Martínez, A. M., Aguilar, O. M., & Acevedo-Triana, C. A. (2017). Meta-Analysis of the Relationship between Deep Brain Stimulation in Patients with Parkinson's Disease and Performance in Evaluation Tests for Executive Brain Functions. *Parkinson's Disease*, 2017, 9641392. <https://doi.org/10.1155/2017/9641392>
- Martinovic, I., Davies, D., Frank, M., Perito, D., Ros, T., & Song, D. (2012). On the feasibility of side-channel attacks with brain-computer interfaces. In *21<sup>st</sup> USENIX Security Symposium (USENIX Security 12)* (pp. 143–158). USENIX Association. Ivan Martinovic; Doug Davies; Mario Frank; Daniele Perito; Tomas Ros; Dawn Song
- Marzbani, H., Marateb, H. R., & Mansourian, M. (2016). Neurofeedback: A Comprehensive Review on System Design, Methodology and Clinical Applications. *Basic and Clinical Neuroscience*, 7(2), 143–158. <https://doi.org/10.15412/J.BCN.03070208>

- Mathewson, K. E., Harrison, T. J. L., & Kizuk, S. A. D. (2017). High and dry? Comparing active dry EEG electrodes to active and passive wet electrodes. *Psychophysiology*, 54(1), 74–82. <https://doi.org/10.1111/psyp.12536>
- McCay, A. (2022, August). Neurotechnology, law and the legal profession: Horizon Report for The Law Society.
- Mihara, M., & Miyai, I. (2016). Review of functional near-infrared spectroscopy in neurorehabilitation. *Neurophotonics*, 3(3), 31414. <https://doi.org/10.1117/1.NPh.3.3.031414>
- Moradi, P., & Levy, K. (2020). The Future of Work in the Age of AI. In M. D. Dubber, F. Pasquale, S. Das, P. Moradi, & K. Levy (Eds.), *The Oxford Handbook of Ethics of AI* (pp. 269–288). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780190067397.013.17>
- Nagl-Docekal, H., & Zacharasiewicz, W. (2022). *Artificial Intelligence and Human Enhancement*. De Gruyter. <https://doi.org/10.1515/9783110770216>
- Nam, C. S., Traylor, Z., Chen, M., Jiang, X., Feng, W., & Chhatbar, P. Y. (2021). Direct Communication Between Brains: A Systematic PRISMA Review of Brain-To-Brain Interface. *Frontiers in Neurobotics*, 15, 656943. <https://doi.org/10.3389/fnbot.2021.656943>
- Neurorights Foundation. *Mission*. <https://neurorightsfoundation.org/mission>
- Nickel, J. (2019). *Stanford Encyclopedia of Philosophy: Human Rights*. <https://plato.stanford.edu/entries/rights-human/>
- Oberleitner, G. (2022). United Nations Educational, Scientific and Cultural Organization (UNESCO). In C. Binder, M. Nowak, J. A. Hofbauer, & P. Janig (Eds.), *Elgar Encyclopedia of Human Rights* (pp. 477–484). Edward Elgar Publishing. <https://doi.org/10.4337/9781789903621.unesco>
- OECD. (2019). *Responsible innovation in neurotechnology enterprises*. [https://www.oecd-ilibrary.org/science-and-technology/responsible-innovation-in-neurotechnology-enterprises\\_9685e4fd-en](https://www.oecd-ilibrary.org/science-and-technology/responsible-innovation-in-neurotechnology-enterprises_9685e4fd-en)
- Office of the High Commissioner for Human Rights (Ed.). *CCPR General Comment No. 16: Article 17 (Right to Privacy) The Right to Respect of Privacy, Family, Home and Correspondence, and Protection of Honour and Reputation: Adopted at the Thirty-second Session of the Human Rights Committee, on 8 April 1988*.
- Olson, J. A., Cyr, M., Artenie, D. Z., Strandberg, T., Hall, L., Tompkins, M. L., Raz, A., & Johansson, P. (2023). Emulating future neurotechnology using magic. *Consciousness and Cognition*, 107, 103450. <https://doi.org/10.1016/j.concog.2022.103450>
- Olson, M. C., Shill, H., Ponce, F., & Aslam, S. (2023). Deep brain stimulation in PD: Risk of complications, morbidity, and hospitalizations: A systematic review. *Frontiers in Aging Neuroscience*, 15, 1258190. <https://doi.org/10.3389/fnagi.2023.1258190>
- Precht, R. D. (2007). *Wer bin ich - und wenn ja, wie viele? Eine philosophische Reise*. Goldmann.
- Proposal for a Regulation of the European Parliament and of the Council laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) and amending certain union legislative acts, [https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CONSIL:ST\\_7536\\_2024\\_INIT\\_COM/2021/206](https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CONSIL:ST_7536_2024_INIT_COM/2021/206). [https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CONSIL:ST\\_7536\\_2024\\_INIT](https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CONSIL:ST_7536_2024_INIT)
- Proposal for a Regulation of the European Parliament and of the Council laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) and amending certain union legislative acts/P9\_TA(2024)0138, [https://www.europarl.europa.eu/RegData/seance\\_pleniere/textes\\_adoptes/definitif/2024/03-13/0138/P9\\_TA\(2024\)0138\\_EN.pdf](https://www.europarl.europa.eu/RegData/seance_pleniere/textes_adoptes/definitif/2024/03-13/0138/P9_TA(2024)0138_EN.pdf). [https://www.europarl.europa.eu/RegData/seance\\_pleniere/textes\\_adoptes/definitif/2024/03-13/0138/P9\\_TA\(2024\)0138\\_EN.pdf](https://www.europarl.europa.eu/RegData/seance_pleniere/textes_adoptes/definitif/2024/03-13/0138/P9_TA(2024)0138_EN.pdf)
- Pycroft, L., Bocard, S. G., Owen, S. L. F., Stein, J. F., Fitzgerald, J. J., Green, A. L., & Aziz, T. Z. (2016). Brainjacking: Implant Security Issues in Invasive Neuromodulation. *World Neurosurgery*, 92, 454–462. <https://doi.org/10.1016/j.wneu.2016.05.010>
- Rahm, L. (2023a). Education, automation and AI: a genealogy of alternative futures. *Learning, Media and Technology*, 48(1), 6–24. <https://doi.org/10.1080/17439884.2021.1977948>
- Rahm, L. (2023b). Educational imaginaries: governance at the intersection of technology and education. *Journal of Education Policy*, 38(1), 46–68. <https://doi.org/10.1080/02680939.2021.1970233>

- Rao, R. P. N., Stocco, A., Bryan, M., Sarma, D., Youngquist, T. M., Wu, J., & Prat, C. S. (2014). A direct brain-to-brain interface in humans. *PLoS One*, 9(11), e111332. <https://doi.org/10.1371/journal.pone.0111332>
- Raspopovic, S. (2020). Advancing limb neural prostheses. *Science (New York, N.Y.)*, 370(6514), 290–291. <https://doi.org/10.1126/science.abb1073>
- Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation).
- Regulation (EU) 2017/745 of the European Parliament and of the Council of 5 April 2017 on medical devices, amending Directive 2001/83/EC, Regulation (EC) No 178/2002 and Regulation (EC) No 1223/2009 and repealing Council Directives 90/385/EEC and 93/42/EEC.
- Regulation (EU) 2019/1020 of the European Parliament and of the Council of 20 June 2019 on market surveillance and compliance of products and amending Directive 2004/42/EC and Regulations (EC) No 765/2008 and (EU) No 305/2011.
- Regulation (EU) 2019/881 of the European Parliament and of the Council of 17 April 2019 on ENISA (the European Union Agency for Cybersecurity) and on information and communications technology cybersecurity certification and repealing Regulation (EU) No 526/2013 (Cybersecurity Act) (Text with EEA relevance).
- Regulation (EU) 2021/2282 of the European Parliament and of the Council of 15 December 2021 on health technology assessment and amending Directive 2011/24/EU.
- Regulation (EU) 2023/988 of the European Parliament and of the Council of 10 May 2023 on general product safety, amending Regulation (EU) No 1025/2012 of the European Parliament and of the Council and Directive (EU) 2020/1828 of the European Parliament and the Council, and repealing Directive 2001/95/EC of the European Parliament and of the Council and Council Directive 87/357/EEC.
- Regulation (EU) No 1025/2012 of the European Parliament and of the Council of 25 October 2012 on European standardisation, amending Council Directives 89/686/EEC and 93/15/EEC and Directives 94/9/EC, 94/25/EC, 95/16/EC, 97/23/EC, 98/34/EC, 2004/22/EC, 2007/23/EC, 2009/23/EC and 2009/105/EC of the European Parliament and of the Council and repealing Council Decision 87/95/EEC and Decision No 1673/2006/EC of the European Parliament and of the Council Text with EEA relevance.
- Regulation (EU) No 910/2014 of the European Parliament and of the Council of 23 July 2014 on electronic identification and trust services for electronic transactions in the internal market and repealing Directive 1999/93/EC.
- Riesco-Matías, P., Yela-Bernabé, J. R., Crego, A., & Sánchez-Zaballos, E. (2021). What Do Meta-Analyses Have to Say About the Efficacy of Neurofeedback Applied to Children With ADHD? Review of Previous Meta-Analyses and a New Meta-Analysis. *Journal of Attention Disorders*, 25(4), 473–485. <https://doi.org/10.1177/1087054718821731>
- Justificativa, [http://proweb.procergs.com.br/consulta\\_proposicao.asp?SiglaTipo=PEC&NroProposicao=298&AnoProposicao=2023](http://proweb.procergs.com.br/consulta_proposicao.asp?SiglaTipo=PEC&NroProposicao=298&AnoProposicao=2023).
- Altera o parágrafo único do artigo 235 da Constituição do Estado do Rio Grande do Sul (SEI 14506-0100/23-7), [http://proweb.procergs.com.br/consulta\\_proposicao.asp?SiglaTipo=PEC&NroProposicao=2023](http://proweb.procergs.com.br/consulta_proposicao.asp?SiglaTipo=PEC&NroProposicao=2023) & rev. PEC 298 2023).
- Ros, T., Enriquez-Geppert, S., Zotev, V., Young, K. D., Wood, G., Whitfield-Gabrieli, S., Wan, F., Vuilleumier, P., Vialatte, F., van de Ville, D., Todder, D., Surmeli, T., Sulzer, J. S., Strehl, U., Sterman, M. B., Steiner, N. J., Sorger, B., Soekadar, S. R., Sitaram, R., . . . Thibault, R. T. (2020). Consensus on the reporting and experimental design of clinical and cognitive-behavioural neurofeedback studies (CRED-nf checklist). *Brain: A Journal of Neurology*, 143(6), 1674–1685. <https://doi.org/10.1093/brain/awaa009>
- Rose, D., Buckwalter, W., & Nichols, S. (2017). Neuroscientific Prediction and the Intrusion of Intuitive Metaphysics. *Cognitive Science*, 41(2), 482–502. <https://doi.org/10.1111/cogs.12310>

