Issue Brief | October 2024

Neurotechnologies and the future of internet governance

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EUROPEAN UNIVERSITY INSTITUTE

Global Initiative for the Future of the Internet

Funded by the European Union

Published by

European University Institute (EUI), Via dei Roccettini 9, I-50014, San Domenico di Fiesole (FI), Italy

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Key takeaways

1. Neurotechnologies are poised to disrupt relevant socioeconomic rights from healthcare to human identity, blurring the lines between mind, machine, and reality. The challenges they pose are unlike any seen before.
2. The intersection of neurotechnology and Internet governance is largely unexplored on the international policy agenda. These technologies encompass not only the direct recording or alteration of brain activity but also the interpretation of emotions and mental states based on data collected from wearable devices, apps, or AI-based analysis.
3. There is fragmentation and limited knowledge about how to approach this topic through the lens of Internet governance. Questions related to neuro infrastructure, standards and access to technologies, as well as protections for neural data remain unaddressed in global Internet policy discussions; nor are they adequately captured by processes such as the Global Digital Compact or the 20th review of the World Summit on Information Society.
4. Multilateral initiatives, such as the Declaration for the Future of the Internet, provide fertile ground to kick off the discussion on the embedding of neurotechnologies as a multifaceted issue governed through a multistakeholder, rights-respecting approach.
5. As the post-2030 sustainable agenda is redefined, it is timely to consider how neurotechnology can be part of future-oriented Internet frameworks currently under negotiation.

1. The Internet to come: a fully-fledged physical-virtual integration

What was once purely speculative—the ability to monitor brain waves, transfer emotions and memories (whether true or false[1]), and influence actions in real-time—is now closer than ever. By 2030, a seamlessly interconnected, intelligent, and immersive world built on the next generation Internet (sometimes referred to as Web 4.0) will enable a fusion of digital and physical objects and environments. It will facilitate more advanced human-machine interactions (HMI) and open new avenues for innovation, growth and sustainable development. From limb rehabilitation to sleep optimisation, these cutting-edge technologies are set to become integral to virtual worlds, spanning domains such as health, education, entertainment, and also the judiciary[2] or the military[3].

Understanding a person's thoughts, preferences, and emotions enables a deeply personalised and responsive experience in virtual worlds, but can also cause unprecedented harm to individuals, communities and societies more broadly. Due to the high sensitivity of the neural processes, neurotechnologies strike at the core of mental self-determination[4] and the very origin of the self. For these reasons, the journey towards immersive world(s) must consider how Internet governance can address neurotechnologies as a key policy element of the post-2030 agenda. The neurotechnologies available today are able to perform three main functions:

- Brain-imaging, or reading the brain activation patterns;
- Neurostimulation – covering short-term interventions in neural processes;
- Neuromodulation – comprises processes inducing longer-term change in brain activity, in particular for medical uses.

Experimentation with implantable technologies, such as brain-computer interfaces (BCIs)[5] which link the human brain with computers or external devices, shows promise in supporting bidirectional communication and control, with applications in domains as diverse as gaming and telemedicine[6]. Other technical tools designed to perform specific functions (such as cochlear implants for restoring hearing), are increasingly complemented by biosensor technologies that infer sensory, motor, and mental states in a non-invasive way. These technologies include eye-tracking, video-oculography, voice recognition and analysis, sleep movement monitoring, or facial emotion recognition systems. Some wereabke IoT devices such as smart earbuds or XR glasses can already monitor neural signals or track physiological responses in real-time[7].

1 Ramirez, S., Liu, X., Lin, P.-A., Suh, J., Pignatelli, M., Redondo, R. L., Ryan, T. J., & Tonegawa, S. (2013). Creating a false memory in the hippocampus. *Science*, 341(6144), 387–391. https://doi.org/10.1126/science.1239073

2 Morse, S. J. (2015). Neuroscience, free will, and criminal responsibility. In W. Glannon (Ed.), *Free will and the brain: Neuroscientific, philosophical, and legal perspectives* (pp. 251–286). Cambridge: Cambridge University Press.

3 Binnendijk, A., Marler, T., Bartels, E. M. (2020). *Brain-computer interfaces: US military applications and implications, an initial assessment*. RAND. https://www.rand.org/pubs/research_reports/RR2996.html; EU Human Brain Project's (HBP's) Dual Use Working Group. (2023). Opinion on "Responsible dual use: Political, security, intelligence and military research of concern in neuroscience and neurotechnology". https://kclpure.kcl.ac.uk/portal/en/publications/opinion-on-responsible-dual-use-political-security-intelligence-a

4 Farahany, N. (2023). *The battle for your brain: Defending the right to think freely in the age of neurotechnology*. New York: St. Martin's Press.

