GENEVA ACADEMY
Académie de droit international humanitaire et de droits humains
Academy of International Humanitarian Law and Human Rights

RESEARCH BRIEF

NEUROTECHNOLOGY AND HUMAN RIGHTS: AN AUDIT OF RISKS, REGULATORY CHALLENGES, AND OPPORTUNITIES

EXECUTIVE SUMMARY: MAPPING KEY RISKS TO HUMAN RIGHTS

Since 2023, the Geneva Academy of International Humanitarian Law and Human Rights has been leading research on the human rights implications (positive and negative) stemming from the development of neurotechnology for both therapeutic and commercial ends. A key finding is that as corporate actors become the main producers and disseminators of neurotechnology, managing risks will require multilateral cooperation towards the development of a common regulatory framework. A key challenge in this regard is the complex nature of neurotechnology coupled with the traditional 'siloing' between the human rights, neuroscience and corporate communities of practice. Against this backdrop, this paper showcases the findings of a human rights 'audit' examining the areas where emerging neurotechnology may create externalities from a human rights perspective, and how these might be dealt with from a regulatory perspective.

Part 1 discusses six areas of human rights considered to be most at risk from advancements in neurotechnology: protection against discrimination, freedom of thought, protection of privacy, rights in the criminal justice system, protection of mental and bodily integrity and workplace rights. For each of these, the discussion sets out (i) the relevant human rights law, (ii) how neurotechnology might impact those rights, (iii) the main risks and (iv) the actions states might consider to strengthen human rights protection.

Some important caveats should be highlighted. First, the risks articulated are not exhaustive; indeed, as the technology develops new scope for rights violations will arise. At the same time, the risks listed are not equal in likelihood. Many of the neurotechnological applications discussed have only been trialled in clinical research settings, they vary widely in terms of efficacy and complex impediments need to be overcome before they are market-ready. The analysis should thus be read *jointly* with Figure 1, which presents risks grouped according to their (i) gravity and (ii) technological probability.

Second, neurotechnology impacts human rights in multidimensional ways, resulting in some necessary repetition and overlap. For example, non-consensual neural monitoring and decoding in a criminal justice context might violate due process rights, as well as rights to privacy *and* be considered a form of inhuman and degrading

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treatment. Conversely, some important areas of rights are mainstreamed throughout the text as opposed to being dealt with separately; the impacts of neurotechnology on the rights of children and persons with disabilities, for example, are integrated across several different sections.

Third, the advent of neurotechnology may result in externalities that, while causing harm, do not amount to human rights violations and are therefore not discussed. Examples include increased inequality between states and heightened risk of conflict, diminished social cohesion and job losses and human redundancy. Moreover, even where neurotechnology is applied in a manner that protects human rights, many ethical questions remain. These include promoting 'ableism', unwarranted interference in the human condition and progress towards a world where neuroenhancement is normalized, expected or even required.

Part 2 tackles the question of how to establish implementable and comprehensive legal standards to mitigate the risks posed by neurotechnology. It explains that while the most effective means of individual rights protection is enforceable domestic legislation, how to get there is technically and politically complex. States are neither well positioned nor incentivized to lead such a process, and the alternate option – crafting international obligations that would then 'trickle down' to states – is unlikely to garner the requisite political will. Against these challenges, it is posited that the most viable solution could be the development of a non-binding 'soft-law' document on neurotechnology. This could shape the substance of existing rights, serve as a normative baseline to guide states in their policy and law-making and promote coordination in policy response.

Drawing from this analysis, Parts 3 and 4 set out key principles that might be considered when developing and retailing neurotechnology, and recommendations for legislative and regulatory reform. Finally, to assist readers who do not have a background in neuroscience, Annex 1 sets out the four prominent applications of neurotechnology covered in this paper, including a plain-language explanation of how they work, what is (and is not) 'consumer-ready' and what might (and might not) happen in the future.

1. HUMAN RIGHTS MOST AT RISK

A. PROTECTION AGAINST DISCRIMINATION

Key legal protections

Article 2 UDHR and Article 26 ICCPR protect all individuals from discrimination, including on the grounds of race, colour, sex, language, religion, political or other opinion, national or social origin, property, birth or other status. The CEDAW and CERD provide specific protections to women and girls, and against racial discrimination respectively.[1]

How neurotechnology innovations might impact human rights

In clinical and research settings, technologies such as functional magnetic resonance imaging (fMRI) have enabled scientists to identify neural patterns that correlate with (mental) health impairments, cognitive performance or specific mental states, such as inner speech, emotions and motor intentions. From this, scientists have been able to develop neural decoding methods that allow semantic content (i.e. inner speech or thoughts) to be translated into text or commands on the basis of brain information, with a high degree of speed and accuracy. Also possible is the identification of preferences (e.g. sexual identity or religiosity); mental health conditions (e.g. depression); future health status (e.g. a predisposition to dementia) and neural proficiencies (e.g. processing speed).

While it is unlikely that technology that can decode complex mental information will be integrated into non-invasive/commercial devices in the near future (if at all), a product that could associate an individual with specific mental states or traits is foreseeable, creating a risk of them being identified/targeted/exploited in a discriminatory manner. A more extant concern is perhaps how neural data might be used as a tool in human selection processes. Indeed, information on an individual's behavioural proclivities, cognitive ability, mental health or disease predisposition is extremely valuable to employers and insurance agencies. While basing decisions on such characteristics is unlikely to violate discrimination protections, negative externalities may still result; for example, individuals with mental health disorders being less able to access employment and healthcare leading to their further marginalization. Moreover, if an individual's ability to access opportunities and advance professionally becomes more tied to neural evidence than actual performance, additional questions around workers' rights are raised (see Section 1F below).

Another form of discrimination that may occur is discrimination on the basis of enhancement status. While this would not violate existing discrimination provisions – as enhancement status is not a protected ground – it may produce a new divide within society (an 'enhancement divide') that could reinforce existing inequalities such as health inequality and socio-economic disparities.

Advancements and innovations in neurotechnology also carry the risk of producing externalities that undermine equality and social justice – values deeply embedded in the human rights principles of non-discrimination and equality. For example, the use of unrepresentative datasets in the development of algorithms for neurotechnologies can perpetuate algorithmic bias. Such biases may lead to the suboptimal functioning of neurotechnological applications for under-represented groups, including women, older adults and individuals with (neurological) disabilities, further marginalizing these populations.[2] Additionally, socio-economic disparities and other structural inequalities can exacerbate unequal access to neurotechnologies, whether in healthcare settings or commercial applications. This inequity risks entrenching and amplifying existing societal divides, as only privileged groups may benefit fully from these innovations, leaving vulnerable populations behind. Such disparities threaten to widen the gap in health outcomes, economic opportunities and overall quality of life, reinforcing systemic inequities.

Key risks

- Neurotechnology generates neural data from which information on an individual's health and health dispositions, cognitive traits and proficiency, behavioural proclivities or mental states can be deduced, creating opportunities for discrimination on the basis of these personal characteristics, particularly in contexts such as education, employment or insurance provision
- Individuals are discriminated against on the basis of their cognitive augmentation (or non-augmentation) status
- Algorithmic bias impairs the performance of neurotechnology for groups that are underrepresented in neurodata sets, such as racial minorities, women, youth and older persons
- Neural data is used to facilitate educational or vocational 'streaming', resulting in unequal access to education and livelihoods and/or reduced vocational autonomy
- Unequal access to neurotechnology (particularly enhancement technology) exacerbates societal inequalities around health and employment and/or results in new forms of inequality (i.e 'super-classes' or 'super-states')

States might consider/evaluate:

- Strengthening regulation to prohibit neural data being used to profile individuals based on protected characteristics such as opinion, religion, sexual identity or political affiliation
- Providing an enabling environment for the collection of extensive, accurate and representative data on brain functioning to underpin the development of new neurotechnology applications and their future optimization
- Strengthening regulation to prevent employers and insurers from discriminating on the basis of cognitive characteristics, dispositions or proclivities that an individual is predisposed to but has not acted upon
- Crafting policy to ensure equal access to neurotechnology with a view to avoiding deepened inequality, including in specific areas such as access to healthcare and employment

B. FREEDOM OF THOUGHT

Key legal protections

Article 18 UDHR and Article 18 ICCPR protect an individual's freedom of thought, conscience and religion. Freedom of thought, together with freedom of opinion and expression (Article 19 UDHR and Article 19 ICCPR), are often considered interdependent rights, protecting both an internal sphere of thought and opinion as well as the freedom to express these thoughts and opinions. The former internal dimension is protected without exception (absolute protection), whereas the latter can be subject to limitations.

