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Neurotechnologies: The New Frontier for International Governance

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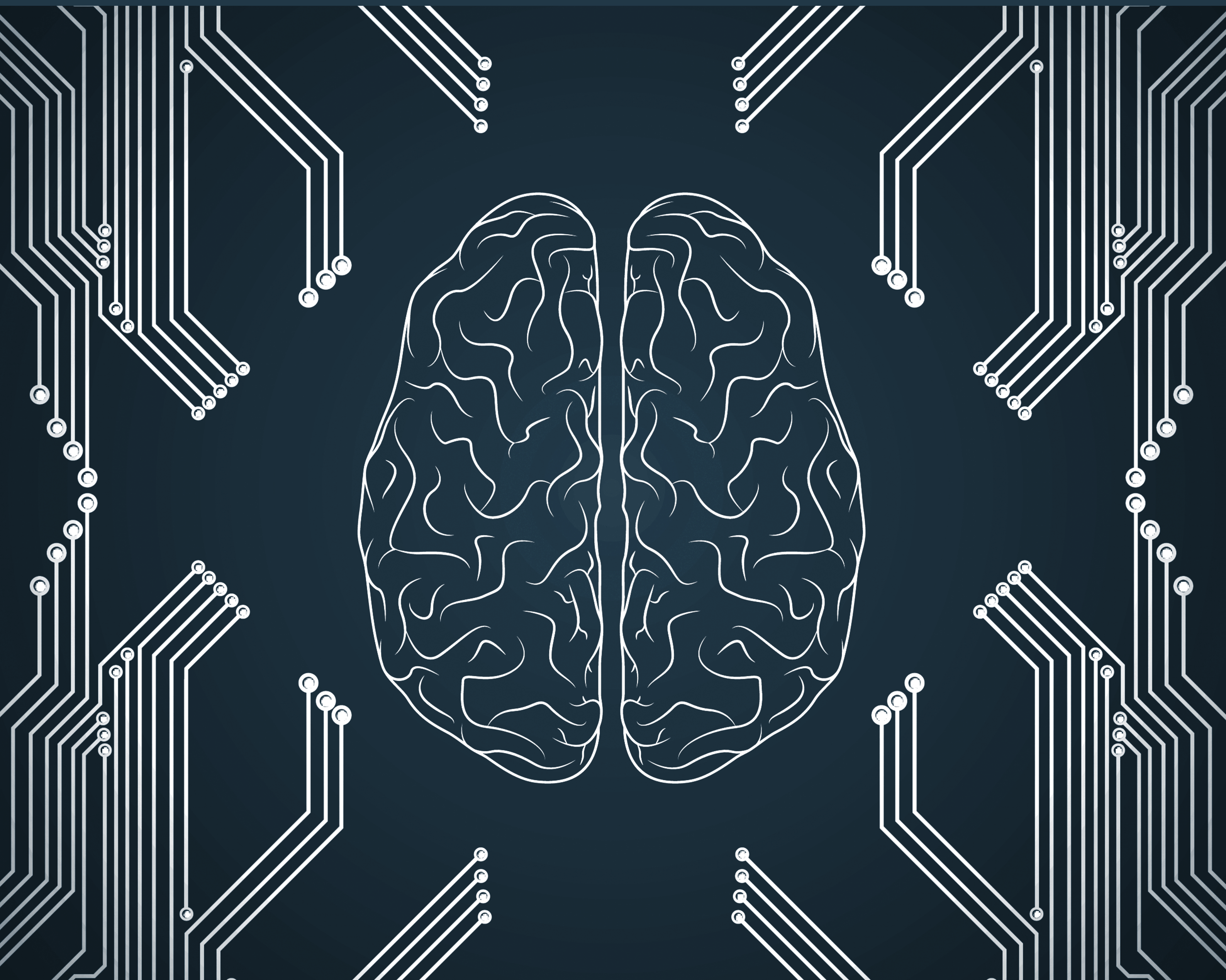

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Key points

- Advances in neuroscience and artificial intelligence (AI) are leading to the rapid development of neurotechnologies that are giving us unprecedented access to and understanding of our brains. With this comes the capability to decode, alter or enhance targeted cognitive processes.
- Broad positive medical applications stem from this, such as the potential curing of mental disorders, or the regaining of lost mobility through the operation of new-age prosthetics controlled with brain-computer interfaces. However, access to mental processes presents us with unprecedented privacy, ethical and security risks.
- New governance frameworks to govern the development and use of neurotechnologies are required to ensure the risks stemming from these new technologies are mitigated before their broad adoption.
- These governance frameworks should be participatory, flexible, global, inclusive, multilateral and multistakeholder. Given the heterogeneity of the technologies in question, their applications and the actors involved in the field, the seamless integration of different governance instruments could be necessary. Additionally, these efforts should not be siloed from governance in seemingly separate – but converging – technological fields such as AI.