5 Botes, M. (2022). Brain-computer interfaces and human rights: Brave new rights for a brave new world. In *Proceedings of the 2022 ACM Conference on Fairness, Accountability, and Transparency* (FAccT '22), June 21-24, 2022, Seoul, Republic of Korea. ACM, New York, NY, USA. https://doi.org/10.1145/3531146.3533176

6 Bernal, S. L., Pérez, M. Q., Bertlán, G. M., & Celdrán, A. H. (2023). When brain-computer interfaces meet the metaverse: Landscape, demonstrator, trends, challenges, and concerns. *arXiv*. https://arxiv.org/pdf/2212.03169

7 Kim, K., Jeong, H., Park, J., Lee, S., & Kang, D. (2023). Metaverse wearables for immersive digital healthcare: A review. *Advanced Science*, 10(32), 2303234. https://doi.org/10.1002/advs.202303234

Research on the long-term impacts of commercial neurotech applications is currently lacking[8], as are scientific studies on brain wellness products. Neuroenhancement and neuromarketing concerns have been insufficiently unaddressed. Whether aimed at improving cognitive functions or influencing consumer behaviour, these strategies could result in unpredicted harm to the nervous system and exacerbate individual and societal inequalities, potentially undermining the essence of what it means to be human. Of particular concern is that these developments take place in a largely unregulated environment, without comprehensive safety and security standards for neurotechnology hardware, software or data. Dual-use considerations aside, brain technologies pose new risks to individuals, communities and societies more broadly.

2. Current trends in neurotechnology

Neurotechnologies are advancing quickly, driven by increased specialisation and significant investments from both the public and private sectors, indicating a long-term market shift. Governments are estimated to have contributed $6 billion to national brain-research initiatives in the past decade, while private investment in neurotechnology companies exceeded $33.2 billion between 2010-2020[9]. The neurotechnology devices market is expected to grow to $24.2 billion by 2027[10].

According to a 2023 UNESCO report, the surge in funding has resulted in a 35-fold increase in neuroscience publications and a 20-fold rise in innovations, as measured by patents. However, 80% of high-impact publications come from just 10 countries, while six countries are responsible for 87% of neurotechnology patents. The United States alone accounts for nearly half of all global patent applications (47%). Other major contributors are the Republic of Korea (11%), China (10%), Japan (7%), Germany (7%), and France (5%). Together, these six countries hold 87% of neurotechnology patents filed between 2000 and 2020 in the world's five largest Intellectual Property offices[11].

The foremost neurotech innovations are primarily patented by private companies, with IBM (US), Ping An Technology (China), Fujitsu (Japan), Microsoft (US), and Samsung (Republic of Korea) leading the ranks. The analysis of patent clusters shows that key areas of focus include multimodal neuromodulation, seizure prediction, neuromorphic computing, and brain-computer interfaces. In China and the Republic of Korea, public sector universities and institutions also hold a significant number of patents, reflecting diverse interests among applicants. However, the commercialisation of neurotech is mostly driven by Big tech companies in the U.S. Significant investments in the field come from Meta, Neuralink, Alphabet and Kernel[12].

Neurotechnologies are now being adapted for a range of non-medical purposes. The example of the electroencephalogram (EEG) headsets is illustrative[13]. Beyond therapeutic purposes, EEG headsets have become available in consumer markets as meditation, stress measuring or gaming aids. By the same token, *large companies* are actively researching BCIs to allow users to control their handheld devices using brain activi-

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8 UNESCO. (2024). Outcome document of the First Meeting of the AHEG First Draft of a Recommendation on the Ethics of Neurtechnology.

9 UNESCO. (2023). Unveiling the neurotechnology landscape: scientific advancements innovations and major trends. Paris: UNESCO.

10 BCC Research. (2023). Neurotech devices: global market outlook.

11 UNESCO. (2023). Unveiling the neurotechnology landscape: scientific advancements innovations and major trends.

12 Royal Society. (2019). iHuman: blurring lines between mind and machine. https://royalsociety.org/-/media/policy/projects/ihuman/report-neural-interfaces.pdf

13 Rashid, M., Sulaiman, N., Perves, M., Musa, R. M., Ab. Nasir, A. F., & Bari, B. S. (2020). Current status, challenges, and possible solutions of EEG-based brain-computer interface: A comprehensive review. *Frontiers in Neurorobotics*, 14, 515104. https://doi.org/10.3389/fnbot.2020.00025

ty[14]. On the near horizon, external interfaces for gaming, equipment control and memory and concentration enhancement will continue to be rolled out. While thought-sharing via implanted interfaces may take decades to develop, speech decoders[15] and "typing by the brain"[16] appear much nearer.

The convergence with AI has accelerated neurotechnology advances. The interest in emotion AI[17], in particular, has been on the rise, with applications extending across healthcare, education, marketing, entertainment, and smart home systems. Neuromarketing, a new advertising field that leverages neural data to predict consumer behaviour, has also gained considerable traction. Together, these trends suggest that the groundwork for a post-2030 future is being firmly laid, highlighting both the groundbreaking innovations and the challenges facing the neurotechnology sector.