How neurotechnology innovations might impact human rights

Within the human rights discourse, freedom of thought has generally concerned an individual's right to not have their thoughts revealed against their will; not be subjected to impermissible alterations of thought; not be punished for thoughts and to express those thoughts by, for example, engaging in (collective) behaviours – including speech – that correlate with or are connected to such thoughts (e.g. praying).

The advent of neurotechnologies that can decode and influence mental states (albeit in a limited, rudimentary manner) has provoked debate on whether these mental interferences violate the freedom of thought. While it seems that neurotechnological interferences with the *forum internum* clearly interfere with the internal dimension of freedom of thought, lack of clarity around this freedom's scope and meaning generates several questions. Specifically, it is debated whether the freedom only protects 'thoughts' in a strict, narrow interpretation – i.e. only coherent thoughts with a certain level of importance such as political or religious thoughts – or whether it protects a broader range of mental states, as well as the mental processes (conscious and subconscious) that underlie thoughts and other mental states. While it remains a contested area of scholarship, acceptance of the latter, broader interpretation would prohibit the non-consensual use of neurotechnologies that interfere with mental states (e.g. emotions, memories, intentions), cognitive disposition (e.g. propensity for violence), mental processes (e.g. making calculations, judgements or decisions) and cognitive capacities (e.g. processing speed) by exposing or altering them.[3] Importantly, such protection would not be a panacea insofar as it would not prevent outcomes that – while compliant with international human rights law (IHRL) – are still socially harmful. Indeed, as data on thoughts, feelings and beliefs – even when consensually collected – become increasingly commodified, the risks of exploitation, theft and disruptive interference all increase. A key example is companies/political groups using information generated by neurotechnology applications (such as electroencephalogram – EEG – brain monitors) concerning consumers'/constituents' thoughts, preferences or cognitive capacities to strengthen marketing/engagement strategies. Provided that this is done with free and informed consent, the freedom of thought would not generally be violated. However, when such insights are combined with other information harvesting techniques (e.g. digital exhaust analysis to reveal a user's income, purchase histories, beliefs, relationship status, vulnerabilities etc.), the result could be a highly customized targeting strategy through which content, ideas or products could be pushed onto an individual.[4] Indeed, the UN Committee on the Rights of the Child pronounced that in the digital environment, emotional analytics might interfere with children's right to freedom of thought, conscience and religion, implying that children's emotions are protected under the right.

Key risks

- The monitoring of or probing for individuals' mental states such as thoughts, emotions and memories or cognitive capacities without their consent for reasons of exploitation, punishment or (commercial or political) persuasion
- The manipulation of thoughts and other mental states through non-consensual (malign) interference with neurostimulation devices
- Companies/political entities combining neuro-marketing research with other digital information harvesting to influence individuals' thoughts, beliefs or preferences in pursuit of their own goals (e.g. profit or political power)
- The imposition of pre-emptive (criminal) sanctions on the grounds of inferred thoughts, such as 'extremism' (to combat terrorism), political dissent (to protect national security) or sexual identity (to combat 'moral crimes')

States might consider/evaluate

- Defining and mandating protection against impermissible interferences, e.g. the punishment of thought, thought manipulation, non-consensual revealing of private thoughts etc.
- Technical guidance on the interpretation of, and how to instrumentalize, freedom of thought in the context of neurotechnology
- Mandating an authority to oversee the development, use and retailing of brain-computer interfaces (BCIs) or brain stimulation devices in compliance with freedom of thought
- Requiring that users of neurotechnology treatments/devices, whether therapeutic, consumer or in the workplace, are adequately educated on the scope of information that can (and will) be inferred from the data collected and provide their full and informed consent for the collection, processing, storage, repurposing or transfer of such data to third party actors

C. PROTECTION OF PRIVACY

Relevant law

Article 17 ICCPR protects against arbitrary or unlawful interference in an individual's privacy, family, home or correspondence, as well as unlawful attacks against honour and reputation. This right can be derogated from in limited circumstances, provided that the requirements of legality, proportionality and necessity are met.

How neurotechnology innovations might impact human rights

In IHRL discourse, privacy guarantees the rights of individuals to contemplate and exchange information and ideas, develop autonomously and engage in relationships, in a space that is free from intrusion, surveillance and the reach of the state and others.[5] The advent of neurotechnology challenges these rights, chiefly because of its scope for generating a vast amount of personal and sensitive data that is rich in information. Specifically, the collection and processing of neural data may lead to the identification of individuals, and the exposure of private information about them, potentially enabling inferences about a person's physical and mental health and health predispositions, cognitive abilities, personal characteristics (e.g. sexual orientation, aggressiveness) and mental states (e.g. thoughts, emotions, intentions or memories). As such, neurotechnologies may be deployed as a surveillance tool to monitor individuals' mental states, such as in work environments or criminal justice contexts.

Against this backdrop, for neurotechnology devices to be used in a manner that complies with privacy protections, the individuals concerned must provide their free and informed consent to the collection, processing and storage of neural data. Specifically, they need to understand the scope and granularity of the personal information that can be derived from the data they make available, how it might be used and who it might be shared with or sold to. This gives rise to several challenges. First, the rapidly advancing nature of neurotechnology means that individuals may not be aware of the depth and range of information that they give access to when consenting to share their neurodata. In other words, *what* an individual believes they have consented to vis-à-vis what can or is being deduced may become increasingly disconnected over time. A further issue is that the *complexity* of data processing involved may make it difficult to clearly describe the method and purpose of processing, and subsequently for users to understand what happens to their sensitive neurodata. As neurotechnology is integrated into commercial lifestyle and entertainment appliances (e.g. neurogaming devices), the scope for individuals to provide consent without a complete understanding of the consequences grows. Indeed, the evidence is that today's platform users are largely willing to accept personal data collection, either because they are unaware of the consequences, gauge such risks as low or lack the technical skills to manage platform privacy settings. A specific risk is children engaging with apps and software that procure neurodata, insofar that their age may not be apparent or can be easily masked. A final challenge is ensuring the free character of informed consent in cases where the deliverance of goods and services depends on access to neurodata, or when neurotechnology is being used in situations involving power asymmetries, such as in healthcare, schools, the workplace, detention settings or in criminal investigations.

Key risks

- Neurodata collected and processed by neurotechnologies becomes a new piece in the 'big data puzzle' that enables third-party actors (e.g. businesses) to make accurate inferences about individuals' mental states such as beliefs, preferences, or cognitive abilities
- The scientific complexity behind how neural data is collected, analyzed and used hampers free and informed consent. Alternatively, as the ability to glean insights from neurodata deepens,

the personal information that is harvested/released/sold becomes disconnected from what an individual believed they were consenting to

- Personal information gleaned from neurodata is released (i) accidentally or benignly resulting in privacy breaches, or (ii) deliberately, exposing sensitive insights around their thoughts, beliefs, emotions or cognitive proficiency, which could be leveraged to impose criminal sanctions, discriminate or manipulate
- Innovation in how neurodata is collected and its informational value leads to its 'commodification', creating incentives for hospitals, workplaces, schools or private hacker organizations to harvest neural data (consensually and non-consensually) for profit
- A popularization of consumer neurotech widens the scope for the collection of neurodata, especially in groups prone to adopting new technologies such as children
- Innovation creates scope for previously released anonymized brain data to be subsequently linked to the individual in question

States might consider/evaluate

- Establishing for which purposes the collection and decoding of neural data would be acceptable
- Crafting consent regulation that (i) requires comprehensive explanation of the purpose of neurodata collection and the (mental) privacy risks, using plain language, to overcome understanding deficits; (ii) deepens the protection afforded to vulnerable groups including in hospitals, detention etc.; (iii) gives individuals the right to revoke their consent including in cases where the insight that can be gleaned from neurodata increases, anonymity cannot be guaranteed etc.; (iv) fully and specifically lists the purposes for and ways in which neural data can be used (thus protecting individuals from future innovation leading to privacy breaches)
- When neural data is collected through online platforms (e.g. BCI-enabled neurogaming), crafting consent regulation that (i) allows users to restrict access to their data through easily navigable steps; (ii) contains specific safeguards to protect children who may be identified online, or who pose as adults
- Strengthening data protection laws that (i) regulate the processing, storage and use of neural data commensurate to its personal nature and magnitude of the attendant privacy risks; (ii) require that all entities storing neural data implement measures to prevent theft and 'leaks'; (iii) grow in scope as the value of neural data increases and the granularity of information that can be gleaned expands; (iv) specifically address the sale and repurposing of neural data held/stored
- Initiating discussions aimed at clarifying the ownership rights of individuals regarding their neural data and the circumstances in which such ownership might transfer to the owners of proprietary technology that is used to harvest, decode or derive information from that data

D. RIGHTS IN THE CRIMINAL JUSTICE SYSTEM

Key legal protections

Article 11 UDHR and Article 14 ICCPR protect the rights of individuals to a fair trial; Article 9 UDHR and Article 9 ICCPR protect against arbitrary arrest and imprisonment, to be recognized as a person before the law, to equal treatment and protection under the law and to a remedy.