Introduction

As new technologies enable the reading and modification of brain activity, discussions arise about their benefits and risks. The possibility of leveraging data acquired from the brain and influencing cognitive process that lie at the core of being human creates new ways to treat mental disorders or recover lost motor or cognitive capabilities. They also open the possibility for security risks at the individual and societal levels. This Strategic Security Analysis discusses emerging calls for a suitable governance framework for neurotechnologies.

Neurotechnologies: state of the art

Over recent years neurotechnology development has proved the viability of interfacing the human brain with artificial systems.

The term neurotechnologies denotes “devices and procedures used to access, monitor, investigate, assess, manipulate, and/or emulate the structure and function of the neural systems of natural persons”.[1] Importantly, the field of neurotechnologies comprises a growing set of heterogeneous systems aimed at a diverse number of applications and end users. Examples of these systems include devices that stimulate the brain using electrical pulses, such as cochlear implants for restoring hearing capabilities or deep-brain stimulation (DBS) systems aimed at alleviating the symptoms of Parkinson’s disease. Another type of systems, termed brain-computer interfaces (BCIs), rely on AI algorithms to translate brain activity into information used to operate prosthetic devices or to infer users’ mental states. Over recent years neurotechnology development has proved the viability of interfacing the human brain with artificial systems, as the commercial success of cochlear implants, currently being used by more than 700,000 people, attests.[2] In contrast, other types of neurotechnologies are still at a research stage and years away from reaching the market.[3] BCIs are examples of the latter where proof-of-concept studies have shown their potential for controlling arm prostheses, exoskeletons, video games and various types of assistive technologies.

Neurotechnologies also offer the possibility of extending current human capacities. There is evidence that electrical stimulations to the brain can result in temporary improvements in memory and attention levels, supporting the possibility of building systems for cognitive enhancement. These systems could be used to enhance educational outcomes (as was reportedly tested in a programme in Chinese schools to improve work efficiency) or to counter age-related cognitive decline.[4] These potential applications, powered by breakthroughs in neuroscience, advanced materials, big data, and AI, have sparked great interest from research organisations, technology-based companies, investors, and governments.

Analysis of the opportunities and risks resulting from the growing development of neurotechnologies and efforts to design suitable governance mechanisms should take into consideration the complex ecosystem in which technology is developed. Neurotechnology systems can target multiple users and be used for multiple purposes, including medical and military applications and direct-to-consumer products.[5] Hence, the neurotechnologies ecosystem comprises public and private research organisations, technology-oriented companies, providers of medical services, public health systems, military forces, insurance companies, and clinical and consumer regulatory bodies. These stakeholders and application fields have distinct development procedures and very different oversight mechanism requirements. This is illustrated by the contrast between the established processes and regulatory frameworks that apply to the development of medical technology, on the one hand, and the weaker regulation and rapid cycles of product development that characterise the consumer technology sector, on the other hand.[6]

Notably, neurotechnology-enabled solutions are the result of integrating several elements that fulfil the functions of recording brain activity, processing data using AI, transferring information via dedicated networks or the Internet, and operating an external device such as a prosthetic device or computer program.[7] Each of these elements uses technologies that can be at different stages of technological maturity, ranging from well-established and proven technologies to recently developed sensors that have only been tested in research laboratories or on non-human animals. Furthermore, a single system can combine elements developed for both clinical and consumer applications, as is the case in recent systems that use virtual-reality headsets for rehabilitation purposes.

Advances in AI are now converging with neuroscience to optimise neurotechnologies and enable better human-machine interaction.

Several analyses document concerns regarding the use and adoption of neurotechnologies.[8] These systems increasingly rely on the analysis of data and the use of AI algorithms to infer information about the user; in fact, the fields of neuroscience and AI are inextricably linked. Modern AI techniques not only borrow a great deal of their language from brain sciences (the term "artificial neural networks", for example), but are often expressly modelled on biological neural networks that make up our brain.[9] Understanding the inner workings of the brain has helped pave the way for many of the advances in the field of AI. A reciprocal process is now also true: advances in AI are now converging with neuroscience to optimise neurotechnologies and enable better human-machine interaction.[10] AI is indeed foundational to bidirectional brain-computer communication, with algorithms enabling the mapping of the brain, the deciphering of brain signals and the improvement of their translation into specific outputs.[11] While the convergence of the two technologies enables neurotechnologies to benefit from the opportunities provided by AI, it also enables the transfer of risks associated with the latter technology.