3. Internet governance and neurotechnology

Leaping from the lab into the limelight, neurotechnologies raise new questions about regulatory gaps and adequate governance structures to be put into place. No binding international framework on neurotechnology exists yet: despite the progress made in identifying the lacunae, the mind-technology intersection remains unprotected. Until now, the discussion has primarily centred on ethical and legal aspects, with more emphasison the "neuro" component and less on the technological aspects. Convergence with AI and the Internet of Things (IoT) further confounds the governance discussion, straddling different sectors, applications and regulatory mandates.

By and large, international discussions on governing neurotechnologies have taken place in silos, disconnected from broader Internet governance debates. In the emerging neurotech field, prominent actors have included intergovernmental organisations like the OECD and UNESCO, professional bodies such as the IEEE, international nonprofits like the Neurorights Foundation and Neuroethics Society, and private companies like Neuralink and Kernel. Wider alliances of policymakers, academics, civil society and citizens are increasingly joining the conversation, as the focus is gradually shifting from responsible innovation towards public governance and oversight of neurotechnologies. This shift offers a timely opportunity to bridge the silos and integrate neurotech into the future Internet and sustainable development agenda.

Significant progress on ethical and legal dimensions has been made since the early 2000s, when ambitious government-funded digital brain research programmes first started. The EU Human Brain Project and the US Brain Research Through Advancing Innovative Neurotechnologies (BRAIN) Initiative were launched in 2013, followed by Japan's Brain/MNDS project in 2014, the Korean Brain Initiative in 2016 and the Chinese Brain Science and Brain-inspired Intelligence Project in 2017. Other nation-wide initiatives focused on brain research include the Australian Brain Alliance (since 2016) and the Canadian Brain Research Strategy (2017). More recently, in 2020, the Iniciativa Cerebro Latinoamericana (LATBrain) was established, comprising ten countries from Latin America and the Carribean.

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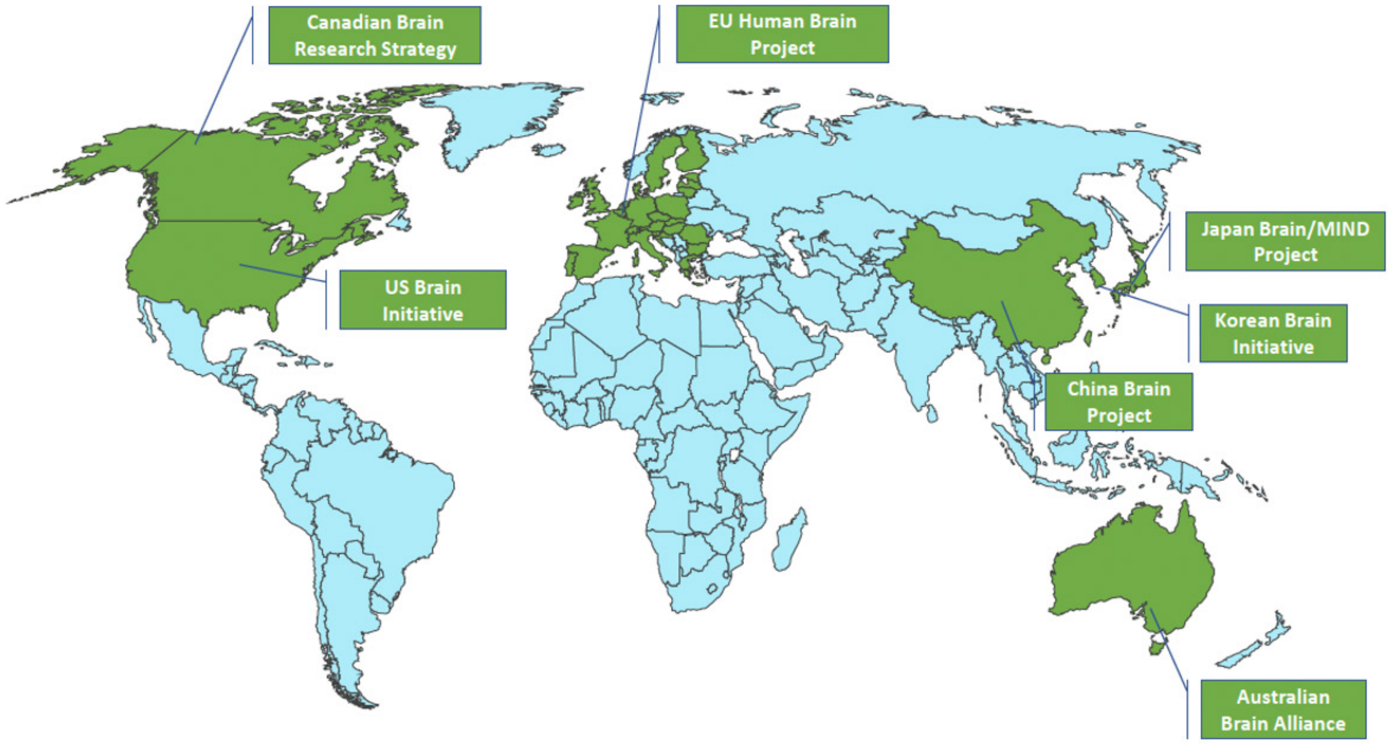
14 Meta. (2020). Imagining a new interface: Hands-free communication without saying a word. *Meta Reality Labs*. https://tech.facebook.com/reality-labs/2020/3/imagining-a-new-interface-hands-free-communication-without-saying-a-word/