How neurotechnology innovations might impact human rights

As brain decoding technology advances, the use of neuroimaging in law enforcement and criminal investigations might be anticipated as a tool to gather information from individuals implicated in crime or witnesses to crime. For instance, neural decoding might be used to detect 'guilty knowledge', such as a suspect's recognition of faces, objects or places relevant to a crime; an emotional state towards a victim or specific episodic memories of a crime. The forced use of neurotechnology for such ends, however, could violate not only the rights to privacy and the freedom of thought but also fair trial guarantees, including the protection against self-incrimination.[6] How different jurisdictions classify neural data – as physical evidence subject to the power of subpoena or as testimony – will be pivotal to answering such questions.

A further issue is whether, in the future, neural data might be used in sentencing to determine an individual's likelihood of re-offending (or other predictive risk assessment).[7] A major concern here is the impact of algorithmic biases that may have been entrenched in neural decoding algorithms. Even if such risks could be controlled, making decisions about an individual's liberty based on unexpressed thoughts or behavioural dispositions, as opposed to an individual's action/agency, may be deemed a fair trial violation or inhuman and degrading treatment.

A third issue concerns the potential future use of neuromodulation as a rehabilitation tool and/or condition of sentencing; for example, an order of neurostimulation to treat an aggression disorder. If used coercively, this would likely constitute inhuman treatment and/or an arbitrary interference in mental privacy (or even freedom of thought). Importantly, in each of these scenarios (investigations, sentencing and rehabilitation), even if the use of neurotechnology is consensual, the power asymmetries at play raise questions regarding the voluntary character of consent.[8]

Key risks

- The coercive use of neuroimaging to obtain evidence in the form of, e.g., witness statements
- The use of neurotechnology devices as a sentencing tool to predict the risk of reoffending, compliance with a court order or other predictive risk assessment
- The use of preventative or investigatory law enforcement based on the results of brain decoding (e.g. homicidal, criminal or violent intent) outside of a crime taking place, potentially resulting in the prosecution of 'thought crimes', especially in contexts of national security and counterterrorism
- The non-consensual use of neuromodulation technologies as a therapeutic tool in the rehabilitation trajectory of convicted persons
- The extension of rehabilitative neuromodulation to treat 'offences' around sexual identity, religion etc.

States might consider/evaluate

- Crafting regulation on whether, and with what safeguards, neurotechnology can be used as a tool in investigations, court proceedings and rehabilitation
- Clarifying the status of neuromodulated or augmented individuals under the law, including with respect to their legal standing, rights and responsibilities
- Clarifying what constitutes actus reus in the case of an individual using a neuro-prosthesis or BCI; specifically, whether the neurotechnology should be considered part of the individual or an external tool
- Clarifying the legal responsibilities of technology producers in situations where technical malfunction results in a crime being committed by a neuromodulated or augmented individual, or an individual using a neuro-prosthesis or BCI
- Clarifying how different forms of neural data should be classified from the perspective of evidence. Specifically, is neural data considered physical evidence that can be subpoenaed, e.g. from a platform owner/workplace, or can an individual deny access to brain data by invoking the right to protection against self-incrimination?

E. PROTECTION OF MENTAL AND BODILY INTEGRITY

Key legal protections

The ICCPR and UDHR protect bodily and mental integrity through different provisions, including the right to privacy (Article 17 ICCPR, Article 12 UDHR) and the prohibition of torture and cruel, inhuman or degrading treatment (Article 7 ICCPR, Article 5 UDHR). The latter offers absolute protection against severe interferences with bodily and mental integrity without exception, whereas the former offers relative protection. Moreover, the protections enshrined in the prohibition of torture and cruel, inhumane or degrading treatment are further elaborated in the CAT; the CRPD also specifically protects mental and physical integrity. Scholarly jurisprudence holds that a right to mental and physical integrity can also be found in Article 17 ICCPR (the right to privacy).

How neurotechnology innovations might impact human rights

The right to bodily integrity, as protected by the right to privacy, provides a right against interference with the body to which an individual does not consent. Being subjected to neurostimulation without consent, or even being subjected to neuroimaging techniques, constitute interference with bodily functions. Yet, as such interferences may be very minor – especially non-invasive neuro-imaging – they may be considered justifiable as they are proportionate in the light of the legitimate purpose pursued.

Vis-à-vis bodily integrity, the meaning and scope of mental integrity are less developed in the scholarship. Indeed, in its current interpretation, it is considered a right against interference with a person's private sphere that generates psychological distress or impairs mental health. If, however, an interpretation analogous to the more established right to bodily integrity emerges, this would expand the right to mental integrity into a safeguard protecting individuals against unsolicited interferences with their mental processes. This would likely include cognitive injury or harm resulting from the non-consensual application of a neurotechnology device or treatment; non-consensual interferences with neurotechnologies, e.g. the hacking of BCI devices; and possibly attendant externalities such as reduced cognitive autonomy, loss of personal identity, changes to cognitive traits etc.[9]

Some argue that the consequences of neurotechnology interventions are insufficiently understood, particularly the long-term side effects. This problematizes the ability of individuals to give consent, creating a risk that patients could be exposed to mental harms in violation of provisions around mental integrity (and even inhuman treatment).[10] Indeed, there is some evidence, albeit not exhaustive, of deep brain stimulation implants and closed-loop BCIs being associated with personality changes, weakened impulse control and self-estrangement.[11] As such treatments become more common, or highly experimental neuromodulation treatments such as optogenetics, memory modification or cognitive response adjustment are realized, these risks are likely to increase.[12]

A further (arguably more conceivable) scenario is if neurotechnology treatments become available to healthy individuals with a view to enhancement or augmentation, begging questions around how this might impact the right to integrity implied in Article 17 ICCPR. Such interventions might take place as a matter of public policy, e.g. to promote innovation, heighten productivity, bolster military prowess or hone specific cognitive capacities in professions that require high levels of alertness or responsivity such as pilots or surgeons. Another scenario is the increasing commercial availability of neurotechnology-enabled lifestyle and wellbeing devices, for example, tDCS and EEG headsets sold as tools to improve attention, cognition, learning and performance.[13] In both cases, efficacy and safety questions arise – some experts argue that manufacturers 'oversell' what these technologies are able to achieve, while others are concerned that the long-term side effects are not sufficiently understood. A further concern is that a popular uptake of devices with brain scanning and recording technology elevates risks around privacy encroachments (see Part 1.3) and exploitative misuse.

The prohibition of torture, cruel, inhuman and degrading treatment is generally understood as protecting bodily and mental integrity – yet the threshold for the severity of the interference with the body or mind is significantly higher than under the right to privacy (with the threshold for torture being higher than for other forms of ill-treatment). As such, provided that consent and safety requirements are upheld, medical applications of neurotechnology such as BCI and neural stimulation that modify brain activity, are unlikely to violate the prohibition of torture. This said, neurotechnologies developed and employed specifically to inflict severe (psychological or bodily) harm to individuals (for instance, in an interrogation context) may be considered violations. A connected risk is that therapeutic neurotechnology applications could be repurposed or misused to punish, coerce, placate or 'fix'/'re-educate' individuals. Such potential is highest in detention and medical settings where power asymmetries heighten vulnerability, and in criminal justice contexts where neurotechnology might be used as an investigatory, interrogation, risk assessment or rehabilitation tool.