AI systems are, for example, prone to algorithmic biases, which have been identified in applications such as facial recognition,[12] hiring processes[13] and surveillance.[14] The risk of bias in neurotechnologies is considerable, since they rely on neuroscientific knowledge that has been documented as lacking diversity. The fact that most research and development activities are undertaken in high-income countries results in theoretical and empirical studies of the brain that do not reflect the global population. In addition, gender differences are currently poorly understood or addressed at the medical[15] and neuroscientific levels.[16] As a result, neurotechnology systems may perform differently depending on the race, gender or other characteristics of the user. Complementarily, the tendency of current AI algorithms to rely on massive amounts of data creates a drive for the collection of large amounts of brain data. China, for instance, has already started using various neurotechnology devices on its citizen to improve various human tasks, while at the same time allowing the Chinese government to start collecting brain data about the country's population.[17] As a result, neurotechnologies will also be affected by the threats associated with big data such as cyber security, privacy breaches or profiling applications.

Neurotechnologies create the possibility of interacting directly with the brain, which is intrinsically linked to the individual's personality and selfhood. This brings a new range of risks that are specific to the very nature of these systems. The advent of increasingly sophisticated BCIs opens the possibility of granting access to personal sensitive information to third parties, potentially without the knowledge or consent of the individual concerned. This constitutes a novel threat to so-called mental privacy. Also, effecting changes in behaviour or cognition using neurotechnology devices is the rationale for their use as therapeutic interventions. However, these approaches can also generate unintended changes, as evidenced by reported side effects affecting personality, identity and autonomy resulting from DBS treatments.[18] These neurotechnology-induced changes, either unintended or due to malicious practice, constitute a threat to the mental integrity of those being treated. The possibility of using neurotechnologies for enhancing human capabilities also raises the question of accessibility and fairness. Indeed, effective mechanisms for cognitive enhancement will likely provide unfair advantages to the individuals who have access to them. This can exacerbate differences between populations sectors at different socioeconomic levels. It can also result in social pressures to use these systems, because they may improve individuals' educational or professional opportunities.

> Continuous monitoring and evaluation of the opportunities and risks generated by neurotechnologies are crucial to better guide research, development, and governance efforts.

As is usually the case with emerging technologies, we currently lack all the knowledge necessary to precisely assess and mitigate these risks. Some only materialise once the systems are used by a large sector of the population, while others may take some time to materialise or even be the outcome of a repurposing of their functions by malicious actors.[19] Hence, continuous monitoring and evaluation of the opportunities and risks generated by neurotechnologies are crucial to better guide research, development, and governance efforts. Technological convergence makes the impact of emerging technologies increasingly unpredictable, disruptive and complex.[20] The further intertwining of AI and neurotechnologies complicates the understanding and anticipation of long-term effects and risks. However, existing efforts in AI regulation can provide valuable insights to guide the development of ways of governing neurotechnologies.[21] Siloed governance frameworks treating technologies as independent and separated therefore proves ill-suited to apprehend risks stemming from the convergence of these technologies.

Governance of neurotechnologies

The unique risks presented by the development of neurotechnologies have increasingly been met with calls for appropriate governance frameworks to be formed around the research, development and deployment of these technologies. As the scientific field advances, and the risks become clearer, these calls have multiplied. The current landscape of neurotechnology governance is highly diversified, ranging from ethical recommendations and guidance documents for research and innovation to international soft-law mechanisms and emerging binding legislation.

