

Ethical Challenges Posed by Brain-Computer Interface in a Medical Context

Wentao Xue *

Department of Psychology, Colby College, Waterville, Maine, USA

* Corresponding Author Email: wxue25@colby.edu

Abstract. Brain-Computer Interface (BCI) is a group of relatively recent technologies that connects Central Nervous System (CNS) activity with an external device. The resulting interconnected pathway may possess a variety of functions, from extracting and showing electrical activity in the brain to modifying entire cognitive functions. Owing to its revolutionary capability of accessing individuals' neural systems and modifying their mental states, BCI accounts for major breakthroughs in medical neuroscience, but are also ethically problematic. Under closer scrutiny, BCI notably gives rise to concerns relevant to privacy, autonomy, and identity, three basic rights of the individual. By focusing on ethical definitions, ethical scenarios, and two specific cases concerning vulnerable social groups, this essay examines the ethical repercussions of Brain-Computer Interface in the context of medical research and treatment.

Keywords: Brain-Computer Interface (BCI), Neurotechnology, Ethics, Privacy, Autonomy, Identity.

1. Introduction and Background

Since the late 1970s when researchers first attempted to apply EEG (Electroencephalogram) signals to control external objects, Brain-Computer Interface (BCI) has seen significant and groundbreaking development in the medical field. While Neuroimaging techniques—EEG, fMRI (functional Magnetic Resonance Imaging), MEG (Magnetoencephalography), fNIRS (functional Near-infrared Spectroscopy) etc.—assisted the diagnosis of brain disorders and vastly contributed to medical research and new discoveries in neuroscience, neuroprosthetics (e.g., cochlear implants) and neurostimulators (e. g. Deep Brain Stimulation/DBS) has shown great potential in treating cognitive deficiencies and mood disorders [1, 2]. Through modifying and enhancing the perceptive or cognitive functions of individuals, BCI technologies have expanded realms of sensation and stretched the boundaries of subjective experience, emerging as valid (and perhaps optimal) treatments for physical and cognitive disabilities.

While giving rise to major breakthroughs in the medical field, BCI technologies, characterized by their unprecedented power to reveal and even change neural systems that are so intimately related to our private minds and identities, also set up various ethical roadblocks. Besides posing challenges within the scope of conventional medical ethics such as patient confidentiality and informed consent, BCI technologies further complicates ethical situations by jeopardizing individuals' basic rights of privacy, autonomy, and identity. Due to BCI's prevalence in medical research and in treating disorders and disabilities, research participants and patients subject to the use of the technology—and thus also subject to information asymmetry—are most susceptible to the potential long-term repercussions associated with it.

2. Ethical Concern: Privacy

A major ethical concern posed by BCI in medical research and treatment is the privacy of individuals subject to BCI operation. Privacy is defined as “an interaction, in which the rights of the different parties collide” [3]. In the medical context, this definition sheds light on the distinct and often conflicting interests between the researchers and the participants, and also between the medical professionals, the patients, and the latter's family members. In a more concrete sense, privacy can be categorized into informational (“what others can learn about a person”), physical (the extent to which

others may “physically access a person”), and decisional (others’ potential to “limit the range of decisions one can make for oneself”) forms, all three of which are relevant to various medical circumstances and procedures [4].

2.1. Privacy in Medical Treatment

Notably, the issue of informational privacy is intimately intertwined with a wide range of BCI technologies. A marked example is imaging techniques such as EEG and fMRI, which measures and converts brain activity into visible waves or maps; in the case of fMRI, the information collected is temporally and spatially detailed enough to determine the region and extent of brain activity during certain mental states or processes [5]. The applications of fMRI allowed researchers to identify and even reconstruct the visual image someone is watching, and to access one’s specific intentions or attitudes under certain circumstances [6, 7]. Chaudhary and Agrawal (2018) identified the potential for manufacturers of consumer BCI devices to gather private data from these gadgets and “use it to make inferences about intentional or unintentional thoughts and mental processes like the extraction of pin numbers” [8]. BCI imaging techniques radically change the way one learns about another person’s cognitions, emotions, and motives, giving one an unprecedented, direct access to the other’s inner world.

2.2. Privacy in Medical Research

In the context of voluntary participation in BCI research, participants’ privacy may be in jeopardy if neuroimaging technologies give participants mean to obtain additional information about their brain functions, aside from the “primary” information the experiment set out to collect [9]. For instance, researchers might, intentionally or not, gather collateral information concerning the affective states of participants while the latter’s sensory functions are measured, disclosing private attitudes towards race or attraction to another person. In this case, participants become prone to manipulation and exploitation by external actors, and especially vulnerable due to their lack of knowledge regarding the data extracted from them. Therefore, the innate informational privacy concerns involved in brain imaging have a considerable potential for collateral harm to an individual and further breach his decisional privacy. With future advancements in imaging technologies, and as one’s brain state becomes more accessible and “transparent” under machines, the risks and implications of information breaches will only increase.