- Schabus, M., Griessenberger, H., Gnjezda, M.-T., Heib, D. P. J., Wislowska, M., & Hoedlmoser, K. (2017). Better than sham? A double-blind placebo-controlled neurofeedback study in primary insomnia. *Brain: A Journal of Neurology*, 140(4), 1041–1052. <https://doi.org/10.1093/brain/awx011>
- Schauer, F. (2020). Freedom of Thought? *Social Philosophy and Policy*, 37(2), 72–89. <https://doi.org/10.1017/S0265052521000054>
- Scherke, K. (2024). *Emotionssoziologie. Einsichten Themen der Soziologie: Vol. 6049*. transcript Verlag.
- Schlosser, M. (2024). Agency. In E. N. Zalta, U. Nodelman, C. Allen, Kim Hannah, & P. Oppenheimer (Eds.), *The Stanford Encyclopedia of Philosophy* (Winter 2019). <https://plato.stanford.edu/archives/win2019/entries/agency/>
- Schmidhuber, M. (2020). *Ein gutes Leben für Menschen mit Demenz: Ethische Herausforderungen in Betreuung und Pflege. Ethik der Lebenswelten: Band 6*. LIT.
- Schöne-Seifert, B. (2007). *Grundlagen der Medizinethik*. Alfred Kroner Verlag. <http://gbv.ebib.com/patron/FullRecord.aspx?p=4341681>
- Selwyn, N. (2022). The future of AI and education: Some cautionary notes. *European Journal of Education*, 57(4), 620–631. <https://doi.org/10.1111/ejed.12532>
- Shaheed, A. (2021, October 5). *Freedom of thought: Interim report of the Special Rapporteur on freedom of religion or belief* (A/76/380). <https://documents.un.org/doc/undoc/gen/n21/274/90/pdf/n2127490.pdf?token=CeR9BnOALayfZJBp3f&fe=true>
- Sharon, T., & Gellert, R. (2023). Regulating Big Tech expansionism? Sphere transgressions and the limits of Europe's digital regulatory strategy. *Information, Communication & Society*, 1–18. <https://doi.org/10.1080/1369118X.2023.2246526>
- Shew, A. (2020). Ableism, Technoableism, and Future AI. *IEEE Technology and Society Magazine*, 39(1), 40–85. <https://doi.org/10.1109/MTS.2020.2967492>
- Spanish presidency. (2023). *León Declaration*. <https://spanish-presidency.consilium.europa.eu/media/o4rh53jr/le%C3%B3n-declaration.pdf>
- Spector, M., & Kitsuse, J. I. (2001). *Constructing social problems*. Transaction Publishers.
- Steindl, E. (2024). Consumer neuro devices within EU product safety law: Are we prepared for big tech ante portas? *Computer Law & Security Review*, 52, 105945. <https://doi.org/10.1016/j.clsr.2024.105945>
- Sturm, W., Willmes, K., Orgass, B., & Hartje, W. (1997). Do Specific Attention Deficits Need Specific Training? *Neuropsychological Rehabilitation*, 7(2), 81–103. <https://doi.org/10.1080/713755526>
- Suchman, L. (2023). The uncontroversial 'thingness' of AI. *Big Data & Society*, 10(2), 1-5. <https://doi.org/10.1177/20539517231206794>
- Susser, D., & Cabrera, L. Y. (2023). Brain Data in Context: Are New Rights the Way to Mental and Brain Privacy? *AJOB Neuroscience*, 1–12. <https://doi.org/10.1080/21507740.2023.2188275>
- Suthana, N., & Fried, I. (2014). Deep brain stimulation for enhancement of learning and memory. *NeuroImage*, 85 Pt 3(0 3), 996–1002. <https://doi.org/10.1016/j.neuroimage.2013.07.066>
- Taylor, L., Martin, A., Souza, S. P. de, & Lopez-Solano, J. (2023). Why are sector transgressions so hard to govern? Reflections from Europe's pandemic experience. *Information, Communication & Society*, 1–5. <https://doi.org/10.1080/1369118X.2023.2264919>
- Tesink, V., Douglas, T., Forsberg, L., Ligthart, S., & Meynen, G. (2024). Right to mental integrity and neurotechnologies: Implications of the extended mind thesis. *Journal of Medical Ethics*, 1–8. <https://doi.org/10.1136/jme-2023-109645>
- Thibault, R. T., Lifshitz, M., & Raz, A. (2017). Neurofeedback or neuroplacebo? *Brain: A Journal of Neurology*, 140(4), 862–864. <https://doi.org/10.1093/brain/awx033>
- Thibault, R. T., Lifshitz, M., & Raz, A. (2018). The climate of neurofeedback: Scientific rigour and the perils of ideology. *Brain: A Journal of Neurology*, 141(2), e11. <https://doi.org/10.1093/brain/awx330>
- Thibault, R. T., & Raz, A. (2017). The psychology of neurofeedback: Clinical intervention even if applied placebo. *The American Psychologist*, 72(7), 679–688. <https://doi.org/10.1037/amp000118>
- Thompson, M. C. (2019). Critiquing the Concept of BCI Illiteracy. *Science and Engineering Ethics*, 25(4), 1217–1233. <https://doi.org/10.1007/s11948-018-0061-1>