Main actors and calls for governance

A wide array of actors are shaping the future of neuroscience and neurotechnologies in terms of their development, the promotion of responsible innovation, and their governance. These include intergovernmental and international organisations such as the Organisation for Economic Co-operation and Development (OECD), the Council of Europe, and the United Nations Educational, Scientific and Cultural Organization (UNESCO), as well as professional organisations such as the Institute of Electrical and Electronics Engineers (IEEE). Research for national security purposes is also conducted, as exemplified by various US Defense Advanced Research Projects Agency (DARPA) projects.[22] These efforts are complemented by international initiatives such as the Neurorights Foundation or the Neuroethics Society. Similarly, research is being conducted across the globe, not only nationally with several "brain initiatives" such as the US Brain Initiative, the China Brain Project, or the Australian Brain Alliance, among others, but also internationally with initiatives such as the International Brain Initiative, or the European Union (EU) Human Brain Project. Private sector actors such Neuralink and Kernel complement the pool of actors in the field by also being key players in the research and development of neurotechnologies. For instance, in December 2022 Neuralink announced that it was ready to conduct experiments on humans in six months.[23] Meta (formerly Facebook) was also pursuing brain-computer interfacing research until it discontinued its efforts in 2021, because it deemed the path to market was too long for such technologies.[24]

Due to the diversity of the actors in this field, calls for governance are already multiplying into a constellation of parallel efforts, differing in breadth, scope, nature and aim.

Due to the diversity of the actors in this field, calls for governance are already multiplying into a constellation of parallel efforts, differing in breadth, scope, nature and aim. Perhaps the most notable example of such an effort is the OECD Recommendation on Responsible Innovation in Neurotechnology. While the document is a non-binding "soft law",[25] as the first negotiated international statement on the issue it represents an important step in international efforts to govern neurotechnologies and can serve as a normative framework forming the basis for future developments in this area.[26] The recommendation is the result of a five-year multistakeholder process coordinated by the OECD Working Party on Biotechnology, Nanotechnology and Converging Technologies. It seeks to "guide governments and innovators to anticipate and address ethical legal, and social challenges raised by novel neurotechnologies while promoting innovation in the field".[27] The recommendation puts forward nine principles for steering responsible innovation and research by governments, universities, companies and investors. By focusing on responsible innovation, this governance effort seeks to address a key dilemma in technology governance: "governing too early can stifle innovation but governing further downstream may be too late to influence how technology operates in society".[28]

The Council of Europe, Europe's foremost human rights organisation, released a Strategic Action Plan on Human Rights and Technologies in Biomedicine in 2020. The action plan seeks to address the key challenges posed by technological developments in biomedical practices. Key parts of the plan are the support for governance in this field and the alignment of innovation with social goals and values. The document emphasises that it is "necessary to change the way in which technologies with an application in biomedicine are governed. Governance models are required to guarantee that the protection of human rights is a guiding consideration throughout the entire process of research, development, and application".[29] In 2021 the UNESCO International Bioethics Committee (IBC) released a report on the ethical issues related to neurotechnologies. The report recommends that UN member states should adopt laws to regulate neurotechnologies and protect mental integrity. It also recommends the promotion of education and empowerment among the public regarding these technologies, and the right of individuals to have access to or refuse the use of neurotechnologies.[30] The report calls for companies to adopt codes of conduct for responsible research and innovation, and for media to objectively inform the public on related issues. Both the Council of Europe and the UNESCO IBC address the governance of neurotechnologies from the perspective of human rights. The Council of Europe proposes to assess whether the existing human rights regime sufficiently protect society against these new risks or if new rights – termed neurorights – are needed.[31] The UNESCO report encourages UN member states to guarantee neurorights as a basic part of developing appropriate legal frameworks for the use and production of neurotechnologies.

The concept of neurorights was simultaneously proposed in 2017 by Roberto Adorno and Marcello Ienca in Zurich, and a group led by Rafael Yuste in the United States.[32] This idea has been championed since by the Neurorights Foundation which advocates for the establishment of neurorights to safeguard the human mind more appropriately. This approach therefore proposes expanding the current human rights framework and including new human rights relating to our minds: so-called "neurorights". Additionally, the Neurorights Foundation is currently drafting a "Technocratic Oath", constituting an ethical framework for entrepreneurs, scientists, companies and investors developing neurotechnologies.[33] While the concept of neurorights has received much acclaim and even inspired legislation, the idea of extending human rights to govern the mind by enshrining neurorights is not unanimously accepted as the right governance approach to mitigate the risks inherent in neurotechnologies.[34] Some critics argue that national and international legal systems already protect freedom, consent, equality, privacy and other concepts that neurorights claim to be able to better protect. They therefore question the need to create a new category of human rights.[35]

This approach therefore proposes expanding the current human rights framework and including new human rights relating to our minds: so-called "neurorights".