2.3. BCI and Opportunities to Enhance Privacy

While much existing discussion cautions against individuals’ loss of privacy from the use of BCI technology, that BCI offers promising opportunities to enhance the privacies of disabled individuals cannot be overlooked. In patients paralyzed due to spinal cord injury, “family members often become primary sources of assistance for various activities of daily living, such as feeding, dressing... and bladder care” [10]. BCI-controlled devices—especially implantable ones such as neuroprosthetics—will relieve caregivers of the burden to care for the disabled person exhaustively, and increasing the latter’s ability to take charge of their own daily lives [11]. The disabled person under successful treatment using BCI devices thus sees improvement in his physical and decisional privacy, where they will deal with much fewer circumstances where they are forced to receive undesired physical assistance or to rely on the decisions of others rather than those of their own.

3. Ethical Concern: Autonomy and Agency

One’s autonomy and identity may also be frequently called into question when placed under medical treatment with BCI technology. In medical ethics, a patient’s autonomy means that a patient “has the ultimate decision-making responsibility for their own treatment” [12]. Most importantly, a person’s autonomy allows him or her to preserve their identity or a stable definition of self over time. By introducing wide-ranging implications on a person’s sensorimotor and cognitive capacities, BCI

and neuroprosthetics alter one's personhood in relation to the world of sensory information, the society, and the self.

3.1. Autonomy Issues Arising from Cochlear Implants in Deaf Children

An ethically challenging case in regards to autonomy and identity issues is cochlear implants in deaf children. Hearing loss and usually underdeveloped moral and conceptual systems puts the child in a particularly vulnerable position, where they often lack a clear understanding of the personal and social implications of deafness, and experience difficulty in communicating their wills and preferences with hearing people (oftentimes including their own parents). These characteristics of the deaf child complicates the standard ethical procedure of seeking informed consent from the patient before medical treatment. For instance, it is hard for the child to comprehend and evaluate the extent of lifestyle changes they will possibly experience after the implant—a likely scenario is that they will become separated from the deaf community and will attend schools for hearing children. Furthermore, though parents and guardians are normally mandated to consent to the cochlear implant procedure “according to the child’s best interests”, the adults’ decisions are inseparable from their own interests and misgivings, and it is not unusual for adults to wrongly assume that their wishes are equivalent to their children’s [13]. Therefore, while the signing of consent forms by the patient and their guardian is mandatory before cochlear implant, a signed consent form is not identical to acquiring true consent from the child [13]. While effort can still be made to “inform” the child about the procedure, and children’s views can still be taken into account, the deaf child facing the decision to undergo cochlear implant has a considerably limited capacity to make choices and act in terms of his interests and his self-definition [13].

3.2. Identity Issues Raised by Deep Brain Stimulation

Since various forms of brain stimulation can give rise to affective change in individuals, their application in people diagnosed with mood disorders also undermine one’s personhood and cause problems related to the attribution of responsibility. In the case of treating depression and OCD with Deep Brain Stimulation (DBS), for instance, individuals may develop side effects “including hypomania, which can lead to gambling, hypersexuality, and overspending”, activities that they don’t feel as being the result of their will [5]. Due to an unprecedented change in mood leading to unusual and involuntary behaviors, individuals subject to DBS treatment may lose continuity of their personal narrative and question the authenticity of their own experience [14]. Yet since conventional ethics regard one as the agent of his own behavior, he is likely to be externally judged as responsible for these reckless actions. Brain stimulation therefore potentially creates a discord between one’s functions and one’s consciousness, which may result in the destabilization of his or her identity.