- Tirabeni, L. (2023). Bounded Well-Being: Designing Technologies for Workers' Well-Being in Corporate Programmes. *Work, Employment and Society*, Article 09500170231203113. Advance online publication. <https://doi.org/10.1177/09500170231203113>
- Treaty of Lisbon Amending the treaty on European Union and the treaty establishing the European community.
- Treaty on European Union.
- Treaty on the Functioning of the European Union.
- UNESCO. (2023). *The Risks and Challenges of Neurotechnologies for Human Rights*. <https://unesdoc.unesco.org/ark:/48223/pf0000384185.locale=en>
- Constitution of the United Nations Educational, Scientific and Cultural Organization.
- van Elk, M. (2019). Socio-cognitive biases are associated to belief in neuromyths and cognitive enhancement: A pre-registered study. *Personality and Individual Differences*, 147, 28–32. <https://doi.org/10.1016/j.paid.2019.04.014>
- Vester, H.-G. (2009). *Kompendium der Soziologie* (1. Aufl.). *Lehrbuch*. VS Verl. für Sozialwiss. <https://doi.org/10.1007/978-3-531-91345-2>
- Vogt, M. (2009). *Prinzip Nachhaltigkeit: Ein Entwurf aus theologisch-ethischer Perspektive*. Zugl.: Luzern, Univ., Habil.-Schr. *Hochschulschriften zur Nachhaltigkeit: Vol. 39*. oekom Verl.
- Warren, S., & Brandeis, L. (1890). The Right to Privacy. *Harvard Law Review*, 4(5), 193–220.
- Wexler, A., & Thibault, R. (2019). Mind-Reading or Misleading? Assessing Direct-to-Consumer Electroencephalography (EEG) Devices Marketed for Wellness and Their Ethical and Regulatory Implications. *Journal of Cognitive Enhancement*, 3(1), 131–137. <https://doi.org/10.1007/s41465-018-0091-2>
- Whitham, E. M., Pope, K. J., Fitzgibbon, S. P., Lewis, T., Clark, C. R., Loveless, S., Broberg, M., Wallace, A., DeLosAngeles, D., Lillie, P., Hardy, A., Fronsco, R., Pulbrook, A., & Willoughby, J. O. (2007). Scalp electrical recording during paralysis: Quantitative evidence that EEG frequencies above 20 Hz are contaminated by EMG. *Clinical Neurophysiology: Official Journal of the International Federation of Clinical Neurophysiology*, 118(8), 1877–1888. <https://doi.org/10.1016/j.clinph.2007.04.027>
- Willoweit, D. (2023). Die vielen Freiheiten, die eine Freiheit und das Recht. In N. J. Saam & H. Bielefeldt (Eds.), *Sozialtheorie. Die Idee der Freiheit und ihre Semantiken: Zum Spannungsverhältnis von Freiheit und Sicherheit* (pp. 161–167). transcript.
- Witte, M., Kober, S. E., & Wood, G. (2018). Noisy but not placebo: Defining metrics for effects of neurofeedback. *Brain: A Journal of Neurology*, 141(5), e40. <https://doi.org/10.1093/brain/awy060>
- Wong, J. K., Mayberg, H. S., Wang, D. D., Richardson, R. M., Halpern, C. H., Krinke, L., Arlotti, M., Rossi, L., Priori, A., Marceglia, S., Gilron, R., Cavanagh, J. F., Judy, J. W., Miocinovic, S., Devergnas, A. D., Sillitoe, R. V., Cerner, S., Oehr, C. R., Gunduz, A., . . . Okun, M. S. (2022). Proceedings of the 10<sup>th</sup> annual deep brain stimulation think tank: Advances in cutting edge technologies, artificial intelligence, neuromodulation, neuroethics, interventional psychiatry, and women in neuromodulation. *Frontiers in Human Neuroscience*, 16, 1084782. <https://doi.org/10.3389/fnhum.2022.1084782>
- Wood, G., Willmes, K., Kober, S. E., & Kober, S. E. (2024). Fat tails and the need to disclose distribution parameters of qEEG databases. *PLoS One*, 19(1), e0295411. <https://doi.org/10.1371/journal.pone.0295411>
- Yadav, D., Yadav, S., & Veer, K. (2020). A comprehensive assessment of Brain Computer Interfaces: Recent trends and challenges. *Journal of Neuroscience Methods*, 346, 108918. <https://doi.org/10.1016/j.jneumeth.2020.108918>
- Yuste, R. (2017). Four ethical priorities for neurotechnologies and AI(551), 159–163. <https://doi.org/10.1109/ECMR.2017.8098658>
- Yuste, R. (2023). Advocating for neurodata privacy and neurotechnology regulation. *Nature Protocols*, 18(10), 2869–2875. <https://doi.org/10.1038/s41596-023-00873-0>
- Yuste, R., Genser, J., & Herrmann, S. (2021). It's Time for Neuro-Rights. *Horizons*(18), 154–164.

Yuste, R., & Quadra-Salcedo, T. de la (2023). Neuro-Rights and New Charts of Digital Rights: A Dialogue Beyond the Limits of the Law. *Indiana Journal of Global Legal Studies*, 30(1), 15–37.

<https://doi.org/10.2979/gls.2023.a886161>

Zarzycki, M. Z., & Domitrz, I. (2020). Stimulation-induced side effects after deep brain stimulation - a systematic review. *Acta Neuropsychiatrica*, 32(2), 57–64. <https://doi.org/10.1017/neu.2019.35>

## Annexes

Table 2 – Products mentioned

Brand/Name	Affordance	Domain of application
Nissan Brain to Vehicle <sup>76</sup>	Detecting Brain Signals to trigger movement of drivers' hands or feet.	Work
Emotiv <sup>77</sup>	Different EEG-based headsets and earplugs	Work
Versus <sup>78</sup>	Headset that facilitates brain sensing and assessment	Work
Nival Inmind	Virtual Reality-enabled neuroscience assessment	Education
Muse <sup>79</sup>	EEG-headset that supports students with ADHD to support their learning needs	Education, Work
Prototype called Group-a-Ware	Ability to measure student group's cognitive load and emotional state overall with the help of neuroheadsets	Education
IBM Cognitive Learning System <sup>80</sup>	Learning platform that may facilitate neurotechnologies	Education
BrainCo <sup>81</sup>	EEG-based (non-invasive) brain training technology	Education
Century.tech	Neuroscience-enabled learning platform	Education
FociAI <sup>82</sup>	Emotion Sensing Wearable	Education
NeuroSky <sup>83</sup>	EEG and ECG based biosensor	Entertainment

In the table above we list some of the products that were specifically mentioned in the literature. These are all consumer-available products and non-invasive.

<sup>76</sup> <https://www.nissan-global.com/EN/INNOVATION/TECHNOLOGY/ARCHIVE/B2V/>

<sup>77</sup> [https://www.emotiv.com/?campaignid=17057185126&adgroupid=138768698289&network=g&device=c&utm\\_term=emotiv&utm\\_source=google&utm\\_medium=ppc&utm\\_content=644974459432&utm\\_campaign=Brand&hsrc=5401365090&hsacam=17057185126&hsagr=138768698289&hsaad=644974459432&hsasrc=q&hsatgt=kwd-315386528571&hsakw=emotiv&hsamt=p&hsanet=adwords&hsaver=3&qadsource=1&qclid=Cj0KCQjwncWvBhDARIsAEb2HW-7Plx2d5bTvm3L382Wzm-9Mimt6UqcW8Ln\\_ceFlzCst6Grcpyji5QaAgurEALw\\_wcB](https://www.emotiv.com/?campaignid=17057185126&adgroupid=138768698289&network=g&device=c&utm_term=emotiv&utm_source=google&utm_medium=ppc&utm_content=644974459432&utm_campaign=Brand&hsrc=5401365090&hsacam=17057185126&hsagr=138768698289&hsaad=644974459432&hsasrc=q&hsatgt=kwd-315386528571&hsakw=emotiv&hsamt=p&hsanet=adwords&hsaver=3&qadsource=1&qclid=Cj0KCQjwncWvBhDARIsAEb2HW-7Plx2d5bTvm3L382Wzm-9Mimt6UqcW8Ln_ceFlzCst6Grcpyji5QaAgurEALw_wcB)

<sup>78</sup> <https://getversus.com/>

<sup>79</sup> <https://choosemuse.com/>

<sup>80</sup> <https://www.ibm.com/watson/advantage-reports/getting-started-cognitive-technology.html>

