INSIGHT 15

AI AND NEUROTECH-NOLOGY

AI-powered neurotechnologies are allowing people to monitor and manipulate the activities of their brain and nervous system. Further developments could bring major advances in health and wellness, but also raise significant privacy, ethical, and social concerns.

TODAY

Neurotechnology has advanced quickly thanks to AI. Neurotechnology (NT) refers to any technology that provides insight into the activity of the brain or nervous system or affects their functioning. AI's ability to process vast amounts of data, parse complex neural signals, and find patterns in brain activity has helped to develop both new **external devices and internal devices**.[1] For example, generative AI trained on brainwaves can roughly reconstruct text, images, or audio based on what a person is thinking.[2, 3, 4] AI can also be an intermediary between the human nervous system and connected devices such as neuroprosthetics. For example, AI is making neuroprosthetic legs more robust and useable, offering a more natural, faster, and less error-prone walking gait.[5]

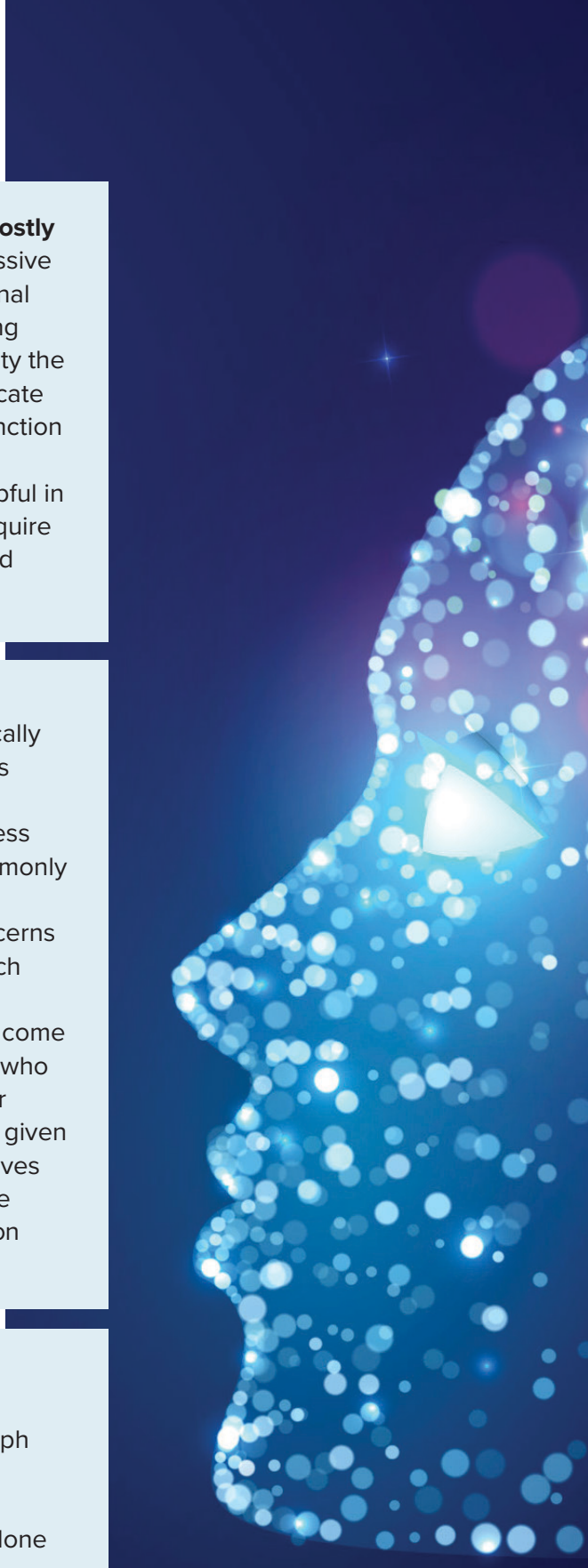
Neurotechnology involves connecting devices directly to the nervous system. They can either read electrical signals from the brain or manipulate it through stimulation.

An internal device is surgically implanted directly onto the nervous system. An external device interacts with the nervous system from outside the body. External devices are less invasive but internal devices are more capable.

The most powerful neurotechnology devices are internal, and mostly limited to medical or research purposes. Many of the most impressive and cutting-edge applications of neurotechnology require an internal device. For example, people with severe motor disabilities are using brain-computer interfaces (BCIs) – which can infer from brain activity the desire to change, move, or interact with something[6] – to communicate and control devices.[7] BCIs are also being used to restore motor function to people with paralysis.[8] Experimental brain implants that provide stimulation when they detect harmful thought patterns may be helpful in treating depression.[9] These internal devices are expensive and require surgery, which has so far limited their commercial development and adoption beyond the fields of medicine and research.