The efforts to govern neurotechnologies have not been only confined to international foundations, organisations and research groups. Governments around the globe are also starting to engage in these discussions to varying degrees. The most notable and often-cited example is the Chilean constitutional amendment that legally protects Chilean citizens' neurorights. Inspired by the above-mentioned efforts of the Neurorights Foundation, passed in the Senate and signed into law by the Chilean president, the amendment legally protects mental privacy and free will, and asserts non-discrimination in the provision of access to the technology.[36] Furthermore, an additional bill to the constitutional amendment, still under review by the Chilean Congress, would establish that neurotechnology devices – even those intended for commercial and entertainment use – should be subject to the same regulation as medical devices. Additionally, it would define neural data as a human organ, hereby prohibiting its sale and purchase.[37]

While the Chilean approach has garnered praise for pioneering the protection of neurorights, it has also received some criticisms.[38] Some critics state that the implementation of this framework may conflict with existing disability rights.[39] Others have argued that that method of regulation is both excessively heavy handed and too premature relative to the maturity of the technology and our understanding of some of the concepts the legislation seeks to govern.[40] For example, free will is not an agreed-upon concept, which makes efforts to protect it legally questionable.[41] Other concepts like mental integrity and psychic continuity are equally murky concepts.[42] A strict interpretation of the former, for instance, could potentially prevent neurosurgeons from conducting brain surgeries.[43] Moreover, critics argue that legislating this early in the life of a technology will stifle innovation. Such criticisms do not inherently mean that all "hard-law" approaches to governing neurotechnologies should be abandoned. Rather, it shows that legislative efforts need to be lean and flexible enough to be updated as the technology progresses and our understanding of its effects evolves. This would make legislation more future proof, while preventing efforts to manage innovation from being overly restrictive.

Other governments have adopted a softer governance approach. Spain recently adopted a Digital Rights Charter, which will articulate what it calls a "reference framework" to guarantee citizens' rights in "the new digital age".[44] As such, the document is not a regulation or a new body of legislation, but aims to be used as a reference guide for future actions by Spanish authorities.[45] While the charter focuses on "digital rights" very broadly, it does mention neurotechnology and neurorights in particular in one of its articles.[46] The "guidance" approach has also been utilised in the United States, notably with the guidance document issued by the Food and Drug Administration (FDA), which describes it as "leapfrog guidance"[47] to guide early regulatory efforts while the FDA collects the necessary knowledge/evidence for future regulations in this field. The need for "leapfrog guidance" – i.e. for an anticipatory form of regulation that precedes the maturity of the technology – demonstrates an appreciation of the need to anticipate governance vis-à-vis the development of neurotechnologies and not wait for the most disruptive kind to be developed and brought to market before commencing regulatory efforts.

Neurotechnologies and the private sector

Across Organisation for Economic Co-operation and Development (OECD) countries, the private sector is responsible for 70% of all research and development.[48] However, there has been little systematic uptake of ethical recommendations and responsible innovation initiatives in this sector relative to the public sector.[49] The importance of the private sector in the development and deployment of new neurotechnologies shows that suitable governance frameworks need to be both flexible and relevant to the sector's dynamics. However, the limited impact that current ethical recommendations and responsible innovation initiatives have had in the private sector shows that they might have missed the mark and have limited utility outside public sector research.[50]

A patchwork of frameworks that lack tangible implementation measures often means that corporations are left to self-regulate. If the recent issues that have plagued technology giants are anything to go by, corporations, when left alone, cannot always be trusted to act in ways that avoid harm at the societal or individual level. In fact, the potential misuse of technologies or worries over their broader negative societal consequences do not translate well into corporate logic and shareholder concerns.[51] Additionally, the concepts they are often asked to abide by in recommendations are often vague and difficult to operationalise.

Geopolitics of neurotechnology governance

The development of neurotechnologies – and by extension the development of governance frameworks for them – does not take place in a geopolitical vacuum. Both processes are driven by geopolitical interests and by the desire of global powers to be leaders in this field. The successful articulation of an international governance framework for neurotechnologies and the regulations it would contain are therefore highly contingent on geopolitical rivalries. The dual-use nature of neurotechnologies, which have both military and civilian applications, means that global powers worldwide are interested in the advantages that technological advances in this field can have in terms of national security and military superiority.[52] Offensively, neurotechnologies could be deployed on the battlefield to gain strategic and tactical advantages. BCIs could augment soldiers' capacities both physically if connected to exoskeletons or cognitively through the control of emotions or heightening of awareness.[53] Advances in BCIs could also accelerate human-machine teaming, enabling the seamless integration of human soldiers with