<sup>81</sup> <https://brainco.tech/>

<sup>82</sup> <https://fociai.com/en-at>

<sup>83</sup> <https://neurosky.com/>

Table 3 – Papers analysed: Education

Number	Paper
ED 1	Zohny, Hazem, David M. Lyreskog, Ilina Singh, und Julian Savulescu. „The Mystery of Mental Integrity: Clarifying Its Relevance to Neurotechnologies". <i>Neuroethics</i> 16, Nr. 3 (21. August 2023): 20. <a href="https://doi.org/10.1007/s12152-023-09525-2">https://doi.org/10.1007/s12152-023-09525-2</a> .
ED 2	Marope, P. T. M. „Brain Science, Education, and Learning: Making Connections". <i>PROSPECTS</i> 46, Nr. 2 (1. Juni 2016): 187–90. <a href="https://doi.org/10.1007/s11125-017-9400-2">https://doi.org/10.1007/s11125-017-9400-2</a> .
ED 3	Williamson, Ben. „Brain Data: Scanning, Scraping and Sculpting the Plastic Learning Brain Through Neurotechnology". <i>Postdigital Science and Education</i> 1, Nr. 1 (1. April 2019): 65–86. <a href="https://doi.org/10.1007/s42438-018-0008-5">https://doi.org/10.1007/s42438-018-0008-5</a> .
ED 4	Unesco Policy Paper
ED 5	Tech Ethos
ED 6	Zambrano, Kleyner Cristóbal Demera, Liseth Stefanía López Vera, Merly Genoveva Zambrano-Romero, David Alejandro Navarrete Solórzano, Nubia Stefanía Quijije Troya, und María Rodríguez Gámez. „Educational Neurotechnology in Attention to the Specific Needs of Higher Basic General Education Student". <i>PalArch's Journal of Archaeology of Egypt / Egyptology</i> 18, Nr. 10 (1. September 2021): 943–57.
ED 7	Williamson, Ben, Jessica Pykett, und Selena Nemorin. „Biosocial spaces and neurocomputational governance: brain-based and brain-targeted technologies in education". <i>Discourse: Studies in the Cultural Politics of Education</i> 39, Nr. 2 (4. März 2018): 258–75. <a href="https://doi.org/10.1080/01596306.2018.1394421">https://doi.org/10.1080/01596306.2018.1394421</a> .
ED 8	Taherisadr, Mojtaba, Berken Utku Demirel, Mohammad Abdullah Al Faruque, und Salma Elmalaki. „Future of Smart Classroom in the Era of Wearable Neurotechnology". <i>arXiv</i> , 21. Oktober 2021. <a href="https://doi.org/10.48550/arXiv.2110.11475">https://doi.org/10.48550/arXiv.2110.11475</a> .
ED 9	Schmied, A., S. Varma, und J. M. Dubinsky. „Acceptability of Neuroscientific Interventions in Education". <i>Science and Engineering Ethics</i> 27, Nr. 4 (5. August 2021): 52. <a href="https://doi.org/10.1007/s11948-021-00328-3">https://doi.org/10.1007/s11948-021-00328-3</a> .
ED 10	Privitera, Adam John, und Hao Du. „Educational neurotechnology: Where do we go from here?" <i>Trends in Neuroscience and Education</i> 29 (1. Dezember 2022): 100195. <a href="https://doi.org/10.1016/j.tine.2022.100195">https://doi.org/10.1016/j.tine.2022.100195</a> .
ED 11	Nefedchenko, Vasyl, Emiliia Ostapenko, Yevhen Bokhonko, Roman Gurevych, Liudmyla Shanaieva-Tsymbal, und Olha Rud. „Features of Information and Communication Technologies in the Educational Process: Neuroscience in Education". <i>BRAIN. Broad Research in Artificial Intelligence and Neuroscience</i> 14, Nr. 4 (19. Dezember 2023): 292–307.
ED 12	Maria Sinaci und Gabriel Hasmağuchi. „Education, Neurotechnologies, and Ethics. An Overview". <i>Eon</i> 4, Nr. 1 (6. Juni 2023): 161-176..
ED 13	Vidal, Catherine. „Neurotechnologies under the Eye of Bioethics". <i>eNeuro</i> 9, Nr. 3 (1. Mai 2022). <a href="https://doi.org/10.1523/ENEURO.0072-22.2022">https://doi.org/10.1523/ENEURO.0072-22.2022</a> .
ED 14	Llamas Salguero, Fátima, Pilar Martín Lobo, Silvia Pradas Montilla, und Marta Gil Nájera. „Study of the Attitude of Students towards New Technological Contexts and Neuroscience Progress". <i>Ingeniería Solidaria</i> 13, Nr. 21 (1. Januar 2017): 27–36. <a href="https://doi.org/10.16925/in.v13i21.1725">https://doi.org/10.16925/in.v13i21.1725</a> .
ED 15	Lalancette, Helene, und Stephen R. Campbell. „Educational Neuroscience: Neuroethical Considerations". <i>International Journal of Environmental and Science Education</i> 7, Nr. 1 (Januar 2012): 37–52.
ED 16	Díaz, Hernán, Lucio Cañete, Cristián Costa, und Fredi Palominos. „NEUROTECHNOLOGIES FOR EDUCATION IMPROVEMENT: SELF-KNOWLEDGE AFTER OPENING THE BLACK BOX". <i>Journal Plus Education</i> , Nr. 2 (o. J.).
ED 17	Alipour, Javad, und Hatef Pourrashidi. „A Critical Study on the Researches about the Application of Neurotechnology in Education". <i>International Journal of Neuroscience</i> 0, Nr. ja (2024): 1–12. <a href="https://doi.org/10.1080/00207454.2024.2311231">https://doi.org/10.1080/00207454.2024.2311231</a> .

Number	Paper
ED 18	Ababkova, M. Yu, N. N. Pokrovskaya, und I. R. Trostinskaya. „Neuro-Technologies For Knowledge Transfer And Experience Communication". European Proceedings of Social and Behavioural Sciences Research Paradigms Transformation in Social Sciences (19. Februar 2018). <a href="https://doi.org/10.15405/epsbs.2018.02.2">https://doi.org/10.15405/epsbs.2018.02.2</a> .
ED 19	Elmalaki, Salma, Berken Utku Demirel, Mojtaba Taherisadr, Sara Stern-Nezer, Jack J. Lin, und Mohammad Abdullah Al Faruque. „Towards Internet-of-Things for Wearable Neurotechnology". In 2021 22nd International Symposium on Quality Electronic Design (ISQED), 559–65, 2021. <a href="https://doi.org/10.1109/ISQED51717.2021.9424364">https://doi.org/10.1109/ISQED51717.2021.9424364</a> .

Table 4 – Papers analysed: Work

Number	Paper
W 1	Martinez, Wendy, Johann Benerradi, Serena Midha, Horia A. Maior, und Max L. Wilson. „Understanding the Ethical Concerns for Neurotechnology in the Future of Work". In Proceedings of the 1st Annual Meeting of the Symposium on Human-Computer Interaction for Work, 1–19. CHIWORK '22. New York, NY, USA: Association for Computing Machinery, 2022. <a href="https://doi.org/10.1145/3533406.3533423">https://doi.org/10.1145/3533406.3533423</a> .
W 2	Giattino, Charles M., Lydia Kwong, Chad Rafetto, und Nita A. Farahany. „The Seductive Allure of Artificial Intelligence-Powered Neurotechnology". In Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society, 397–402. AIES '19. New York, NY, USA: Association for Computing Machinery, 2019. <a href="https://doi.org/10.1145/3306618.3314269">https://doi.org/10.1145/3306618.3314269</a> .
W 3	Karwowski, Waldemar, Włodzimierz Siemionow, und Krystyna Gielo-Perczak. „Physical neuroergonomics: The human brain in control of physical work activities". Theoretical Issues in Ergonomics Science 4, Nr. 1–2 (1. Januar 2003): 175–99. <a href="https://doi.org/10.1080/1463922021000032339">https://doi.org/10.1080/1463922021000032339</a> .
W 4	Mathews, Debra, Amy Abernethy, Atul J. Butte, Juan Enriquez, Bob Kocher, Sarah H. Lisanby, Timothy M. Persons, u. a. „Neurotechnology and Noninvasive Neuromodulation: Case Study for Understanding and Anticipating Emerging Science and Technology". NAM Perspectives, 15. November 2023. <a href="https://doi.org/10.31478/202311c">https://doi.org/10.31478/202311c</a> .
W 5	Parasuraman, Raja. „Neuroergonomics: Research and practice". Theoretical Issues in Ergonomics Science 4, Nr. 1–2 (1. Januar 2003): 5–20. <a href="https://doi.org/10.1080/14639220210199753">https://doi.org/10.1080/14639220210199753</a> .
W 6	Mehta, Ranjana, und Raja Parasuraman. „Neuroergonomics: a review of applications to physical and cognitive work". Frontiers in Human Neuroscience 7 (2013). <a href="https://www.frontiersin.org/articles/10.3389/fnhum.2013.00889">https://www.frontiersin.org/articles/10.3389/fnhum.2013.00889</a> .
W 7	Parasuraman, Raja, und Matthew Rizzo. Neuroergonomics. Oxford University Press, 2006. <a href="https://doi.org/10.1093/acprof:oso/9780195177619.001.0001">https://doi.org/10.1093/acprof:oso/9780195177619.001.0001</a> .
W 8	Navarro, Marta Sosa, und Salvador Dura-Bernal. „Human Rights Systems of Protection from Neurotechnologies That Alter Brain Activity Neurotech: Neurotechnology and the Law". Drexel Law Review 15, Nr. 4 (2023): 893–942.
W 9	Zohny, Hazem, David M. Lyreskog, Ilina Singh, und Julian Savulescu. „The Mystery of Mental Integrity: Clarifying Its Relevance to Neurotechnologies". Neuroethics 16, Nr. 3 (21. August 2023): 20. <a href="https://doi.org/10.1007/s12152-023-09525-2">https://doi.org/10.1007/s12152-023-09525-2</a> .
W 10	"Khare, Smith K., Victoria Blanes-Vidal, Esmaeil S. Nadimi, und U. Rajendra Acharya. „Emotion recognition and artificial intelligence: A systematic review (2014–2023) and research recommendations". Information Fusion 102 (1. Februar 2024): 102019. <a href="https://doi.org/10.1016/j.inffus.2023.102019">https://doi.org/10.1016/j.inffus.2023.102019</a> .
W 11	Gramann, Klaus, Stephen H. Fairclough, Thorsten O. Zander, und Hasan Ayaz. „Editorial: Trends in Neuroergonomics". Frontiers in Human Neuroscience 11 (2017). <a href="https://www.frontiersin.org/articles/10.3389/fnhum.2017.00165">https://www.frontiersin.org/articles/10.3389/fnhum.2017.00165</a> .
W 12	Paek, Andrew Y., Justin A. Brantley, Barbara J. Evans, und Jose L. Contreras-Vidal. „Concerns in the Blurred Divisions Between Medical and Consumer Neurotechnology". IEEE Systems Journal 15, Nr. 2 (Juni 2021): 3069–80. <a href="https://doi.org/10.1109/JSYST.2020.3032609">https://doi.org/10.1109/JSYST.2020.3032609</a> .
W 13	Dehais, Frederic, Waldemar Karwowski, und Hasan Ayaz. „Brain at Work and in Everyday Life as the Next Frontier: Grand Field Challenges for Neuroergonomics". Frontiers in Neuroergonomics 1 (2020). <a href="https://www.frontiersin.org/articles/10.3389/fnrgo.2020.583733">https://www.frontiersin.org/articles/10.3389/fnrgo.2020.583733</a> .
W 14	Waas, Dr Bernd. „Artificial Intelligence and Labour Law", Nr. 17 (2022).
W 15	Ahmed, Aliyu Aminu, und Rukayya Aminu Muhammed. „Accessibility, Use and Effectiveness of Neurotechnology Devices for Improved Productivity in Workplace". International Journal of Scientific and Research Publications (IJSRP) 11, Nr. 10 (6. Oktober 2021): 15–22. <a href="https://doi.org/10.29322/IJSRP.11.10.2021.p11803">https://doi.org/10.29322/IJSRP.11.10.2021.p11803</a> .