15 Naddaf, M. (2024). Brain-reading device is best yet at decoding "internal speech". *Nature*. https://www.nature.com/articles/d41586-024-01424-7

16 Meta. (2021). BCI milestone: New research from UCSF with support from Facebook shows the potential of brain-computer interfaces for restoring speech communication. *Meta Reality Labs*. https://tech.facebook.com/reality-labs/2021/7/bci-milestone-new-research-from-ucsf-with-support-from-facebook-shows-the-potential-of-brain-computer-interfaces-for-restoring-speech-communication/

17 Karizat, N., Guarino, N., Kenna, D., Petralia, A., & Doorn, N. (2024). Patent applications as glimpses into the sociotechnical imaginary: Ethical speculation on the imagined futures of emotion AI for mental health monitoring and detection. *Proceedings of the ACM Conference on Human Factors in Computing Systems*. https://doi.org/10.1145/3637383

Figure 1: Government-backed and/or nation-wide brain research initiatives across the world



Source: UNESCO. (2023). Unveiling the neurotechnology landscape: scientific advancements innovations and major trends. Paris: UNESCO.

Collectively, these projects created momentum for articulating key ethical, legal and governance challenges brought about by neurotechnologies. As the fields of neuroethics and neurolaw have expanded, advocacy and policy responses have grown at both national and international levels. Since 2020, two specific areas have gained traction: (1) the development of ethical principles and (2) the alignment with human rights.

The first international soft law instrument was adopted in 2019. The OECD Recommendation on Responsible Innovation in Neurotechnology to which 39 countries have adhered outlines nine principles (see Box 1 below). More recently, in 2023, the Organization of American States has published the Inter-American Declaration of Principles regarding neuroscience, neurotechnologies, and human rights[18], which lists ten principles and builds in transparent governance, oversight and access to effective protection and remedies. In the Council of the European Union, telecommunications and digital ministers signed the first European declaration on neurotechnology in October 2023, committing to a human-centric and rights-oriented approach, while strengthening the EU's competitiveness in the field and its open strategic autonomy in a digital world[19].

18 OAS. (2023). Inter-American Declaration of Principles regarding neuroscience, neurotechnologies, and human rights

19 Council of the European Union. (2023). European declaration on neurotechnology

Figure 2. Selection of international instruments on neurotechnology by commitments

Year	International instruments	Issued by	Commitments
2019	Recommendation on Responsible Innovation in Neurotechnology	OECD	**Principles:** 1. Promoting responsible innovation 2. Prioritising safety assessment 3. Promoting inclusivity 4. Fostering scientific collaboration 5. Enabling societal deliberation 6. Enabling capacity of oversight and advisory bodies 7. Safeguarding personal brain data and other information 8. Promoting cultures of stewardship and trust across the public and private sector 9. Anticipating and monitoring potential unintended use and/or misuse.
2023	Inter-American Declaration of Principles regarding neuroscience, neurotechnologies, and human rights	Organization of American States	**Principles:** (1) identity, autonomy, and privacy of neural activity; (2) protection of human rights in the design of neurotechnologies; (3) neural data as sensitive personal data; (4) express and informed consent regarding neural data; (5) equality, non-discrimination, and equal access to neurotechnologies; (6) exclusive therapeutic application respecting cognitive enhancement; (7) neurocognitive integrity; (8) transparent governance of neurotechnologies; (9) supervision and control of neurotechnologies; (10) access to effective protection and remedies for neurotechnology-related issues.
2023	European Declaration on Neurotechnology	Council of the European Union	**Call to action:** (1) Encourage public-private co-operation for the development of rights-oriented, evidence-based and cybersecure neurotechnologies (2) Nurture a dynamic ecosystem that allows to close the gap between research, innovation, and the market (3) Consider accompanying and investment measures in neurotechnologies (4) Facilitate specialised high-level expert discussions (5) Foster dialogue with the European Commission and among Member States (6) Compel European neurotechnology innovators to be aware and adhere to a human-centred and rights-oriented approach by design and by default (7) Actively inform and involve the public (8) Create a trustworthy, transparent, and accountable ecosystem for EU-citizens to use neurotechnology (9) Collaborate with standardisation bodies to explore the need for the creation of standards for neurotechnologies, including cybersecurity standards with a focus on upholding human rights.