Key risks

- Lack of certainty around the long-term mental impacts of neurotechnology complicates free and informed consent, especially in the case of vulnerable groups such as those in medical settings or detention
- Therapeutic and non-therapeutic applications of neurotechnology result in mental harm, such as mental health issues and distress, and disruptions in one's mental life, such as personality changes, weakened impulse control and self-estrangement
- Broad access to neuro-enhancement manifests in a new form of quasi-coercion to use neurotechnologies in different societal settings, undermining the free character of informed consent
- Corporate entities supplying/maintaining therapeutic neurotechnology cease to operate, resulting in a patient having no access to continuity in care or redress in the case of a malfunction
- Neurotechnologies are misused, for example in medical or detention contexts, to punish, coerce, placate or 'fix'/'re-educate' individuals
- In criminal justice contexts, neurotechnology is used as an investigatory or interrogation tool, a risk assessment tool or a rehabilitation tool in ways that amount to inhuman or degrading treatment
- States compel neuro-enhancement as a means of developing a more effective and efficient labour market or strengthened military force
- Weaponized forms of neurohacking to advance military objectives

States might consider/evaluate

- Strengthening regulation on the development, trial and approval of therapeutic treatments to ensure that risk assessment, safeguards etc. on mental and physical harm are accorded equivalent protection. Such regulation should take particular account that mental harm may not become perceivable in the short term and/or may not physically manifest.
- Promoting robust standards for free and informed consent that take into account (i) the potential for mental harm associated with neurotechnology therapeutic treatment, including over the longer term, and (ii) the vulnerability of persons in medical and detention contexts, and of persons with disabilities
- Ensuring that regulations dealing with torture and cruel, inhuman and degrading treatment clearly encompass existing and emerging violations of mental integrity that can stem from neurotechnology
- Prohibiting the use of neurotechnology treatment for 'correcting' cognitive or behavioural traits protected under anti-discrimination and other laws, such as sexual identity or religiosity
- Developing specific regulation on the use of neurotechnology treatment as a tool to placate or

coerce in situations of detention, criminal justice processes and health settings
- Including a clear definition of mental integrity in relevant legislation
- Developing safeguards for individuals who benefit from neurotechnology devices provided by private sector actors in the event that they close or change ownership
- Concerning consumer neurotechnology, crafting regulation to ensure full and transparent disclosure with respect to expected benefits and potential side effects, with specific protections for children and older persons
- Requiring that users of neurotechnology treatments/devices, whether therapeutic, consumer or in the workplace, are adequately educated on the risks and provide their full and informed consent

F. WORKPLACE RIGHTS

Key legal protections

Article 7 ICESCR recognizes the right to just and favourable conditions of work, including safe and healthy working conditions, promotion based on seniority and competence and equal remuneration for work of equal value.

How neurotechnology innovations might impact human rights

The advent of neurotechnology may change the workplace in complex and material ways. One possibility is EEG-enabled neural monitoring headsets, which would leverage readouts of an individual's brain activity to make automatic adjustments to workplace conditions such as music or temperature, or mandating a pause in activity ('neuro-breaks'). The goal would be to foster the conditions most conducive to concentration, innovation and problem-solving, thereby reducing workplace accidents, maximizing productivity and promoting mental wellbeing. In professions that require long periods of sustained attention, such as air traffic controllers or truckers, neural monitoring might even be regarded as a public safety necessity. The counter-argument is that neural monitoring can create an environment where employees feel hyper-regulated, surveilled and/or under unreasonable pressure to perform, in a manner that is incompatible with the right to safe and reasonable working conditions. Moreover, issues arise concerning the data collected, its ownership and the potential for an employee's privacy to be violated. Indeed, the amount of information that *can* be gleaned from neural data may far exceed what is relevant and reasonable to meet employer goals. This creates scope for employers to collect neural data for one purpose, but use it more extensively, including punitively, or to engage in 'neuroprofiling' or 'neurodiscrimination'. A related risk concerns the growing market for sales of raw neural data, which may incentivize employers to transact, either without employee knowledge or by claiming ownership of the data. As previously discussed, even where employees provide consent, power asymmetries can bring the validity of such consent into question.

A final human rights issue is worker augmentation through neurostimulation. Neurostimulation devices with the purpose of enhancing attentional focus, awareness, processing speed or decision-making proficiency may enhance overall productivity and are, as such, appealing tools for employers. Such augmentations might be justified (or even encouraged) as a means of enhancing public safety (e.g. in the case of pilots, armed police or surgeons) or to innovate (e.g. solving global challenges such as cancer or climate change). There are risks, however; for example, if enhancement becomes a condition of employment or prerequisite of employability, essentially removing worker choice. Such (quasi) forced uses of neurostimulation (or other enhancement tools) would violate the worker's right to privacy and integrity. In the future, additional questions may need to be addressed, for instance around workplace equity (e.g. pay gaps between enhanced and non-enhanced workers).

Key risks

- In employment contexts, hiring, firing or promotion decisions based on cognitive abilities, personality traits, beliefs or behavioural dispositions, as opposed to individual performance or actions
- Brain data is used to facilitate educational or vocational 'streaming', resulting in unequal access to education and livelihoods and/or reduced vocational autonomy
- The 'commodification' of neural data incentivizes employers to harvest it (consensually and non-consensually) for profit
- Neuroenhancement becomes a prerequisite, or a compulsory condition, of employment
- Pay discrimination (positive or negative) between augmented and non-augmented workers
- States compel neuro-enhancement as a means of developing a more effective and efficient labour market or strengthened military force

States might consider/evaluate

- Developing specific regulation on the use neurotechnology for enhancement purposes in the workplace, protecting workers from coercion
- Strengthening regulation to prevent employers from discriminating on the basis of cognitive characteristics, dispositions or proclivities that an individual is predisposed to but has not acted upon
- Developing safeguards for individuals who, after being fitted with a neuro-enhancive device, change employers, or if the company closes or changes ownership
- Upholding the right of individuals in legislation to not enhance in the workplace
- Clarifying whether information derived from neural data is a valid ground for decision-making in the workplace (hiring, promotion, demotion etc.)

FIGURE 1. HUMAN RIGHTS RISKS GROUPED BY GRAVITY AND TECHNOLOGICAL PROBABILITY

HIGH HR RISK / HIGH LIKELIHOOD

- In criminal justice contexts, neurotechnology is used as an investigatory/risk assessment/ rehabilitation tool, in ways that amount to inhuman or degrading treatment
- The non-consensual use of neuromodulation in the rehabilitation of e.g. convicted persons
- The coercive use of neuroimaging to obtain evidence in the form of e.g. witness statements
- The complexity behind how neural data is collected, analysed and used hampers free and informed consent. Alternatively, as more complex information can be gleaned from neurodata, the information that is harvested/released/sold becomes disconnected from what an individual believed they consented to
- Innovation in how neurodata is collected and its informational value leads to its 'commodification', creating incentives for hospitals, workplaces, schools or hacker organizations to harvest neural data (consensually and non-consensually) for profit
- The popularization of consumer neurotech widens the scope for collecting neurodata, especially in tech-savvy groups such as children
- Corporate entities supplying/maintaining therapeutic neurotechnology cease to operate, resulting in a patient having no access to continuity in care or redress in the case of a malfunction
- Companies/political entities combining neuro-marketing research with other digital information harvesting to influence individuals' thoughts, beliefs or preferences for profit or political ends
- Neurodata collected and processed by neurotechnologies enables third-party actors (e.g. businesses) to make accurate inferences about individuals' mental states such as beliefs, preferences or cognitive abilities

LOW HR RISK / HIGH LIKELIHOOD

- Workplace hiring, firing or promotion decisions are based on cognitive abilities, beliefs or behavioural dispositions, as opposed to individual performance or actions
- Pay discrimination between augmented and non-augmented workers
- Unequal access to neurotechnology (particularly neuro-enhancement) exacerbates societal inequalities e.g. around health and employment
- The use of neurotechnology as a sentencing tool to predict the risk of reoffending, compliance with a court order etc.
- Algorithmic bias reduces the performance of neurotechnology for groups that are under-represented in neurodata sets, such as racial minorities, children and older persons
- Broad access to neuro-enhancement manifests in a new form of quasi-coercion to use neurotechnologies, undermining the free character of informed consent