Number	Paper
W 16	Dehais, Frédéric, Alex Lafont, Raphaëlle Roy, und Stephen Fairclough. „A Neuroergonomics Approach to Mental Workload, Engagement and Human Performance". <i>Frontiers in Neuroscience</i> 14 (2020). <a href="https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2020.00268">https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2020.00268</a> .
W 17	Hopkins, Patrick D., und Harvey L. Fiser. „,This Position Requires Some Alteration of Your Brain': On the Moral and Legal Issues of Using Neurotechnology to Modify Employees". <i>Journal of Business Ethics</i> 144, Nr. 4 (2017):783–97.
W 18	Alana M. Campbell, Matthew Mattoni, Mae Nicopolis Yefimov, Karthik Adapa, und Lukasz M. Mazur. „Improving Cognitive Workload in Radiation Therapists: A Pilot EEG Neurofeedback Study". <i>Frontiers in Psychology</i> , 3. Dezember 2020. <a href="https://doi.org/doi:10.3389/fpsyg.2020.571739">https://doi.org/doi:10.3389/fpsyg.2020.571739</a> .
W 19	Stefano, Valerio De. „Neuro-Surveillance and the Right to Be Human at Work". <i>OnLabor</i> , 15. Februar 2020. <a href="https://onlabor.org/neuro-surveillance-and-the-right-to-be-humans-at-work">https://onlabor.org/neuro-surveillance-and-the-right-to-be-humans-at-work</a> .
W 20	Gaudry, Kate S., Hasan Ayaz, Avery Bedows, Pablo Celnik, David Eagleman, Pulkit Grover, Judy Illies, u. a. „Projections and the Potential Societal Impact of the Future of Neurotechnologies". <i>Frontiers in Neuroscience</i> 15 (2021). <a href="https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2021.658930">https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2021.658930</a> .
W 21	Fontanillo Lopez, Cesar Augusto, Guangye Li, und Dingguo Zhang. „Beyond Technologies of Electroencephalography-Based Brain-Computer Interfaces: A Systematic Review From Commercial and Ethical Aspects". <i>Frontiers in Neuroscience</i> 14 (2020). <a href="https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2020.611130">https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2020.611130</a> .

Table 5 – Papers analysed: Entertainment

Number	Paper
E 1	Wang, Zhihua, Yang Yu, Ming Xu, Yadong Liu, Erwei Yin, und Zongtan Zhou. „Towards a Hybrid BCI Gaming Paradigm Based on Motor Imagery and SSVEP". <i>International Journal of Human-Computer Interaction</i> 35, Nr. 3 (7. Februar 2019): 197–205. <a href="https://doi.org/10.1080/10447318.2018.1445068">https://doi.org/10.1080/10447318.2018.1445068</a> .
E 2	Putri, Finda, Hao Ding, Abdullah Garcia, und Aleksandra Vuckovic. „Towards Successful Multi-User Brain-Computer Interface (BCI) Gaming: Analysis of the EEG Signatures and Connectivity": In <i>Proceedings of the 3rd International Conference on Computer-Human Interaction Research and Applications</i> , 59–65. Vienna, Austria: SCITEPRESS - Science and Technology Publications, 2019. <a href="https://doi.org/10.5220/0008201400590065">https://doi.org/10.5220/0008201400590065</a> .
E 3	Paek, Andrew Y., Justin A. Brantley, Barbara J. Evans, und Jose L. Contreras-Vidal. „Concerns in the Blurred Divisions Between Medical and Consumer Neurotechnology". <i>IEEE Systems Journal</i> 15, Nr. 2 (Juni 2021): 3069–80. <a href="https://doi.org/10.1109/JSYST.2020.3032609">https://doi.org/10.1109/JSYST.2020.3032609</a> .
E 4	Nukala, Vidya N, und William E Halal. „Emerging Neurotechnologies: Trends, Relevance and Prospects", 2010.
E 5	Nijholt, Anton. „BCI for Games: A 'State of the Art' Survey". In <i>Entertainment Computing - ICEC 2008</i> , herausgegeben von Scott M. Stevens und Shirley J. Saldamarco, 225–28. <i>Lecture Notes in Computer Science</i> . Berlin, Heidelberg: Springer, 2009. <a href="https://doi.org/10.1007/978-3-540-89222-9_29">https://doi.org/10.1007/978-3-540-89222-9_29</a> .
E 6	Marshall, David, Damien Coyle, Shane Wilson, und Michael Callaghan. „Games, Gameplay, and BCI: The State of the Art". <i>IEEE Transactions on Computational Intelligence and AI in Games</i> 5, Nr. 2 (Juni 2013): 82–99. <a href="https://doi.org/10.1109/TCIAIG.2013.2263555">https://doi.org/10.1109/TCIAIG.2013.2263555</a> .
E 7	Ienca, Marcello, und Roberto Andorno. „Towards new human rights in the age of neuroscience and neurotechnology". <i>Life Sciences, Society and Policy</i> 13, Nr. 1 (26. April 2017): 5. <a href="https://doi.org/10.1186/s40504-017-0050-1">https://doi.org/10.1186/s40504-017-0050-1</a> .
E 8	Fontanillo Lopez, Cesar Augusto, Guangye Li, und Dingguo Zhang. „Beyond Technologies of Electroencephalography-Based Brain-Computer Interfaces: A Systematic Review From Commercial and Ethical Aspects". <i>Frontiers in Neuroscience</i> 14 (2020). <a href="https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2020.611130">https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2020.611130</a> .
E 9	Bonaci, Tamara, Ryan Calo, und Howard Jay Chizeck. „App stores for the brain: Privacy & security in Brain-Computer Interfaces". In <i>2014 IEEE International Symposium on Ethics in Science, Technology and Engineering</i> , 1–7, 2014. <a href="https://doi.org/10.1109/ETHICS.2014.6893415">https://doi.org/10.1109/ETHICS.2014.6893415</a> .

Table 6 – Number of proposed neurorights

Year	Title	Authors	Number of proposed neurorights
2017	Towards new human rights in the age of neuroscience and neurotechnology (Ienca & Andorno, 2017)	Marcello Ienca, Roberto Andorno	4
2017	Four ethical priorities for neurotechnologies and AI (Yuste, 2017)	Rafael Yuste, Sara Goering, Blaise Agüera y Arcas, Guoqiang Bi, Jose M. Carmena, Adrian Carter, Joseph J. Fins, Phoebe Friesen, Jack Gallant, Jane E. Huggins, Judy Illes, Philipp Kellmeyer, Eran Klein, Adam Marblestone, Christine Mitchell, Erik Parens, Michelle Pham, Alan Rubel, Norihiro Sadato, Laura Specker Sullivan, Mina Teicher, David Wasserman, Anna Wexler, Meredith Whittaker, Jonathan Wolpaw	- Concerns
2021	Recommendations for Responsible Development and Application of Neurotechnologies (Goering et al., 2021)	Sara Goering, Eran Klein, Laura Specker Sullivan, Anna Wexler, Blaise Agüera y Arcas, Guoqiang Bi, Jose M. Carmena, Joseph J. Fins, Phoebe Friesen, Jack Gallant, Jane E. Huggins, Philipp Kellmeyer, Adam Marblestone, Christine Mitchell, Erik Parens, Michelle Pham, Alan Rubel, Norihiro Sadato, Mina Teicher, David Wasserman, Meredith Whittaker, Jonathan Wolpaw, Rafael Yuste	3
2021	It's time for neuro-rights. new human rights for the age of neurotechnology (Yuste et al., 2021)	Rafael Yuste, Jared Genser, Stephanie Herrmann	5
2022	International Human Rights Protection Gaps in the Age of Neurotechnology (Genser et al., 2022)	Jared Genser, Stephanie Herrmann, Rafael Yuste	5
2022	Chapter 13: Neuro Rights: A Human Rights Solution to Ethical Issues of Neurotechnologies (Baselga-Garriga et al., 2022)	Clara Baselga-Garriga, Paloma Rodriguez, Rafael Yuste	5
2022	Horizon Report for Law Society. Neurotechnology, law and the legal profession (McCay, 2022)	Allan McGay	5
2023	Neuro-Rights and New Charts of Digital Rights: A Dialogue Beyond the Limits of the Law (Yuste & Quadra-Salcedo, 2023)	Rafael Yuste, Tomas de la Quadra-Salcedo	4

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Year	Title	Authors	Number of proposed neurorights
2024	Safeguarding Brain Data: Assessing the Privacy Practices of Consumer Neurotechnology Companies (Genser et al., 2024, p. 14)	Jared Genser, Stephen Damianos, Rafael Yuste	5
2024	Homepage <sup>84</sup>	-	5