Source: Author's elaboration (2024) based on documents from the OECD, the OAS and the Council of the European Union

In the UN system, the Secretary-General's 2021 "Our Common Agenda" report identified neurotechnology as a critical frontier issue needing further clarification[20]. Subsequently, the UN Human Rights Council requested a report on neurotechnologies and their potential infringements to human rights, due in September 2024. Ahead of the UN *Summit of the Future*, however, the work stream on the Global Digital Compact and its third revised version[21] have not included a single reference to neurotechnology, despite wider engagement with emerging technologies in the text.In early 2024, UNESCO published a first draft of a Recommendation on the Ethics of Neurotechnology[22], based on the work of an expert group tasked to create a framework addressing neurotechnology's challenges and benefits . The draft recommendation aims to "bring a globally accepted normative instrument that focuses not only on the articulation of values and principles, but also on their practical realisation, through concrete policy recommendations and implementation plans that will be impactful for the global community". The draft – which provides a comprehensive overview of ethical challenges and calls on states to take action - was open to feedback from stakeholders until mid-July 2024. The revised text will form the basis of an intergovernmental consultation starting in September 2024, with a final Recommendation expected to be adopted in November 2025.

Closely intertwined with ethical approaches, human rights discussions have been divided between updating interpretations of existing rights and creating new ones. Proposals for novel rights aimed at safeguarding the brain, referred to as "neuro-rights"[23] have surged since 2017. By now, there is agreement in the philosophical-legal scholarship that "mental privacy, mental integrity, and cognitive liberty […] need to be considered in legal response to advances in neurotechnology"[24]. Other proposed neuro-rights include: (1) the right to identity, encompassing control over both physical and mental integrity; (2) the right to agency, ensuring freedom of thought and the ability to choose one's actions; (3) the right to fair access to mental augmentation, ensuring equitable distribution of neurotechnology's benefits for enhancing sensory and cognitive abilities; and (4) the right to protection from algorithmic bias, ensuring technologies remain free from embedded prejudices[25].

This approach has influenced a few pieces of legislation and national-level initiatives. Chile offers a paradigmatic example, having pioneered a constitutional amendment in 2021 to enshrine neurorights by protecting "cerebral activity and its data" in 2021, with the Senate approving a neuroprotection bill at the same time, establishing the rights to personal identity, free will and mental privacy. In August 2023, Chile's Supreme Court upheld these neurorights in a landmark decision[26] by ordering the neurotech company Emotiv to delete all brain data collected from former Senator Guido Girardi.

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20 United Nations. (2020). Our Common Agenda

21 Full text available here: https://www.un.org/techenvoy/sites/www.un.org.techenvoy/files/general/GDC_Rev_3_silence_procedure.pdf

22 UNESCO. (2024)`. First draft of a Recommendation on the Ethics of Neurotechnology

23 Yuste, R., Goering, S., Arcas, B. A. Y., Bi, G., Carmena, J. M., Carter, A., & others. (2017). Four ethical priorities for neurotechnologies and AI. *Nature,* 551(7679), 159–163. https://doi.org/10.1038/551159a; Ienca, M., & Andorno, R. (2017). Towards new human rights in the age of neuroscience and neurotechnology. *Life Sciences, Society and Policy*, 13(1), 5. https://doi.org/10.1186/s40504-017-0050-1; Sommaggio, P., Mazzocca, M., Gerola, A., & Ferro, F. (2017). Cognitive liberty: A first step towards a human neuro-rights declaration. *BioLaw Journal—Rivista di BioDiritto*, 3, 27–45.

24 Ligthart, S., Ienca, M., Meynen, G., & others. (2023). Minding rights: Mapping ethical and legal foundations of 'neurorights.' *Cambridge Quarterly of Healthcare Ethics*, 32(4), 461–481. https://doi.org/10.1017/S0963180123000245

25 Yuste, R., Genser, J., & Herrmann, S. (2021). It's time for neuro-rights. *Horizons: Journal of International Relations and Sustainable Development*. https://www.cirsd.org/en/horizons/horizons-winter-2021-issue-no-18/its-time-for-neuro--rights

26 Full text available at: https://static1.squarespace.com/static/60e5c0c4c4f37276f4d458cf/t/64ff46f25469ad0d0cf0c0d5/1694451443065/Sentencia+Corte+Suprema+Emotiv.pdf

Alternative proposals suggest that existing national and international legal systems already safeguard freedoms such as consent, equality, and privacy—concepts that neuro-rights claim to enhance. Internationally, the Council of Europe[27] and UNESCO's International Bioethics Committee[28] have independently determined that rather than creating new human rights, existing human rights laws and regulations should be adapted to address the specific issues posed by neurotechnology. Different civil society groups and human rights experts have issued similar opinions[29].