HIGH HR RISK / LOW LIKELIHOOD

- Neural data is used to facilitate educational or vocational 'streaming', resulting in unequal access to education and livelihoods
- Neuroenhancement becomes a prerequisite of employment
- Neurotechnologies are misused in medical or detention contexts, to punish, coerce, placate or 're-educate'
- States compel neuro-enhancement as a means of heightening labour market/military effectiveness and efficiency
- Rehabilitative neuromodulation to treat 'offences' around sexual identity, religion etc.
- Preventative or investigatory law enforcement based on brain decoding (e.g. criminal or violent intent) outside of a crime taking place, potentially resulting in the prosecution of 'thought crimes'
- Personal information gleaned from neurodata is released (i) accidentally resulting in privacy breaches, or (ii) deliberately exposing thoughts, beliefs, emotions or cognitive proficiency, which is then leveraged to impose criminal sanctions, discriminate or manipulate
- Weaponized forms of neurohacking to advance military objectives
- Thought manipulation through non-consensual interference with neurostimulation devices
- The imposition of pre-emptive (criminal) sanctions on the grounds of inferred thoughts, such as 'extremism' (to combat terrorism), political dissent (to protect national security) or sexual identity (to combat 'moral crimes')
- Neural data reveals information on health/ health dispositions, cognitive traits/proficiency, behavioural proclivities or mental states, creating opportunities for discrimination, e.g. in education, employment or insurance provision
- The non-consensual monitoring of or probing for individuals' mental states such as thoughts, emotions and memories, or cognitive capacities, for exploitation, punishment or (commercial or political) persuasion

LOW HR RISK / LOW LIKELIHOOD

- Innovation creates scope for previously released anonymized brain data to be subsequently linked to the individual in question
- Individuals are discriminated against on the basis of their cognitive augmentation (or non-augmentation) status
- Brain data is used to facilitate educational or vocational 'streaming', resulting in unequal access to education and livelihoods and/or reduced vocational autonomy

2. REGULATORY RESPONSES: TRANSLATING DEBATE INTO ACTIONABLE PROTECTIONS

How to establish implementable and comprehensive legal standards to mitigate the risks posed by neurotechnology will prove challenging. As set out below, while the most effective means of individual rights protection is enforceable domestic legislation, how to get there is technically and politically complex. States are neither well positioned nor incentivized to lead such a process, and the alternate option – crafting international obligations that would then 'trickle down' to states – is unlikely to garner the requisite political will. These various regulatory pathways, together with their advantages and disadvantages, are set out below.

A. State-Led Law Reform

For individuals to enjoy rights protection, legislation, complaints mechanisms and avenues for redress need to exist within a domestic legal framework. Building such a framework, however, is fraught with difficulty. First, the emergent nature of neurotechnology – what is scientifically possible, the potential harms that may accrue and with whom responsibility should sit – gives rise to complex questions that are beyond the scope and remit of most regulatory bodies. Second, a framework that places the protection of human rights at its centre may sit uncomfortably with the incentives (financial and security) states have to accelerate the development of neurotechnology. Even if these challenges could be overcome, the digital nature of neurotechnology, and thus its transferability between states, means that comprehensive protection for individuals will be contingent on a level of consistency between national responses.

B. New International Law

An alternate approach is to craft new international law, which states would then be obligated to incorporate into domestic legislation. This proposition is equally difficult. The first issue is the fast pace of innovation and the extant nature of the threats posed by neurotechnology vis-à-vis the length of time involved in developing a treaty-based solution. A further issue is that in the current political climate, there is little political receptivity to introducing new, or even elaborating existing, human rights treaties. In this context, a push for 'neurorights' might be met with, at best, a lukewarm response, and at worst, collective dismissal. This may problematize and/or delegitimize attempts to then invoke existing human rights as a bulwark against the risks posed by neurotechnology, potentially resulting in an erosion of the overall level of protection enjoyed.[14]

C. Elaboration of Existing International Law/Soft-law Options

A third option is an elaboration of existing human rights law, particularly the protections around privacy, freedom of thought and integrity.[15] Indeed, IHRL is a flexible framework that can (and has been) progressively interpreted to apply to novel situations, including through treaty body General Comments, reports of thematic Special Rapporteurs and the jurisprudence of regional human rights courts.[16] Again, the timeliness of such processes may prove prohibitive; General Comments, for example, generally involve a two-year deliberative process and treaty bodies often have several topics waiting in a 'pipeline'. Special Rapporteurs are likewise well-positioned to develop authoritative guidance that could be used by states, however as 'independent experts' there is no mechanism to compel a report dedicated to neurotechnology, irrespective of the value this would hold.[17] A final issue is comprehensiveness. Even if a treaty body, Special Rapporteur or human rights court did issue deliberative guidance, it would be limited to the mandate/issue in question and thus narrow in scope, whereas the impacts of neurotechnology can cut across several areas of human rights, often simultaneously. So, while such guidance would have value as a tool in standard setting and reform, it would not offer a comprehensive solution and could invite a level of rights incoherence.

The 2021 report of the Special Rapporteur on freedom of religion or belief highlighted the capabilities of emerging technology to violate freedom of thought and encouraged states to work with the UN human rights system to clarify the legal content and scope of the right.[18]

A final solution – arguably the most viable – is the development of a specific non-binding 'soft-law' document on neurotechnology.[19] This could shape the substance of existing rights, serve as a normative baseline to guide states in their policy- and law-making and promote coordination in policy responses. A soft-law document might, for example, (i) elaborate the risks that neurotechnology poses to specific human rights; (ii) set out how these risks co-relate to other bodies of law (such as health law, data protection, trade rules, consumer protection etc.); (iii) highlight the areas of intersection between neurotechnology and other technologies, such as machine learning and (iv) propose possible solutions, such as guiding principles or sample legislation. Such a process could be led by the Human Rights Council's Advisory Committee. Indeed, in October 2022, the Council adopted (by consensus) Resolution 51/3, requesting its Advisory Committee to prepare a study examining the impacts, opportunities and challenges associated with neurotechnology.[20] The recommendations of this study include developing guiding principles on the application of the human rights framework to neurotechnologies. For the Advisory Committee to undertake this process, the Human Rights Council would need to pass a mandating resolution. An alternate process, that would not require action by the Council, might involve a collaboration of thematic Special Rapporteurs whose mandates have direct relevance to the dangers posed by neurotechnology (and indeed OHCHR has proposed the creation of a 'coordination group' composed of Special Procedures with mandates on digital technologies). This would have the advantage of dealing with those complex situations where a single application of neurotechnology impacts several rights simultaneously or even contradictorily (i.e. upholds one right while violating another). Importantly, such an approach would not preclude, and might be a pathway to, the development of a binding international instrument. Soft-law principles can be endorsed by the Human Rights Council or General Assembly by resolution, which can lead to the formation of an open-ended intergovernmental group charged with negotiating a legally binding instrument.

In considering these options, it is important to highlight that other multilateral bodies are engaged in the development of regulation and principles related to neurotechnology, into which human rights perspectives could be fed. Examples include UNESCO's International Bioethics Committee, the OECD's Working Party on Biotechnology, Nanotechnology and Converging Technologies, the Secretary-General's High-Level Advisory Board on Artificial Intelligence and the Secretary-General's Scientific Advisory Board.

FIGURE 2. THE COMPETING POSITIONS OF 'NEURORIGHTS' AND EVOLUTIVE INTERPRETATION

NEURORIGHTS

Advocates of 'neurorights' posit that advancements in neurotechnology give rise to risks that were not foreseeable when the main human rights treaties were being drafted, leaving them lacking in precision and comprehensiveness. The solution, it is argued, is to create new rights – specifically tailored to protect individuals' brains and minds from undue interferences and manipulation – and integrate these into existing international human rights instruments. [21]

While there is no consensus on what a neurorights framework might comprise, the following are the most frequently cited areas of protection:[23]

1. Cognitive liberty (sometimes referred to as self-determination or human agency) encapsulates an individual's ability to make decisions without external obstacles, barriers or prohibitions. Recognition of such a right would effectively protect individuals from neural monitoring, interference or other non-consensual use of neurotechnologies.
2. Mental privacy protects an individual's right to control, access and use their neural data, to the exclusion of others. It would include inner thoughts not disclosed by an individual, and subconscious data that is not, or is only, partially under voluntary control.
3. Mental integrity recognizes that in the future, it may be possible to modify or manipulate neural processes, possibly without an individual's consent or awareness and/or in a manner that does not result in observable physical harm. Such a right would protect the ability to realize one's brain processes without interference and protect against any unauthorized monitoring during neurotechnology processes.
4. A right to personal identity (also referred to as psychological continuity) would protect individuals from any process that alters behaviour, thinking or modalities of feeling. This would include less invasive processes and unperceivable interventions that might (intentionally or unintentionally) impact neural processes.