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<sup>84</sup> <https://neurorightsfoundation.org/mission>

Table 7 – Neurorights timeline

Towards new human rights in the age of neuroscience and neurotechnology (Ienca & Andorno, 2017)	Four ethical priorities for neurotechnologies and AI (Yuste, 2017) (Concerns)	Recommendations for Responsible Development and Application of Neurotechnologies (Goering et al., 2021)	It's time for neuro-rights, new human rights for the age of neurotechnology (Yuste et al., 2021)	International Human Rights Protection Gaps in the Age of Neurotechnology (Genser et al., 2022)	Chapter 13: Neuro Rights: A Human Rights Solution to Ethical Issues of Neurotechnologies (Baselga-Garriga et al., 2022)	Horizon Report for Law Society, Neurotechnology, law and the legal profession (McCay, 2022)	Neuro-Rights and New Charts of Digital Rights: A Dialogue Beyond the Limits of the Law (Yuste & Quadra-Salcedo, 2023)	Safeguarding Brain Data: Assessing the Privacy Practices of Consumer Neuroscience Companies (Genser et al., 2024)	Homepage (2024)
'Cognitive liberty'									
'The right to mental privacy'	'Privacy consent' and	'The right to mental privacy'	'The right to mental privacy, or the ability to keep thoughts protected against disclosure'	'The right to mental privacy'	'The right to mental privacy'	'The right to mental privacy'	'The right to mental privacy, or the ability to keep mental activity protected against disclosure'	'The right to mental privacy, or the ability to keep mental activity protected against disclosure'	'The right to mental privacy'
'The right to mental integrity'	'Agency identity' and	'The right to mental integrity'	'The right to identity, or the ability to control both one's physical and mental integrity'	'The right to mental identity or "sense of self"'	'The right to personal identity'	'The right to personal identity'	'The right to identity, or the ability to control one's mental integrity and sense of self'	'The right to identity, or the ability to control one's mental integrity and sense of self'	'The right to personal identity'
'The right to psychological continuity'		'The right to mental liberty'							
				'The right to mental agency or "free will"'	'The right to free will'	'The right to free will'	'The right to agency, or the freedom of thought and free will to choose one's own actions'	'The right to agency, or the freedom of thought and free will to choose one's own actions'	'The right to free will'
	'Augmentation'			'The right to fair access to mental agency or "free will"'	'The right to equal access to mental augmentation'	'The right to equal access to mental augmentation'	'The right to fair access to mental augmentation, or the ability to ensure that the benefits of improvements to sensory and mental capacity through neurotechnology are distributed justly in the population'	'The right to fair access to mental augmentation, or the ability to ensure that the benefits of improvements to sensory and mental capacity through neurotechnology are distributed justly in the population'	'The right to equal access to mental augmentation'
	'Bias'			'Protection from algorithmic bias'	'Protection from algorithmic bias'	'The right to protection from algorithmic bias, or the ability to ensure technologies do not insert prejudices'			'The right to protection from algorithmic bias'

Homepage (2024): <https://neurorightsfoundation.org/mission>

Table 8 – Original wording 'mental privacy'

Title (Year)	Neuroright-Headline	Description
Towards new human rights in the age of neuroscience and neurotechnology (Ienca & Andorno, 2017)	'The right to mental privacy'	'[...] Based on these specific challenges, we argue that current privacy and data protection rights are insufficient to cope with the emerging neurotechnological scenarios. Consequently, we suggest the formal recognition of a right to mental privacy, which aims to protect any bit or set of brain information about an individual recorded by a neurodevice and shared across the digital ecosystem. This right would protect brainwaves not only as data but also as data generators or sources of information. In addition, it would cover not only conscious brain data but also data that are not (or are only partly) under voluntary and conscious control. Finally, it guarantees the protection of brain information in absence of an external tool for identifying and filtering that information. In short, the right to brain privacy aims to protect people against illegitimate access to their brain information and to prevent the indiscriminate leakage of brain data across the infosphere. [...]' (Ienca & Andorno, 2017, p. 15)
Four ethical priorities for neurotechnologies and AI (Yuste, 2017)	'Privacy and consent'	'[...] We believe that citizens should have the ability — and right — to keep their neural data private (see also "Agency and identity"). [...] For all neural data, the ability to opt out of sharing should be the default choice, and assiduously protected. [...] A default of opting out would mean that neural data are treated in the same way that organs or tissues are in most countries. Individuals would need to explicitly opt in to share neural data from any device. This would involve a safe and secure process, including a consent procedure that clearly specifies who will use the data, for what purposes and for how long. Even with this approach, neural data from many willing sharers, combined with massive amounts of non-neural data — from Internet searches, fitness monitors and so on — could be used to draw 'good enough' conclusions about individuals who choose not to share. To limit this problem, we propose that the sale, commercial transfer and use of neural data be strictly regulated. Such regulations — which would also limit the possibility of people giving up their neural data or having neural activity written directly into their brains for financial reward — may be analogous to legislation that prohibits the sale of human organs, such as the 1984 US National Organ Transplant Act. Another safeguard is to restrict the centralized processing of neural data. We advocate that computational techniques, such as differential privacy or "federated learning", be deployed to protect user privacy

Title (Year)	Neuroright-Headline	Description
		(see "Protecting privacy"). The use of other technologies specifically designed to protect people's data would help, too. [...] Lastly, open-data formats and open-source code would allow for greater transparency about what stays private and what is transmitted.' (Yuste, 2017, pp. 161–162)
Recommendations for Responsible Development and Application of Neuro-technologies (Goering et al., 2021)	'The right to mental privacy'	'[...] Such rights would not mean that someone could act with impunity in defining their identity or exercising their agency but they would protect individuals from unwanted intrusion. Similarly, to preserve individual privacy and individual power to control access to their own intimate mental spaces, we recommend that all entities engaged in collection, analysis, use, and sharing of brain data recognize several baseline rights that individuals have with respect to their data. First, people have a strict right to not be compelled to have brain data or code written into them. Second, people have a strict right to not be compelled to give up brain data. Third, people have a right to the restriction of the commercial transfer and use of their brain data, such that commercial reading and writing of brain data is prohibited (regardless of consent status), depending on what information is contained in (or could be inferred from) that data. [...]' (Goering et al., 2021)
It's time for neuro-rights. new human rights for the age of neuro-technology (Yuste et al., 2021)	'The right to mental privacy, or the ability to keep thoughts protected against disclosure'	-
International Human Rights Protection Gaps in the Age of Neurotechnology (Genser et al., 2022)	'The right to mental privacy'	-
Chapter 13: Neuro Rights: A Human Rights Solution to Ethical Issues of Neuro-technologies (Baselga-Garriga et al., 2022)	'The right to mental privacy'	'[...] As discussed above, given the current socio-political climate, this NeuroRight is the most urgently threatened. Because surveillance tools are being legitimized in society as a means to provide broader health and safety, citizens in different contexts and democracies are becoming accustomed to sacrificing their right to privacy.' (Baselga-Garriga et al., 2022, p. 160)
Horizon Report for Law Society. Neurotechnology, law and the legal	'The right to mental privacy'	-

Title (Year)	Neuroright-Headline	Description
profession (McCay, 2022)		
Neuro-Rights and New Charts of Digital Rights: A Dialogue Beyond the Limits of the Law (Yuste & Quadra-Salcedo, 2023)	'The right to mental privacy'	'[...] the content of our mental activity should not be decoded without the consent of the person subject to these new technologies. This mental privacy includes both conscious thinking and the subconscious. Most brain activity is actually subconscious; we are not even aware of its existence, yet it determines our way of life and who we are. Despite its "hidden" nature, subconscious mental activity can be deciphered in the same way, given that it is generated by neurons.' (Yuste & Quadra-Salcedo, 2023, p. 23)
Safeguarding Brain Data: Assessing the Privacy Practices of Consumer Neurotechnology Companies (Genser et al., 2024)	'The right to mental privacy, or the ability to keep mental activity protected against disclosure,'	-
Homepage (2024)	'The right to mental privacy'	'Any NeuroData obtained from measuring neural activity should be kept private. If stored, there should be a right to have it deleted at the subject's request. The sale, commercial transfer, and use of neural data should be strictly regulated.' <sup>85</sup>

Table 9 – Original wording 'personal identity'

Title (Year)	Neuroright-Headline	Description
Towards new human rights in the age of neuroscience and neurotechnology (Ienca & Andorno, 2017)	'The right to mental integrity'	'[...] Mental integrity in this broader sense should not only guarantee the right of individuals with mental conditions to access mental health schemes and receive psychiatric treatment or support wherever needed. In addition to that, it should also guarantee the right of all individuals to protect their mental dimension from potential harm. This reconceptualized right should provide a specific normative protection from potential neurotechnology-enabled interventions involving the unauthorized alteration of a person's neural computation and potentially resulting in direct harm to the victim. For an action X, to qualify as a threat to mental integrity, it has to: (i) involve the direct access to and manipulation of neural signaling (ii) be unauthorized –i.e. must occur in absence of the informed consent of the signal generator, (iii) result