Around the world, governments have started considering national approaches to neurotechnology governance. Apart from the constitutional reform that took place in Chile, France issued a Charter for the Responsible Development of Neurotechnologies in 2022[30]. Elsewhere, countries like the UK are exploring under what circumstances neural data might be classified as a special category of data under existing data protection frameworks, such as the UK's GDPR[31]. Other jurisdictions, such as Spain, have specifically targeted technological convergence. Neurotechnology research is one of the priorities of the Spanish National Strategy for Artificial Intelligence, and the launch of a new National Center on Neurotechnologies has recently been approved by the government. The 2021 Charter of Digital Rights[32] included neurorights as part of citizens' rights for the digital era.

The diverse range of international, national, and regional initiatives on neurotechnology present a complex picture. While the specific opportunities and challenges of neurotechnology are well-documented in international discussions, there is less clarity on protections and path(s) forward.

4. The intersection of neurotech and Internet governance

There are specific issues that need to be addressed at the intersection of internet governance and neurotechnology, in particular around (1) **Infrastructure, standards and access**; and (2) **Neural data**. While the focus on neurotechnologies is new for Internet governance, its long history of scrutinising power distribution, public interest and multistakeholder participation would serve well the emerging neurotech discussion. The fast technological convergence in the context of virtual worlds makes this challenge more urgent.

Infrastructure, standards and access

In the Web 4.0, many neurotechnologies are expected to operate as part of complex wireless ecosystems, which can combine unimpeded movement with higher levels of network connectivity to allow for faster processing of neural data. The underlying infrastructure might be part of the global internet or distinct and specific for virtual worlds. Significant investments from private companies have targeted the creation of "enabling" platforms[33] for neurodevices, equivalent to operating systems for computers or mobile phones. The dual-use

27 Council of Europe. (2020). Strategic Action Plan on Human Rights and Technologies in Biomedicine (2020-2025). Strasbourg: Council of Europe.

28 International Bioethics Committee. (2021). Ethical issues of neurotechnology. Paris: UNESCO

29 See, for example: Global Partners Digital. (2024). Global Partners Digital contribution: Response to consultation on the first draft of UNESCO recommendation on the ethics of neurotechnology. *Global Partners Digital*. https://www.gp-digital.org/news/gpd-responds-to-consultation-on-the-first-draft-of-unesco-recommendation-on-the-ethics-of-neurotechnology/; Alegre, S. (2023).We don't need new "neurorights – we need to apply the existing law. *Financial Times*. https://www.ft.com/content/e8fcb5f2-94a2-4b2f-94f5-bc6e27d7c136

30 Full text available at: https://www.enseignementsup-recherche.gouv.fr/fr/charte-de-developpement-responsable-des-neuro-technologies-87964

31 UK's Information Commissioner's Office. (2023). ICO Tech futures: neurotechnology

32 Full text available at: https://www.lamoncloa.gob.es/lang/en/gobierno/news/Paginas/2021/20210713_rights-charter.aspx

33 See, for example, the vision of Kernel at: https://www.kernel.com/about

nature of neurotechnologies could also incentivise the separation of infrastructure or the establishment of rules covering only certain jurisdictions.

In an already uneven landscape with with Research and Development (R&D) concentrated in a few geographic regions and driven by technologically-advanced countries, the distribution of benefits comes into question. Adding to this, the significant concentration of AI computing power and manufacturing resources in the hands of a few tech giants already structure the market for neurotech. Geopolitical interests and trade wars can also affect the development of the infrastructure, limiting the choices available to middle-income and lower-income countries and regions. Access to technological and medical infrastructure is especially critical in the least developed countries and small island developing states, where communities experience significant digital divides. It is crucial to ensure equal access to the infrastructure and to the latest scientific and technological knowledge.

In the absence of interoperability standards and cybersecurity protocols, neurotechnologies pose important challenges to the Internet governance ecosystem. The evolution of the Internet has already been hindered by unequal participation in technology design and security issues[34]. Therefore, international discussions on neurotechnology need to consider the value of non-proprietary solutions and standardisation from the outset. These technologies have global consequences, making it essential for international standardisation efforts to be participatory and inclusive of perspectives from around the globe. This multistakeholder perspective is increasingly called upon by international initiatives such as the Declaration for the Future of the Internet (DFI), whose focus is to support an open, secure, reliable, free, interoperable, rights-respecting Internet governance approach that is that is capable of embedding policy needs such as neurotechnologies represent. To design brain-based systems without accounting for the specific needs of different groups, cultures, communities, and vulnerable populations would be potentially dangerous and lead to discriminatory practices.

The standardisation of neurotechnologies is uneven and incomplete, and their integration within the broader Internet systems is not adequately covered by current efforts. While safety, security and privacy are recognised as top priorities, there are significant limitations to addressing these issues using standardisation. These include a lack of agreed-upon terminology, limited community engagement, insufficient standards for data sharing, limited reporting on neurotech developments, and the need to specify complementary standards that scale from consumer to clinical applications[35]. Alignment with existing frameworks on emerging technologies is also much needed in order to address wider societal and environmental implications. This would ensure safe implementation techniques, adequate security layers and trust in the technology[36]. This approach should also integrate product lifecycle and disposal considerations from the outset. Although non-for-profit and professional organisations have started to advocate for a “Technocratic Oath”[37] or an “ethical-by-design” approach[38], standard-setting organisations, including Internet-related organisations, are not consistently involved in testing and securing the networks reaching the brain.