EVOLUTIVE INTERPRETATION OF HUMAN RIGHTS

Scholars opposed to neurorights argue that a 'normative lacunae' in the human rights framework has not been sufficiently or convincingly demonstrated. On the contrary, IHRL is a flexible framework that can (and has been) progressively interpreted to apply to novel situations. For example, freedom of thought (which arguably encapsulates three of the proposed neurorights) could be interpreted and applied jointly with other relevant rights to address existing challenges. The neurorights approach also poses dangers. The absence of a clear conceptual basis, coupled with overlaps between proposed and existing rights, risks obstructing effective implementation and eroding existing legal protections.[22]

An elaboration or progressive interpretation of existing human rights might be realized through one of the following processes:

Case law: The most prominent and common, yet often overlooked, way for human rights law to evolve is through its application by courts as they assess cases brought before them. This similarly applies to the rights put at risk by neurotechnological advancement. Yet, it is rightly argued that cases involving neurotechnology are unlikely to reach courts swiftly enough to enable proactive legal responses.

Treaty bodies: The nine human rights treaty bodies develop interpretative guidelines known as General Comments to clarify the scope and meaning of particular rights, a state's obligations and best practices. General Comments are non-binding but are regarded as authoritative legal opinion and thus serve as important tools for dealing with contemporary challenges such as technological innovation.

Elaboration of existing law by human rights Special Rapporteurs: Special Rapporteurs have an important role to play in the development of human rights standards. Existing mandate-holders, especially on freedom of thought, protection from torture and the right to privacy, could contribute to an elaboration of how specific rights might apply to neurotechnology, including through thematic reports or conference-room papers.

Soft-law approaches: An academic institution, the Human Rights Council's Advisory Committee, or a consortium of Special Rapporteurs could develop guidance on the human rights challenges associated with neurotechnology, regulatory approaches to overcoming such challenges and modalities for strengthening protection frameworks. Such guidance could serve as a benchmark for member states, overcoming some of the challenges stemming from the complexity of the technology, and promote a coherent approach globally.

3. GUIDING PRINCIPLES AROUND THE DEVELOPMENT, RETAILING AND USE OF NEUROTECHNOLOGY

1. Human-centered regulatory solutions.

Advancement in neurotechnology cannot be pursued at the expense of fundamental human values, sustainability or the needs of future generations. Research and development should be grounded in human rights and guided by the importance of enhancing individual wellbeing and improving the welfare of society. Such an approach should be promoted throughout the technology lifecycle, including in design and development, clinical and non-clinical testing and deployment and commercialization.

2. A precautionary approach.

Advances in neurotechnology create risks that it will be repurposed for malign ends. While such threats are often exaggerated in the media, a level of cautious anticipation is prudent. The swift advancement in (non-invasive) neurotechnologies, bolstered by the growing potential of AI and its applications such as machine learning and generative AI, means that watershed moments will arrive faster and more frequently. Applying a precautionary approach aims at optimally fostering the benefits of neurotechnological advancement, while simultaneously mitigating against negative societal impacts and minimizing the risk of serious and irreversible harm in cases where the scientific evidence is uncertain.

3. Prioritizing extant risks.

The development of regulation should distinguish between what neurotechnology can currently deliver and what might be delivered in the future. Equally, there is a need to distinguish between externalities that will have direct human rights implications, those that will not infringe human rights, but nonetheless warrant a policy response, and those that demand an ethical analysis. The conflation of these areas can divert attention towards alarmist scenarios and crowd out discussions on how to most effectively regulate extant and near-term risks.

4. Intersecting regulatory frameworks.

Neurotechnology is a dynamic field with many moving parts, vested interests and visions of success. These elements need to be brought together, coordinated and cross-positions reconciled. At a minimum, domestic legal frameworks need to integrate import laws and other trade controls, laws around enabling technology such as AI, corporate self-regulation and oversight mechanisms that monitor industry, non-state groups and the state itself.

5. Striking a suitable balance that enables innovation and protects rights.

Any regulatory framework needs to balance safeguarding of human rights against the strong arguments that can be levelled in support of innovation in neurotechnology. These include the rights of individuals to benefit from scientific progress[24] and the highest standards of health,[25] and the scope to leverage neurotechnology to solve global challenges, raise productivity and improve public safety.

6. Committing to an enabling framework for 'neurotech for good'.

To guard against negative spillovers and maximize the scope for neurotechnology to be leveraged for beneficial ends, producing states should commit to principles around equality of access, technology sharing with countries in the global south (e.g. license-free use agreements) and development collaborations aimed at solving global challenges or issues specific to the Global South.

7. Corporate self-regulation.

Companies developing, retailing and using neurotechnology have an important role to play in promoting a human-centred approach, protecting human rights and preventing misuse. While comprehensive domestic laws are imperative, variability in the robustness of laws between states, coupled with neurotechnology's ease of transferability, means that self-regulation measures (codes of conduct, industry best practices etc.) will also be important.

8. An ethical approach to realizing the right to health.

Advances in neurotechnology have transformed the quality of life of individuals affected by degenerative neurological diseases, mental health disorders and learning differences, particularly in terms of their dignity, agency and independence. To this end, proactive steps must be taken to ensure that such gains can be broadly enjoyed and are not available only to the rich or certain groups. At the same time, particularly in the case of persons with disabilities, the right to not 'be fixed' must always be respected. Moreover, medical innovation should not consolidate systemic 'ableism', nor divert attention away from equally important issues such as discrimination and multi-factor accessibility.

4. RECOMMENDATIONS FOR REGULATORY AND LEGISLATIVE REFORM

Health and Safety Regulation

- Upgrading regulation on the development, trial and approval of therapeutic treatments to ensure that risk assessment, safeguards etc. on mental and physical harm are accorded equivalent protection. Such regulation should take particular account that mental harm may not become perceivable in the short term and/or may not physically manifest.
- Strengthening legislation to ensure that victims of rights violations (such as privacy violations) resulting from the misuse (or malfunctioning) of neurotechnology have the right to an effective remedy
- Promoting robust standards for free and informed consent that take into account (i) the potential for mental harm associated with neurotechnology therapeutic treatment, including over the longer term, (ii) the vulnerability of persons in medical and detention contexts, and persons with disabilities
- Concerning consumer neurotechnology, crafting regulation to ensure full and transparent disclosure with respect to expected benefits and potential side effects, with specific protections for older persons

Business Regulation

- Developing safeguards for individuals who benefit from neurotechnology devices provided by private sector actors in the event that they close, change ownership or merge
- Clarifying the legal responsibilities of technology producers in situations where technical malfunction results in a crime being committed by a neuromodulated or augmented individual, or an individual using a neuro-prosthesis or BCI
- Mandating an authority to oversee the development, use and retailing of neurotechnology with decoding and neuromodulating capabilities in compliance with human rights

Data Protection Regulation

- Initiating discussions aimed at clarifying the ownership rights of individuals regarding their neural data and the circumstances in which such ownership might transfer to the owners of proprietary technology that is used to harvest, decode or derive information from that data
- Monitoring and amending data protection laws to (i) regulate the processing, storage and use of neural data commensurate to its personal nature and magnitude of the attendant privacy risks; (ii) require that all entities storing neural data implement measures to prevent theft and 'leaks'; (iii) grow in scope as the value of neural data increases and the granularity of information that can be gleaned expands; (iv) specifically address the sale and repurposing of neural data held
- Requiring that users of neurotechnology treatments/devices, whether therapeutic, consumer or in the workplace, are adequately educated on the risks and provide full and informed consent insofar as neural data is collected, stored or may be repurposed or used by third-party actors
- Crafting consent regulation that (i) requires comprehensive explanation using plain language to overcome understanding deficits; (ii) deepens the protection afforded to vulnerable groups including in hospitals, detention etc.; (iii) gives individuals the right to revoke their consent including in cases where the insight that can be gleaned from neurodata increases, anonymity cannot be guaranteed etc.; (iv) fully and specifically lists the purposes for and ways in which neural data can be used (thus protecting individuals from future innovation leading to privacy breaches)
- When neural data is collected through online platforms, crafting consent regulation that (i) allows users to restrict access to their data through easily navigable steps; (ii) contains specific safeguards to protect children who may be identified online, or who pose as adults

Employee/Workplace Regulation

- Developing specific regulation on the use of neural monitoring and enhancement neurotechnology in the workplace, protecting workers from coercion and setting minimum standards around how neural data will be used, stored and protected
- Strengthening regulation to prevent employers from discriminating on the basis of cognitive characteristics, dispositions or proclivities that an individual is predisposed to but has not acted upon
- Developing safeguards for individuals who, after being fitted with a neuro-enhancive device, change employers, or if the company closes or changes ownership
- Upholding the right of individuals in legislation to not neuro-enhance (e.g. in employment contexts).
- Prohibiting discrimination within the workplace (positive or negative) on the grounds of augmentation
- Clarifying whether information derived from neural data is a valid ground for decision-making in the workplace (hiring, promotion, demotion etc.)