<sup>85</sup> <https://neurorightsfoundation.org/mission>

Title (Year)	Neuroright-Headline	Description
		in physical and/or psychological harm. [...] (Ienca & Andorno, 2017, p. 18)
Four ethical priorities for neurotechnologies and AI (Yuste, 2017)	'Agency and identity'	'[...] As neurotechnologies develop and corporations, governments and others start striving to endow people with new capabilities, individual identity (our bodily and mental integrity) and agency (our ability to choose our actions) must be protected as basic human rights. [...] Such declarations must also protect people's rights to be educated about the possible cognitive and emotional effects of neurotechnologies. [...]' (Yuste, 2017, p. 162)
Recommendations for Responsible Development and Application of Neurotechnologies (Goering et al., 2021)	'The right to mental integrity'	'[...] Such rights would not mean that someone could act with impunity in defining their identity or exercising their agency but they would protect individuals from unwanted intrusion. Similarly, to preserve individual privacy and individual power to control access to their own intimate mental spaces, we recommend that all entities engaged in collection, analysis, use, and sharing of brain data recognize several baseline rights that individuals have with respect to their data. First, people have a strict right to not be compelled to have brain data or code written into them. Second, people have a strict right to not be compelled to give up brain data. Third, people have a right to the restriction of the commercial transfer and use of their brain data, such that commercial reading and writing of brain data is prohibited (regardless of consent status), depending on what information is contained in (or could be inferred from) that data. [...]' (Goering et al., 2021)
It's time for neuro-rights. new human rights for the age of neurotechnology (Yuste et al., 2021)	'The right to identity, or the ability to control both one's physical and mental integrity'	-
International Human Rights Protection Gaps in the Age of Neurotechnology (Genser et al., 2022)	'The right to mental identity or "sense of self"'	-
Chapter 13: Neuro Rights: A Human Rights Solution to Ethical Issues of Neurotechnologies (Baselga-Garriga et al., 2022)	'The right to personal identity'	'[...] In the same way that one has the right to decide whether they wish to donate their organs, a person should be able to decide if they want their neural information to be accessed and shared. This would involve a process of informed consent. Additionally, the Morningside Group suggested strict regulations to limit the sale, use, and trading of neural data in order to avoid other routes of

Title (Year)	Neuroright-Headline	Description
		access to the information in an individual's neural activity.' (Baselga-Garriga et al., 2022, p. 159)
Horizon Report for Law Society. Neurotechnology, law and the legal profession (McCay, 2022)	'The right to personal identity'	-
Neuro-Rights and New Charts of Digital Rights: A Dialogue Beyond the Limits of the Law (Yuste & Quadra-Salcedo, 2023)	'The right to mental identity'	'[...] This possibility clashes with one of the most fundamental principles of social life: the need to establish protections that guarantee the preservation of this inner sanctum of identity that determines who we are. The right to mental identity is intertwined with the next right on the list.'(Yuste & Quadra-Salcedo, 2023, p. 23)
Safeguarding Brain Data: Assessing the Privacy Practices of Consumer Neurotechnology Companies (Genser et al., 2024)	'The right to identity, or the ability to control one's mental integrity and sense of self'	-
Homepage (2024)	'The right to personal identity'	'Boundaries must be developed to prohibit technology from disrupting the sense of self. When neurotechnology connects individuals with digital networks, it could blur the line between a person's consciousness and external technological inputs.' <sup>186</sup>

<sup>86</sup> <https://neurorightsfoundation.org/mission>

Table 10 – Original wording 'free will'

Title (Year)	Neuroright-Headline	Description
Towards new human rights in the age of neuroscience and neurotechnology (Ienca & Andorno, 2017)	'Cognitive liberty'	'[...] In addition, while we welcome the introduction of the right to cognitive liberty, we argue that this notion is not sufficient alone to cover the entire spectrum of ethical and legal implications associated with neurotechnology. Rather, the establishment of cognitive liberty as a human right should be coordinated with a simultaneous reconceptualization of existing rights or even the creation of other new neurospecific rights. These are the right to mental privacy, the right to mental integrity and the right to psychological continuity.' (Ienca & Andorno, 2017, p. 11)
Four ethical priorities for neurotechnologies and AI (Yuste, 2017)	-	
Recommendations for Responsible Development and Application of Neurotechnologies (Goering et al., 2021)	'The right to mental liberty'	'[...] Such rights would not mean that someone could act with impunity in defining their identity or exercising their agency but they would protect individuals from unwanted intrusion. Similarly, to preserve individual privacy and individual power to control access to their own intimate mental spaces, we recommend that all entities engaged in collection, analysis, use, and sharing of brain data recognize several baseline rights that individuals have with respect to their data. First, people have a strict right to not be compelled to have brain data or code written into them. Second, people have a strict right to not be compelled to give up brain data. Third, people have a right to the restriction of the commercial transfer and use of their brain data, such that commercial reading and writing of brain data is prohibited (regardless of consent status), depending on what information is contained in (or could be inferred from) that data. [...]' (Goering et al., 2021)
It's time for neuro-rights. new human rights for the age of neuro-technology (Yuste et al., 2021)	'The right to agency, or the freedom of thought and free will to choose one's own actions'	-
International Human Rights Protection Gaps in the Age of Neurotechnology (Genser et al., 2022)	'The right to mental agency or "free will"'	-
Chapter 13: Neuro Rights: A Human Rights Solution to Ethical Issues of Neurotechnologies	'The right to free will'	'The second NeuroRight protects individuals' free will by establishing that every person should have the right to make their own decisions without the manipulation of external neurotechnologies. [...]' (Baselga-Garriga et al., 2022, p. 160)

Title (Year)	Neuroright-Headline	Description
(Baselga-Garriga et al., 2022)		
Horizon Report for Law Society. Neurotechnology, law and the legal profession (McCay, 2022)	'The right to free will'	-
Neuro-Rights and New Charts of Digital Rights: A Dialogue Beyond the Limits of the Law (Yuste & Quadra-Salcedo, 2023)	'The right to agency or free will'	'The right to agency or free will: this means that human decisions belong squarely in our brains, and they should not be interfered with from the outside through the use of new technology. [...]'(Yuste & Quadra-Salcedo, 2023, pp. 23–24)
Safeguarding Brain Data: Assessing the Privacy Practices of Consumer Neurotechnology Companies (Genser et al., 2024)	'The right to agency, or the freedom of thought and free will to choose one's own actions'	-
Homepage (2024)	'The right to free will'	'Individuals should have ultimate control over their own decision making, without unknown manipulation from external neurotechnologies.' <sup>87</sup>

<sup>87</sup> <https://neurorightsfoundation.org/mission>

Table 11 – Original wording 'equal access to mental augmentation'

Title (Year)	NeuroRight-Headline	Description
Towards new human rights in the age of neuroscience and neuro-technology (Ienca & Andorno, 2017)	-	
Four ethical priorities for neurotechnologies and AI (Yuste, 2017)	'Augmentation'	'[...] But we urge that guidelines are established at both international and national levels to set limits on the augmenting neurotechnologies that can be implemented, and to define the contexts in which they can be used — as is happening for gene editing in humans. [...] In particular, we recommend that the use of neural technology for military purposes be stringently regulated. [...]' (Yuste, 2017, p. 162)
Recommendations for Responsible Development and Application of Neurotechnologies (Goering et al., 2021)	-	
It's time for neuro-rights. new human rights for the age of neurotechnology (Yuste et al., 2021)	'The right to fair access to mental augmentation, or the ability to ensure that the benefits of improvements to sensory and mental capacity through neurotechnology are distributed justly in the population'	-
International Human Rights Protection Gaps in the Age of Neurotechnology (Genser et al., 2022)	'The right to fair access to mental augmentation'	-
Chapter 13: Neuro Rights: A Human Rights Solution to Ethical Issues of Neurotechnologies (Baselga-Garriga et al., 2022)	'The right to equal access to mental augmentation'	'The fourth NeuroRight aims to provide everyone with equal access to mental augmentation. [...] The fourth NeuroRight is based on the concept of justice and states that there ought to be guidelines established at the international and national levels that regulate the development and application of mental-enhancement neurotechnologies.' (Baselga-Garriga et al., 2022, p. 160)

Title (Year)	Neuroright-Headline	Description
Horizon Report for Law Society. Neurotechnology, law and the legal profession (McCay, 2022)	'The right to equal access to mental augmentation'	-
Neuro-Rights and New Charts of Digital Rights: A Dialogue Beyond the Limits of the Law (Yuste & Quadra-Salcedo, 2023)	'A general right to equality and justice (in context in which mental augmentation is part of our lives)'	'[...] Technology has the potential to improve human capabilities, but it poses a great challenge to the value of equality. The implementation of this sort of technology could have the unintended consequence of fracturing society by creating two types of human beings: humans that are augmented and humans that have not been enhanced. There is a need to establish regulations that prevent the most pernicious effects of a phenomenon that is likely to occur in the next couple of decades. Access to mental augmentation should be regulated under the universal principle of justice.'(Yuste & Quadra-Salcedo, 2023, pp. 24–25)
Safeguarding Brain Data: Assessing the Privacy Practices of Consumer Neurotechnology Companies (Genser et al., 2024)	'The right to fair access to mental augmentation, or the ability to ensure that the benefits of improvements to sensory and mental capacity through neurotechnology are distributed justly in the population'	-
Homepage (2024)	'The right to equal access to mental augmentation'	'There should be established guidelines at both international and national levels regulating the use of mental enhancement neurotechnologies. These guidelines should be based on the principle of justice and guarantee equality of access.' <sup>88</sup>