Despite some concerns, the consumer market for external neurotechnology devices is growing. Consumer devices are typically headbands or headphones equipped with electroencephalographs (EEG) that can monitor and stimulate the brain by applying a low-level electrical current. As external devices, they are significantly less powerful than their medical counterparts. These products are commonly marketed as wellness, fitness, or educational devices that claim to improve focus, learning, sleep, meditation, or athletic performance.[10, 11, 12] Concerns include lack of regulation; limited evidence of efficacy, with research suggesting a placebo effect; and possible long-term health and cognitive effects. Discrimination is also an issue, given factors of income and also useability, since 15-30% of BCI users are non-responders who cannot control a BCI accurately.[13, 14] Privacy can also be a worry: for example, in 2018, some Chinese military and factory workers were given government-sponsored hats and helmets to monitor their brain waves for fatigue and sudden changes in emotional state.[15, 16] Despite these issues, the market is projected to nearly double from USD $13.47 billion globally in 2023 to USD $25.66 billion by 2028.[17]

The latest consumer devices have more capabilities, creating new use cases. For example, in 2024 Meta unveiled prototype AR glasses with a “neural wristband” equipped with an electromyograph (EMG) that can interpret motor nerve signals associated with hand gestures, allowing discreet control of AR interfaces through subtle finger movements.[18] Meta intends to sell the wristband as a standalone product as early as 2025.[19] The forthcoming version of Empatica’s wearable – which currently notifies caregivers when an individual has had a seizure – aims to use AI to predict a seizure before it happens.[20]



FUTURES

Neurotechnology could become much more widespread and accessible. As AI and scientific understandings of the brain improve, external consumer devices could become more capable of doing what medical implants can do today. For example, commercially viable, non-invasive thought-to-text products could appear in the next ten years.[21] EEGs and EMGs could be integrated into wearables such as smart watches, fitness trackers, and headphones, making NT capabilities related to cognitive or physical performance as common as heart-rate sensors. As implants such as BCIs also become more capable, healthy individuals could decide that the enhancement or entertainment benefits they offer are worth the risks of surgery.[22]

Neurotechnology has a wide-ranging potential to revolutionize healthcare. NTs are well-positioned to target many of the leading causes of disability.[23] Neuroprosthetics and BCIs could enhance quality of life for individuals with physical disabilities. Chronic pain could be treated not by opioids but by neuromodulators, which alter nerve activity through targeted stimulus of specific neurological sites.[24] Brain monitoring might enable early detection and treatment of neurodegenerative diseases such as dementia. NT devices could treat common and debilitating conditions such as depression and anxiety.[25] AI-powered mood monitoring could become commonplace, providing continuous mental health support.

AI-powered neurotechnologies could increasingly raise concerns about cognitive rights and privacy. More capable NTs that allow access to – and influence over – people's thoughts and memories give rise to immense potential risks of harm from misuse. Consumer neurotech devices that use Bluetooth or connect to the cloud could create opportunities for sensitive brain activity data to be collected, analyzed, or sold to third parties, with or without the user's knowledge. "Brainjacking", or maliciously taking control of brain implants, could emerge as a risk.[26] As NT becomes more capable, widespread, and accessible, it is likely to come under greater scrutiny. People may increasingly demand rights to "cognitive liberty" and "mental privacy."[27, 28] More jurisdictions may follow Chile in enshrining "neurorights" in their constitution.[29]

IMPLICATIONS

- NT could increasingly be used to **read people's thoughts or anticipate their movements in real-time**.
  - This could lead to increased uptake for uses such as **predicting driver or operator fatigue to prevent accidents**.
  - However, it could also be used in more ethically fraught contexts, such as **policing, military, or worker surveillance**.
- NT interfaces could lead to **people's privacy of thought being violated**, whether by families and friends, private companies, or governments.
  - **Hacks of neurological data** could cause new psychological and physiological harms.
- **Cognitive augmentation** could improve people's ability to learn at school or perform at work.
  - If access to augmentation technology is determined by wealth, this could **widen social and economic inequities**.
  - Widespread use of cognitive augmentation could lead to **more stress and burnout at school and work**.
  - If augmentation devices remain unregulated, it may be **challenging to assess their efficacy, potential for discrimination, or safety**.
- NT could **enhance accessibility** for people with physical disabilities or cognitive impairments.
- New NT systems could emerge for **treating conditions such as depression**.
- NTs embedded in fitness trackers and earbuds could make it easier **to predict and prevent brain conditions** such as aneurysms, Alzheimer's, and dementia.
  - As devices become better able to flag emerging health conditions, **health systems that struggle with preventative care could come under increased strain**.
- Jurisdictions that support research and development in NT could reap **economic and scientific benefits from its rapid growth**.

Endnotes

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