4. Conclusion

In conclusion, while medical BCI technologies provide promising possibilities for individuals with disorders or disabilities to recover and to live their lives as normal people with sufficient agency and privacy, their alteration of individuals’ sensory and cognitive systems—and their innate ability to alter the boundaries and definition of the self—give rise to ethical concerns in relation to the basic human rights to privacy, autonomy, and identity. While BCI is the source of generic ethical concerns such as reduced informational privacy of individuals, it also increases the vulnerability of specific populations with deficient or underdeveloped decision-making power, such as children and individuals with disabilities and disorders. Some BCIs, however, offers opportunities promises to improve individuals’ privacy and autonomy by enabling users to “better express and present themselves as persons who have thoughts, desires, and goals” and improving their potential for healthy, long-lasting relationships. It should be noted that, though many of BCI’s ethical impacts may not seem apparent and immediate, they gradually manifest in the long term, where they can become life-changing and affect the self-concept over time. The magnitude of BCI’s ethical repercussions is

projected to grow as the technology itself advances, since an enhanced ability for privileged individuals such as authorities to detect and change mental states in others likely exacerbates existing power imbalance, information asymmetry, and potential for exploitation. Therefore, it is all the more essential for the current medical society to thoroughly assess the social impact of BCI technologies, and evaluate the interests of various stakeholders in ethical situations, before approving them for widespread therapeutic use.

References

- [1] Freeman, W. J., Ahlfors, S. P., & Menon, V. (2009). Combining fMRI with EEG and MEG in order to relate patterns of brain activity to cognition. *International journal of psychophysiology*, 73(1), 43-52.
- [2] George, M. S., Nahas, Z., Li, X., Kozel, F. A., Anderson, B., Yamanaka, K., ... & Foust, M. J. (2002, October). Novel treatments of mood disorders based on brain circuitry (ECT, MST, TMS, VNS, DBS). In *Seminars in clinical neuropsychiatry* (Vol. 7, No. 4, pp. 293-304).
- [3] Noam, Eli. "Privacy and Self-Regulation: Markets for Electronic Privacy." 1997. http://www.citi.columbia.edu/elinoam/articles/priv_self.htm (last visited June 28, 2012).
- [4] DeCew, Judith. 1997. *In Pursuit of Privacy: Law, Ethics, and the Rise of Technology*. Ithaca, N.Y.: Cornell University Press.
- [5] Klein, E., & Rubel, A. (2019). Privacy and Ethics in Brain-Computer Interface Research. In *Brain-Computer Interfaces Handbook: Technological and theoretical advances*. essay, CRC PRESS.
- [6] Schoenmakers, Sanne, Markus Barth, Tom Heskes, and Marcel van Gerven. 2013. "Linear Reconstruction of Perceived Images from Human Brain Activity." *NeuroImage* 83: 951-961.
- [7] Haynes, John-Dylan, and Geraint Rees. 2006. "Decoding Mental States from Brain Activity in Humans." *Nature Reviews Neuroscience* 7 (7): 523-534.
- [8] Chaudhary, P., & Agrawal, R. (2018). Emerging threats to security and privacy in brain computer interface. *International Journal of Advanced Studies of Scientific Research*, 3(12).
- [9] Zander, T. O., and S. Jatzhev. (2009). "Detecting Affective Covert User States with Passive Brain-Computer Interfaces." In *2009 3rd International Conference on Affective Computing and Intelligent Interaction and Workshops*, 1-9. doi:10.1109/ACII.2009.5349456.
- [10] Dreer, Laura E., Timothy R. Elliott, Richard Shewchuk, Jack W. Berry, and Patricia Rivera. 2007. "Family Caregivers of Persons with Spinal Cord Injury: Predicting Caregivers at Risk for Probable Depression." *Rehabilitation Psychology* 52 (3): 351. doi:10.1037/0090-5550.52.3.351.
- [11] Blain-Moraes, Stefanie, Riley Schaff, Kirsten L. Gruis, Jane E. Huggins, and Patricia A. Wren. 2012. "Barriers to and Mediators of Brain-computer Interface User Acceptance: Focus Group Findings." *Ergonomics* 55 (5): 516-525.
- [12] Nineham, L. (2021, February 1). Medical ethics: Autonomy. The Medic Portal. Retrieved September 24, 2022, from <https://www.themedicportal.com/application-guide/medical-school-interview/medical-ethics/medical-ethics-autonomy/>
- [13] Hinton, V. J. (2002). Ethics of neuroimaging in pediatric development. *Brain and Cognition*, 50(3), 455-468. DeCew, Judith. 1997. *In Pursuit of Privacy: Law, Ethics, and the Rise of Technology*. Ithaca, N.Y.: Cornell University Press.
- [14] Klein, E. Informed Consent in Implantable BCI Research: Identifying Risks and Exploring Meaning. *Sci Eng Ethics* 22, 1299-1317 (2016). <https://doi.org/10.1007/s11948-015-9712-7>
- [15] Sample, Met. al. (2019). "Brain-computer Interfaces and Personhood: Interdisciplinary Deliberations on Neural Technology." *Journal of Neural Engineering* 16 (6): 1-7.