<sup>88</sup> <https://neurorightsfoundation.org/mission>

Table 12 – Original wording 'protection from algorithmic bias'

Title (Year)	Neuroright-Headline	Description
Towards new human rights in the age of neuroscience and neurotechnology (Ienca & Andorno, 2017)	-	
Four ethical priorities for neurotechnologies and AI (Yuste, 2017)	'Bias'	'[...] We advocate that countermeasures to combat bias become the norm for machine learning. We also recommend that probable user groups (especially those who are already marginalized) have input into the design of algorithms and devices as another way to ensure that biases are addressed from the first stages of technology development.' (Yuste, 2017, p. 162)
Recommendations for Responsible Development and Application of Neurotechnologies (Goering et al., 2021)	-	
It's time for neuro-rights. new human rights for the age of neurotechnology (Yuste et al., 2021)	'The right to protection from algorithmic bias, or the ability to ensure that technologies do not insert prejudices'	-
International Human Rights Protection Gaps in the Age of Neurotechnology (Genser et al., 2022)	'Protection from algorithmic bias'	-
Chapter 13: Neuro Rights: A Human Rights Solution to Ethical Issues of Neurotechnologies (Baselga-Garriga et al., 2022)	'Protection from algorithmic bias'	'[...] In order to address this challenge, measures to combat bias should be taken, such as allowing user groups, especially those that are already subordinated, to add input into designed algorithms.' (Baselga-Garriga et al., 2022, p. 160)
Horizon Report for Law Society. Neurotechnology, law and the legal profession (McCay, 2022)	'The right to protection from algorithmic bias'	-

Title (Year)	Neuroright-Headline	Description
Neuro-Rights and New Charts of Digital Rights: A Dialogue Beyond the Limits of the Law (Yuste & Quadra-Salcedo, 2023)	-	
Safeguarding Brain Data: Assessing the Privacy Practices of Consumer Neurotechnology Companies (Genser et al., 2024)	'The right to protection from algorithmic bias, or the ability to ensure that technologies do not insert prejudices'	-
Homepage (2024)	'The right to protection from algorithmic bias'	'Countermeasures to combat bias should be the norm for algorithms in neurotechnology. Algorithm design should include input from user groups to foundationally address bias.' <sup>89</sup>

<sup>89</sup> <https://neurorightsfoundation.org/mission>

Table 13 – Original wording 'furtherneurorights'

Title (Year)	Neuroright-Headline	Description
Towards new human rights in the age of neuroscience and neurotechnology (Ienca & Andorno, 2017)	'The right to psychological continuity'	<p>'[...] In short, the right to psychological continuity ultimately tends to preserve personal identity and the coherence of the individual's behavior from unconsented modification by third parties. It protects the continuity across a person's habitual thoughts, preferences, and choices by protecting the underlying neural functioning. [...] The right to psychological continuity can be seen as a special neuro-focused instance of the right to identity. [...] What the right to psychological continuity aims to prevent is not the unrestricted access to brain information but the induced alteration of neural functioning.[...] In fact, while this family of rights protects the translation of mental states into action, psychological continuity guarantees protection at an antecedent level: at the level of raw neural functioning. [...]' (Ienca &amp; Andorno, 2017, pp. 21–22)</p>

Table 14 – Glossary of all used terms

Term	Definition
Agency	Agency can be understood as the ability of an individual to make and communicate choices, often through action The feeling of agency develops when the outcome of an action and initial intention match (Olsen et al., 2016)
Artificial Intelligence (AI)	At its simplest form, artificial intelligence is a field, which combines computer science and robust datasets, to enable problem-solving. It also encompasses sub-fields of machine learning and deep learning, which are frequently mentioned in conjunction with artificial intelligence. These disciplines are AI algorithms which seek to create expert systems which make predictions or classifications based on input data. <sup>90</sup>
Biohybrid	Combining biological and non-biological components e.g. when integrating synthetic material with human tissue in a prosthesis
Brain-Computer Interface (BCI)	Enables an interface between a computer/machine without using any peripheral nerves and is activated/controlled via 'mind-power'
BCI-Illiteracy	The inability to successfully use BCI/NF systems as a user
Brainjacking	Gaining unauthorised control of an electronic brain implant; hacking a BCI. <sup>91</sup>
Cybersickness	Sickness that emerges during the interaction with virtual environments. The symptoms are comparable to those emerging in motion sickness and include nausea, disorientation and oculomotor problems.
Deep Brain Stimulation (DBS)	High frequency electrical stimulation by means of electrodes implanted into the brain. As a surgical tool, DBS can directly measure pathological brain activity and can deliver adjustable stimulation for therapeutic effect in neurological and psychiatric disorders correlated with dysfunctional circuitry. <sup>92</sup>
Electrocorticography (ECoG)	Recording of electrical potentials directly from the cerebral cortex
Electroencephalography (EEG)	Measuring electrical current fluctuations of the cortex of the brain via electrodes placed on the scalp
Hybrid mind	Hybridization of the biological body and technology with respect to the mind (Soekadar et al., 2021); key elements are BCI systems
Hyperscanning	Synchronous and simultaneous brain measurements between two or more people
Identity	We define personal identity as the concept of self for an individual agent
Invasive	Physically entering the body (see ECoG)
Magnet-Resonance Imaging	Creating functional and structural images of the brain by measuring hydrogen atoms and neuronal blood oxygenation
Neuro-enchantment	Inherent persuasiveness of the term 'neuro'
Neuroenhancement/ Brain augmentation	Improvement of brain functioning of healthy people. Hereby, substances like caffeine are consumed, drugs, medication but also wearable neurotechnology devices.

<sup>90</sup> <https://www.ibm.com/topics/artificial-intelligence>

<sup>91</sup> <https://pubmed.ncbi.nlm.nih.gov/30595661/>

<sup>92</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6397644/>

Term	Definition
	'Augmentation of brain function' describes approaches from different disciplines, aimed at the improvement of brain performance in both healthy people and patients suffering from neurological disabilities
Neurofeedback (NF)	A form of biofeedback where users learn to alter their own brain activation via real-time feedback
Neuro-engineering/Neural engineering	The discipline of neural engineering uses engineering approaches to understand, repair, replace, enhance, or exploit the properties of neural systems, often accompanied by scientific research directed at the interface between living neural systems and non-living components. <sup>93</sup>
Neural Interface	Devices that enable direct communication with the nervous system by leveraging the electrical excitability of nervous tissues to stimulate and/or record neural activity. BCIs are one form of neural interface
Neurocrime	Computer-crime on neural devices <sup>94</sup>
Neurohacking	See Brainjacking
Neural modulation (medical context)	Influencing neural activity through specifically targeted stimulation (e.g. electrical, drugs) to modulate nervous tissue function
Neuroimaging methods	Methods to make brain activation visible, both indirectly or directly
Neuroprosthesis	Neuroprostheses are devices used to replace lost nervous system functioning
Near-infrared spectrum	Optical neuroimaging method; blood oxygenation is measured via near infrared light
Non invasive brain stimulation (NIBS)	Superficially stimulating the brain; see tES, tMS
Non-responder	BCI/NF users who are not able to influence their own brain-activation. Can be led back to brain morphological, psychological or technical reasons among others
Tele-rehabilitation	Rehabilitation under the usage of information and communication technology
Teleprogramming of DBS devices	Remotely change program settings of implanted DBS devices (Esper et al., 2022)
Transcranial electrical stimulation (tES)	Sending a weak electrical impulse to the brain (usually around 1-2mA) via on the scalp placed electrodes Electrical impulse can be: direct current (tDCS), alternating current (tACS) or random noise (tRNS)
Transcranial magnetic stimulation	Stimulating nerve cells using locally applied magnetic fields
Thought insertion	Implanting thoughts that are not one's own

<sup>93</sup> <https://iopscience.iop.org/article/10.1088/1741-2560/5/3/N01/pdf>

<sup>94</sup> <https://link.springer.com/article/10.1007/s10676-016-9398-9>

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Advancements in (neuro)technological developments led to an increase in the usage and accessibility of neurotechnologies (NT). Brain activity can hereby be recorded, analysed, and manipulated by neurotechnological devices. While they were originally used in a mere clinical domain, they are becoming more and more attractive for healthy populations willing to enhance cognitive or physical abilities. Consumer-grade devices can be acquired and used by lay persons without supervision in work, education, and entertainment sets. This state-of-affairs leads to a multitude of open questions and possible threats to data security, privacy, neuropsychological, ethical, and societal implications. As a result, the Neurorights Foundation (NRF) was formed in 2017 to investigate and discuss those questions and make them visible to the public. In this report, we address their claims and suggestions and evaluate the need of their proposed neurorights. After disciplinary evaluations of those questions, we will provide recommendations and policy options.

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