Cutting across infrastructure, standards and access issues, sustainability considerations need to be integrated from the start. Neurotech uses critical materials and device components resulting from processes that are detrimental to the environment and create toxic waste. Standards for environmental sustainability introduced early can help reduce their harmful impact, as stated by some initiatives from UNESCO, OECD and also the DFI as one of its commitments. As the science around technological convergence and biodegrability pro-

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34 Radu, R. (2019). *Negotiating Internet Governance*. Oxford: Oxford University Press

35 IEEE. (2020). Standards roadmap: Neurotechnologies for brain-machine interfacing. *IEEE Standards Association*.

36 IEEE. n.d. Neurotechnologies – the next technology frontier

37 Based on the proposal made by the Neurorights Foundation.

38 In line with the Neuroethics framework proposed by the IEEE

gresses, there is an opportunity to leverage technological leapfrogging alongside sustainable growth, particularly in resource-constrained settings. In the near future, changes in the business models are also needed, shifting the start-up focus on quick gains and short-term objectives towards "longer-term vision and plans required for neural interface work"[39].

Neural data and adequate protections

UNESCO's 2024 draft Recommendation on the Ethics of Neurotechnology distinguishes between neural and cognitive biometric data, but treats them in tandem as "uniquely sensitive because they provide deep insights into the pre-behavioural processes that underpin our mental states and cognitive functions". While the former refers to the brain activity patterns, thought and memory, cognitive biometric data comprises all other inferences about mental states (often AI-enabled) derived from devices and biosensors. Both types of data can influence neural processes in ways that are unanticipated or undesirable, affecting an individual's mental state and potentially transforming their societal interactions.

For these reasons, there has been a growing demand for ethical approaches and legal reconsiderations in recent years. Similarly, equitable access to (longitudinal) neurodata could be complicated by data sharing practices[40], particularly when it comes to cultural differences and the diversity of governance systems around the world.

Neural and cognitive biometric data are more difficult to anonymise, increasing the potential for identification[41] beyond the initial context of data collection. From a cybersecurity perspective, misuse might include "hacking the brain"[42] to cause disruptions, as well as new forms of data tampering and user impersonation in virtual worlds. Related security and surveillance concerns include questions about who collects the data, for how long, where they are stored and local regulations regarding companies' obligations to share data with the host country. The life cycle approach to neurotechnology is all the more important considering the types of data processed.

From the protection of individual to collective rights, brain data pose a novel set of challenges that require immediate attention. Vulnerable populations, as well as those vulnerable states, require additional safeguards. The best interests of children and adolescents need to be preserved, as neurotechnology evolves. The UN Committee on the Rights of the Child states that practices relying on "neuromarketing, emotional analytics, immersive advertising and advertising in virtual and augmented reality environments to promote products, applications and services should [also] be prohibited from engagement directly or indirectly with children"[43]. The brain's development and its plasticity require special protections, especially considering the potential to influence life chances and future opportunities.

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39 Royal Society. (2019). iHuman: blurring lines between mind and machine. https://royalsociety.org/-/media/policy/projects/ihuman/report-neural-interfaces.pdf

40 Garden, H., Winickoff, D., Arnaldi, S., & Revuelta, G. (2019). Responsible innovation in neurotechnology enterprises. *OECD Science, Technology and Industry Working Papers*, No. 2019/05. OECD Publishing, Paris. https://doi.org/10.1787/9685e4fd-en

41 Schwarz, C. G., Kremers, W. K., Therneau, T. M., Sharp, R. R., Gunter, J. L., Vemuri, P., & Jack, C. R. (2019). Identification of anonymous MRI research participants with face-recognition software. *The New England Journal of Medicine*, 381(17), 1684–1686. https://doi.org/10.1056/NEJMc1908881

42 Ienca, M., & Haselager, P. (2016). Hacking the brain: Brain–computer interfacing technology and the ethics of neurosecurity. *Ethics and Information Technology*, 18(2), 117–129. https://doi.org/10.1007/s10676-016-9398-9

43 Committee on the Rights of the Child. (2021). General comment No. 25 on children's rights in relation to the digital environment

For these reasons, it is essential to consider the long-term effects of neurotechnology on individuals using it for both medical and non-medical purposes, particularly regarding its impact on their intuition, autonomy, and decision-making abilities. Collectively, the aggregation of such data could threaten societal norms and freedoms if left unaddressed.

The opportunity to govern neurotechnologies

The nascent national and regional frameworks addressing neurotechnology, whether directly or indirectly, remain fragmented and incomplete efforts, with many regulatory and protection gaps. As such, they are likely to fall short in addressing the critical challenges outlined in this brief, specifically those related to (1) infrastructure, standards, and access, and (2) neural data. Engagement with safeguards and neuro protections for both sets of challenges is still in its early stages, largely due to the ongoing evolution of debates concerning the unique nature of brain activity. The digital rights agenda serves as a cautionary tale. Despite being on the international agenda for over a decade, its interpretation is evolving with emerging technologies, leading to very different levels of protection across the globe.