Criminal Regulation

- Clarifying the status of neuromodulated or augmented individuals under the law, including with respect to their legal standing, rights and responsibilities
- Clarifying what constitutes actus reus in the case of an individual using a neuro-prosthesis or BCI. Specifically, is the neurotechnology considered to be part of the individual or an external tool?
- Clarifying how different forms of neural data should be classified from the perspective of evidence. Specifically, is neural data considered physical evidence that can be subpoenaed, e.g. from a platform owner/workplace, or can an individual deny access to brain data by invoking the right to protection against self-incrimination?
- Possible Impermissible Uses

- Prohibiting the use of neurotechnology treatment for 'correcting' cognitive or behavioural traits protected under anti-discrimination and other laws, such as sexual identity, religiosity etc.
- Developing specific regulation on the use of neurotechnology treatment as a tool to punish, placate or coerce in situations of detention, criminal justice processes and health settings, and extending the prohibition of medical or scientific experimentation on individuals to include neurotechnology
- Defining and mandating protection against 'impermissible' interferences, e.g. punishment of thought, thought manipulation, non-consensual revealing of private thoughts etc.
- Strengthening regulation to prohibit neural data being used to profile individuals based on protected characteristics such as opinion, religion, sexual identity or political affiliation.
- Crafting regulation on how, and with what safeguards, neurotechnology can be used as a tool in investigations, risk assessment and rehabilitation
- Amending regulations dealing with torture and cruel, inhuman and degrading treatment to integrate violations of mental integrity that can stem from neurotechnology
- Providing technical guidance on the interpretation of and how to instrumentalize freedom of thought in the context of neurotechnology

Other

- Expanding the coverage of protected persons to include cognition and augmentation/non-augmentation status in anti-discrimination and/or worker rights legislation
- Strengthening legislation to ensure that victims of rights violations (such as privacy violations) resulting from the misuse (or malfunctioning) of neurotechnology have the right to an effective remedy
- Providing an enabling environment for the collection of extensive, accurate and representative data on brain functioning to underpin the development of new neurotechnology applications and their future optimization
- Crafting policy to ensure equal access to neurotechnology with a view to avoiding deepened inequality, including in specific sectors, access to healthcare and employment
- Including a clear definition of mental integrity in relevant human rights legislation

ANNEX :
WHAT IS NEUROTECHNOLOGY AND HOW DOES IT WORK?

To assist readers who do not have a background in neuroscience, this annex sets out the four prominent applications of neurotechnology covered in this paper. It seeks to offer a plain-language explanation of how they work, what is (and is not) 'consumer-ready' and what might (and might not) happen in the future. It is important to note that there is some degree of overlap between these applications, and therefore sections. For example, BCI integrates neuroimaging and decoding technology, and neuromodulation is the main technique used in neuroenhancement.

A. NEUROIMAGING AND NEURAL DECODING

How the science works.

Neuroimaging technologies are used to monitor and record both the structure and functioning of the brain. Structural neuroimaging, such as magnetic resonance imaging (MRI) and computer tomography (CT) are mainly used in medical settings, for example to diagnose brain lesions or tumours. Functional neuroimaging measures brain activity and includes non-invasive techniques such as electroencephalogram (EEG), functional magnetic resonance imaging (fMRI) and positron emission tomography (PET).[26] The most accurate information, however, is generated using invasive neuroimaging techniques such as electrocorticography (ECoG), which involves placing electrodes directly on the brain's surface. Neural decoding refers to the processing of neural data collected through these neuroimaging techniques and translating it into information on mental states, processes or events. This translation is realized through the use of sophisticated AI-driven decoding algorithms that correlate brain activity patterns with certain individual cognitive, perceptive or affective states such as visual perception, imagined speech, emotions or motor intentions.

Plain-language translation.

Every thought, intention, emotion, movement and the mental processes underlying these mental states creates a unique pattern of neural network activity. Neuroimaging techniques, including fMRI, can record this brain activity.[27] Using AI-driven algorithms to interpret large sets of such neural data, scientists can link specific neural patterns with mental processes and states, including visual perception,[28] memories,[29] semantic knowledge,[30] emotions,[31] dreams,[32] inner speech[33] and intentions.[34] The upshot is that in controlled laboratory settings, unexpressed mental states such as thoughts (i.e. inner speech) can be reconstructed based on neural data.[35]

Scope for use outside of clinical and research settings.

Neural decoding is in its infancy, and the science is nowhere near passive or surreptitious 'brain-reading'. Current neuroimaging tools and decoding algorithms only allow for the reconstruction of very rudimentary information on mental states and remain error prone. Moreover, especially in the case of affordable and non-invasive approaches such as EEG, techniques have not been able to overcome the impediments posed by the skull, hair, flesh and exterior 'noise' to produce resolution quality close to that needed for decoding complex mental states beyond levels of arousal indicating, e.g., alertness, stress or fatigue.[36] As such, the likelihood of commercially available devices capable of decoding complex mental states such as thoughts or emotions in real time is presently low.[37]

Prediction for the future.

The pace of innovation in both neuroimaging techniques, and AI's capacity to extract patterns from large datasets suggests that the range and accuracy of 'decipherable' mental information will grow quickly and exponentially. In the future, this technology may allow for inferences to be made about a wide array of mental states and processes. However, it is unlikely that a universal 'cypher' to decode thoughts from brain activity exists, making the risk of broad-use neural decoding of complex mental states low.

Possible near-medium-term future applications.

In criminal justice contexts: to assess criminal responsibility or reveal 'guilty knowledge'; in the workplace: not to reveal thoughts but as a tool to monitor productivity, manage cognitive load, reduce attention-related accidents etc.; in recruitment: as a tool to assess a worker's cognitive attributes (and also beliefs, mental health or sexual identity); in classroom settings: to track attentiveness, refine pedagogy and/or identify students with learning differences; and in identification processes: the use of an individual's brain activity patterns as a unique biometric identifier.

B. NEUROMODULATION

How the science works.

Neuromodulation (also called neurostimulation) technologies aim to influence brain activity by modifying, bypassing or substituting existing neural structures or processes.[38] This is typically done by exposing the brain to electrical currents or magnetic fields; Deep Brain Stimulation (DBS), for example, delivers targeted electrical pulses via surgically implanted electrode arrays. Non-invasive methods use magnetic fields, electrical currents or ultrasound to stimulate specific areas of the brain via a coil (transcranial magnetic stimulation – TMS), electrodes (transcranial direct current stimulation – tDCS) or focused ultrasound.[39] Optogenetics uses different technology. This is a highly advanced technique that genetically modifies brain cells to make their functioning susceptible to modulation by light pulses.[40]

Plain-language translation.

Neuromodulation procedures target specific areas of the brain, for example with electrical currents or ultrasound, to modulate neural activity. These methods can be invasive (e.g. implanted electrodes) or non-invasive (e.g. ultrasound) and are used to treat cognitive disease (e.g. Parkinson's disease and epilepsy), mental health disorders (e.g. post-traumatic stress disorder and depression) and learning differences (e.g. attention deficit disorder). It is increasingly researched and marketed – despite insufficient scientific backing – as an enhancement tool in healthy individuals.

Scope for use outside of clinical and research settings.

The enhancement potential attributed to neuromodulation devices – despite limited evidence of their effectivity beyond the medical realm – and the increasing efforts to develop non-invasive applications, render them deployable in various contexts, ranging from wellness and leisure to education and the workplace. The current reality, however, is that invasive neuromodulation is limited to clinical settings and uses expensive equipment that is narrowly available, while non-invasive neuromodulation has greatly reduced efficacy. The specific targeting of complex mental states, such as thoughts or beliefs, is not likely in the near future.

Prediction for the future.

The prospect of widespread use of neurostimulation devices beyond clinical contexts largely depends on scientists' success in developing non-invasive applications that match the effectiveness of invasive applications. Indeed, the risks associated with invasive neurostimulators (e.g. infection or intracranial bleeding) make it unlikely that these approaches will be applied for purposes other than treating neurological diseases (e.g. Parkinson's disease, epilepsy) and neuropsychiatric diseases (e.g. major depression, obsessive compulsive disorder). The reality, however, is that neurotech companies are eager to market non-invasive neurostimulation devices directly to consumers, promising augmentation of cognitive abilities such as memory, learning, focus or relaxation. The growing state of knowledge around which neural circuits attach to certain emotions/behaviours/states, coupled with techniques to target them, creates a theoretical risk that neuromodulation could be applied to healthy individuals to achieve malign outcomes.