The development of neurotechnologies – and by extension the development of governance frameworks for them – does not take place in a geopolitical vacuum.

robotic equipment creating centaur soldiers.[54] Military neurotechnologies could therefore be the only way in which "augmented" human soldiers could stay relevant on the battlefields of tomorrow, as the tempo of war accelerates and the information soldiers need to process increases concomitantly with cognitive overload. Furthermore, neurotechnologies have the potential to drastically alter the way wars will be waged in the future by highlighting the predominance of the cognitive domain over the other domains of war.[55] Ultimately, national security interests sometimes trump the desire to strictly govern some dual-use technologies.[56] Major military powers might therefore be hesitant to forgo some of the more disruptive neurotechnologies due to fears of falling behind relative to others, which would in turn dilute most international governance efforts.

Furthermore, neurotechnologies have the potential to drastically alter the way wars will be waged in the future by highlighting the predominance of the cognitive domain over the other domains of war.

It is also important to note the relative geographical concentration of the development of neurotechnologies in a few (mainly Western, with the exception of China) countries worldwide. These technologies will, however, have global impacts, so it is primordial that international regulatory efforts are truly participatory and inclusive of views from all over the world, not only from the few wealthy nations leading the development of these technologies. This will ensure the most comprehensive global protection from the most disruptive effects of neurotechnologies.

Conclusion and recommendations

As this Strategic Security Analysis shows, most neurotechnologies are still in their infancy, but have the potential to disrupt how humans interact with each other and with machines. Some applications of neurotechnologies could change what it means to be human. This requires a global discussion about the ethical standards that these technologies should rely on and about setting limitations on certain uses. This study therefore provides the following five recommendations to guide any governance system designed to ensure that the development of neurotechnologies will benefit humanity and not undermine it.

Recommendation 1: The future evolution of neurotechnologies is difficult to characterise and predict. Their advance will be potentiated by breakthroughs in AI and other enabling technologies. Moreover, neurotechnology-based solutions will be subjected to different regulatory regimes depending on whether they focus on medical, consumer or military applications. Evidence-based policymaking to control the rapid developments in this field requires reliable and unbiased sources of qualitative and quantitative information. Hence, it will be important to develop tools and means for allowing the up-to-date, comprehensive monitoring of trends in the development of neurotechnologies, their reported or foreseen impacts, and existing policy instruments. These tools can build on existing precedents such as the OECD STIP Compass,[57] the UNESCO GO->SPIN Global Observatory[58] or the EU Observatory for ICT Standardisation,[59] and provide neurotechnology-specific information.

Recommendation 2: Given the breadth of neurotechnology applications and the diversity of involved stakeholders, existing approaches to devising governance mechanisms may not be well suited to the evolution of this field. Innovative governance approaches are required to steer development and innovation in a responsible way. The seamless integration of a range of different governance instruments may be necessary to provide the reach and agility required to address the heterogeneity of the systems in question. This may take the form of a coherent suite of international soft-law instruments, legally binding treaties and laws, regulatory frameworks, technical standards, and ethical recommendations.

Recommendation 3: The development of a governance framework for neurotechnologies should be undertaken through a global, multilateral and multistakeholder process. The extent of the risks and benefits characterising the field and its geopolitical importance require wide agreement on the general principles and limits that should rule neurotechnologies. This process should aim at establishing a broadly accepted governance framework that facilitates the economically viable innovation of neurotechnologies that respect human dignity and promote sustainable development. This process should be characterised by diversity and inclusion to ensure that all sectors of society are properly represented, in particular minorities and people susceptible to being disproportionately affected by the new technologies. Geopolitical rivalries should not lead to a downgrading of ethical standards in order to gain military or power advantages.

Technological convergence means that discussions of governance systems for various emerging technologies should not be siloed and take place independently from each other.

Recommendation 4: Technological convergence means that discussions of governance systems for various emerging technologies should not be siloed and take place independently from each other. Discussions on the governance of neurotechnologies should therefore be aware of and coordinated with the corresponding discussions on the governance of other topics such as AI, data protection and privacy, bioethics, and bioweapons.

Recommendation 5: There is a need for increasing general awareness of the present and foreseen impact of neurotechnologies. All sectors of society will be impacted by these technologies and should therefore participate in the development of their governance mechanisms. Increasing efforts should be made to convey information on the state of neurotechnology-related developments and their impacts on society at large. Thus, journalists and media, policymakers, and organisational leaders need to be equipped with a clear and balanced understanding of neurotechnology advances and uses.

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