Crafting new international treaties to address these concerns is notoriously challenging, which makes convergence with the Internet governance agenda essential. Efforts by individual countries to regulate emerging technologies are often insufficient, raising concerns that neurotech companies might relocate to more favourable jurisdictions. On the other hand, soft law instruments lack formal enforcement mechanisms, rely on voluntary compliance and often result in inconsistent applications. For a domain as critical as neurotechnology, effective governance needs to go beyond in order to address the broader social consequences of technological change.

Previously siloed efforts are beginning to come together as a result of technological convergence, in particular around AI and IoT. At the regional level, the EU's AI Act[44] outlines different levels of risks induced by the development and deployment of AI systems "with the objective to or the effect of materially distorting human behaviour". While regulatory discussions in the context of emerging technologies might incorporate neurotechnology, they are not sufficiently advanced to capture the unique challenges posed by it. These new challenges, likely to affect the very essence of being human, require thorough discussions across all Internet governance and policy venues, as well as in specialised virtual worlds and Web 4.0 forums. Before definitions of key issues are agreed and governance trajectories are locked in, there is a need to include a more diverse group of actors in this process, including the different Internet governance communities active for more than three decades. For a more nuanced and comprehensive perspective on leveraging the benefits of neurotechnology, the role of the state and of regional and international organisations, as well as the responsibilities of the private sector need to be clearly outlined.

Existing internet governance frameworks and processes for a trusted Internet continue to have neurotech as their blind spot. The Global Digital Compact is a case in point, as it does not carve out space for neurotechnology in the governance trajectories it shapes. Similarly, the preparatory work for the World Summit on Information Society 20th review (known as the WSIS+20) has not referenced cutting-edge technologies that focus on the brain. Increasing awareness, transparency and safety standards for neurotechnologies used for non-medical purposes is a must for a stable and equitable Internet future. The policy dialogue on Web 4.0 would benefit from regular updates and monitoring of neurotechnology, as well as coordination across sectors and international fora.

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44 Full text available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32024R1689

Another pathway for integration stems from the implementation of the Declaration for the Future of the Internet[45]. The document outlines a shared vision of a future for the Internet that is an open, free, global, interoperable, reliable, and secure. It incorporates commitments across five pillars, including the protection of human rights and fundamental freedoms, inclusive and affordable access to the Internet and a trustworthy digital ecosystem. It embraces a collaborative governance model relying on multi-stakeholder participation to preserve a global Internet, with open and competitive markets aligned with sustainable development. Broadly formulated, these principles allow for configuring a specific focus on neuro protections in the next phase on Internet governance, combining a vision of technological development with safeguards for the inner-most sensitive part of the human body, the brain.

5. Conclusions and recommendations

Neurotechnologies are still in their early stages of development, but their potential is immense, especially when paired with AI. By leveraging neural data, these innovations promise to transform both medical and non-medical applications, fundamentally altering our daily lives in ways we have yet to fully grasp. As they develop, they raise urgent questions about access to the underlying infrastructure and technical standards, as well as neural data safeguards for both individual users and communities more broadly.

Nearly all of today's transformative neurotechnologies are connected to the Internet. Yet most international and national discussions often occur in isolation from broader Internet governance conversations. This disconnect risks ignoring the need for a unified approach that integrates neurotechnology into existing frameworks. This policy brief has examined the importance of addressing these concerns alongside Internet policy and emphasized the urgency of taking action sooner rather than later. To address these pressing challenges, a collective effort is essential, one that invites diverse stakeholder input into the development and regulation of these technologies as part of ongoing Internet governance initiatives, using the post-2030 agenda as a stepping stone.

In the short term, the deployment of neurotechnology for non-medical purposes should be top of the agenda for Internet policy-makers. This technology adds complexity to existing digital infrastructure and regulation dynamics, accelerating the need to implement clear safety and security standards across the stack. As the post-2030 sustainable development agenda is redefined, it is timely to consider how neurotechnology can fit into future-oriented frameworks under negotiation, including the WSIS+20 review due in 2025.

In the long-term, neurotechnologies could reshape human experience and societal structures in ways we are only beginning to imagine. Failing to address these concerns promptly could deepen the existing disparities and vulnerabilities and create new ones, impacting both users and the wider Internet ecosystem. Equitable access to digital and neural infrastructure, coupled with robust governance mechanisms, will be crucial in navigating the complexities of a future where neurotechnology is woven into the fabric of our lives.

45 Full text available at: https://digital-strategy.ec.europa.eu/en/library/declaration-future-internet

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Publications Office
of the European Union

doi:10.2870/6363515
ISBN:978-92-9466-621-5
QM-01-24-137-EN-N

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