Possible near-medium-term future applications.

Possible applications include: (i) the extension of neuromodulation to treat a wider variety of neurological and psychiatric disorders or learning disorders; (ii) integrating neuromodulation techniques in closed-loop systems, whereby brain modulation is directly controlled and triggered by information on brain events generated by neuroimaging. Such closed-loop neuromodulation would eliminate the need for human (physician) intervention to initiate brain modulation in a timely manner; instead, it would respond directly to neural events preceding, for instance, upcoming seizures or depressive episodes.

C. BRAIN-COMPUTER INTERFACE (BCI)

How the science works.

BCIs facilitate operational connectivity between a brain and an external machine. They employ neuroimaging such as EEG to record brain activity signals, which are then translated through decoding algorithms into technical commands that can operate external devices such as computers, smartphones, prosthetic limbs or wheelchairs. The linkage established by BCIs allows external devices to be controlled solely by brain activity, thus bypassing neuromuscular pathways.[41] They can be invasive (using ECoG) or non-invasive (using EEG or functional near-infrared spectroscopy – fNRIS), the former generating the most effective and precise control over an external device. There is also (successful) research directed towards the development of a bidirectional BCI.[42] This BCI enables control over, for instance, a prosthetic limb and, through brain stimulation that is initiated on the basis of sensors on the prosthetic, tactile perception in the user. In this way, a paralysed patient cannot only move a robotic limb but also regain a sense of touch through neurosensory feedback delivered via this robotic limb.

Plain-language translation.

BCIs work by recognizing a pattern of brain activity and translating it into technical commands that can be functionalized by external electrical devices such as a computer or robotic limb. This technology, for instance, allows a quadriplegic to 'think' a movement, which is subsequently realized on an external device. These movements could be the movement of a cursor on a screen or the movement of a prosthetic limb that reaches to grasp a cup. This technology is used primarily for therapeutic purposes, for example allowing individuals affected by amyotrophic lateral sclerosis (ALS), cerebral palsy, stroke or spinal cord injury to control neuroprostheses or communicate. Commercial, non-medical applications are being extensively researched, and some are even currently available on the (online) market – yet they are restricted to basic functionalities within contexts such as gaming.

Scope for use outside of clinical and research settings.

The uses of BCI technology are predominantly therapeutic and experimental in nature. These systems are expensive and bulky, and the technology relied on is limited to a small number of high-income countries. As such, BCIs are far from being systematically deployed in healthcare practice. Commercial and recreational applications are also being developed, such as BCI-enabled 'neuro-gaming', mind-operated smartphones and neural interfaces that connect individuals in the workplace. Most of these devices are still in the development stage, although some are commercially available. One example is an EEG-based BCI headset that allows users to control digital characters and objects on a screen (changing their shape or altering the image scale) using only their mind.[43] Research into military applications of BCIs (such as brain-controlled weapons or aircraft) is also taking place; however, the readiness of such technology is largely unknown.

Prediction for the future.

Steep technological advances, particularly around machine learning, mean that therapeutic BCIs are becoming faster and more accurate. This is promising for patients suffering from motor or communication impairments due to neurological disorders or brain trauma. The science in this field is advancing swiftly. However, for both therapeutic BCI and commercial and consumer applications to become more commonplace, a number of technological and functionality impediments need to be overcome. Currently, the decoding capability of even the most sophisticated BCI is very basic and unable to translate mental content in a rich or granular manner comparable to what could be envisioned, or communicated orally/in writing.[44] A further barrier to commercial application (and a safeguard against them being used covertly or involuntarily) is that most BCI technology only works though user cooperation, i.e. only when the patient chooses to make their intentions or commands 'heard' (e.g. by imagining a movement) can the system read and interpret them. Even then, effective use of a BCI requires lengthy training on the part of the user, and a process of synchronization between his/her brain activity and the machine. Likewise for neuro-gaming devices, in order to work properly, they must be calibrated to a user's specific brain activity, which takes time and adds expense to the product.

Possible near-medium-term future applications.

The BCI applications that enable paralyzed patients to move, or locked-in patients to communicate, generally require invasive devices. Non-invasive BCI systems are steadily evolving but are not systematically deployed in healthcare practice. Yet, advances are taking place, for example a semantic decoder that is able to extract semantic content directly from the brain, demonstrating the future potential of an operational 'thought-to-text' device that could restore the power of communication in victims of stroke, anarthria and other forms of paralysis. More speculative BCI developments include brain-to-brain interfaces that enable direct communication between two or more brains by transmitting neural signals, thus allowing for shared sensory or cognitive experiences without verbal or physical interaction.

D. NEURO-ENHANCEMENT

How the science works.

Different forms of neurotechnology can be employed to enhance the mental/cognitive, motor, sensory and communication capacities of individuals. The most prominent enhancement methods include neuromodulation, neurofeedback devices and BCIs. Neurostimulation techniques such as tDCS show promise in enhancing memory and attention. Neurofeedback devices gather information on individuals' brain activity through neuroimaging. This information is delivered to the user through auditory or visual stimuli, allowing them to practise controlling their brain activity and ultimately gain greater mastery over their mental states. This can be effective in reducing stress or heightening focus and productivity. BCIs comprise a wide range of devices, including sensory BCIs that enable the restoration or augmentation of sensory abilities, motor abilities (e.g. BCI-enabled exoskeleton or prosthetic arms) and communicative capacities (e.g. BCI-enabled speech prosthetics).

Plain-language translation.

Three types of neurotechnology are generally understood as having the potential to be repurposed to achieve enhancive outcomes. (i) Neuromodulation, which is deployed in a medical setting to treat both motor and cognitive impairments related to neurological and psychiatric disorders, as well as in healthy people to enhance cognitive functions such as working memory, situational awareness, and processing speed. The latter application is growing rapidly, largely due to the development of non-invasive enhancement techniques including transcranial electrical stimulation (tES), TMS and tDCS (yet proof of their effectiveness is sparse and varies across individuals).[45] (ii) Neurofeedback devices enable self-training by using neuroimaging interfaces that provide users with real-time information regarding their brain activity, helping them learn to control specific mental states. For example, there is growing interest in developing EEG-based devices that provide direct feedback on individuals' brainwave patterns, enabling self-monitoring and the subsequent training of mental processes such as attention or relaxation.[46] (iii) BCI applications that facilitate the restoration or enhancement of motor or communication functions.

Scope for use outside of clinical and research settings.

Neuromodulation and neurofeedback devices with purported enhancement capability are widely available on consumer markets or are otherwise in use. For instance, tDCS headsets that deliver electrical currents to stimulate or arrest the firing of neurons, are commercially available, as are EEG-based brain monitors. It is important to underscore that while retailers market these devices as performance/learning enhancive, there is little evidence to support their efficacy outside of clinical settings.

Prediction for the future.

Enhancement technologies are among the most investigated neurotechnology application due to their wide marketability across different sectors, beyond the medical realm. Their future development will largely depend on manufacturers' ability to demonstrate the efficacy of non-invasive neurostimulators and neurofeedback devices. Nonetheless, the commercial availability of these technologies appears to be inevitable.

ANNEX:
LIST OF ACRONYMS

BCI	Brain-computer interface
CAT	Convention against Torture and Other Cruel, Inhuman and Degrading Treatment (1984)
CEDAW	Convention on the Elimination of all forms of Discrimination against Women (1979)
CERD	Convention on the Elimination of all forms of Racial Discrimination (1966)
CRPD	Convention on the Rights of Persons with Disabilities (2008)
ECoG	Electrocorticography
fMRI	Functional magnetic resonance imaging
ICCPR	International Covenant on Civil and Political Rights (1966)
ICESCR	International Covenant on Economic, Social and Cultural Rights (1966)
IHRL	International Human Rights Law
OHCHR	United Nations Office of the High Commissioner for Human Rights
tDCS	Transcranial direct current stimulation
TMS	Transcranial magnetic stimulation
UDHR	Universal Declaration of Human Rights (1948)

END NOTES

1 See: Arts 2 and 7, UDHR; Arts 2(1) and 26, ICCPR; Art 12, CEDAW and Art 5, CERD.

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