

## DEVELOPMENT OF NEUROTECHNOLOGIES: ETHICAL ISSUES AND PUBLIC DISCUSSIONS

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At present, neurotechnologies are emerging rapidly. The scope of state and private investment in the trend, which is the investment priority, is growing steadily. Interstate, national initiatives and public-private alliances for their development are created. Meanwhile, a significant potential of neurotechnologies consists not only in treatment of a wide specter of diseases and disorders of the nervous system, but also in improvement of human nature. At the same time, uncontrolled use of these technologies can violate fundamental rights. This raises the questions associated with accessibility and potential use of neurotechnologies to improve the human nature. It can produce a deep effect both on certain people, and the entire society. Development of neurotechnologies requires a highly organized approach on the part of ethics and morality with subsequent fixation of these provisions in the legislative and regulatory acts. International, state and non-governmental organizations play a great role in this case.

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## РАЗВИТИЕ НЕЙРОТЕХНОЛОГИЙ: ЭТИЧЕСКИЕ ПРОБЛЕМЫ И ОБЩЕСТВЕННЫЕ ДИСКУССИИ

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В настоящее время стремительное развитие получили нейротехнологии. Неуклонно растет объем государственных и частных инвестиций в данное направление, выступающее инвестиционным приоритетом. Создаются межгосударственные, национальные инициативы и государственно-частные альянсы по их развитию. При этом демонстрируется значительный потенциал нейротехнологий не только в лечении широкого спектра заболеваний и расстройств нервной системы, но и в улучшении природы человека. В то же время бесконтрольное использование данных технологий, может нарушать его основополагающие права. Все это поднимает вопросы, связанные с доступностью и потенциалом использования нейротехнологий в целях совершенствования сущности, что может оказать глубокое воздействие как на отдельных людей, так и на общество в целом. Развитие нейротехнологий требует высокоорганизованного подхода со стороны этики и морали, с последующим закреплением данных положений в установочных нормативно-правовых актах. В этом большая роль отводится международным, государственным и общественным организациям.

**Ключевые слова:** нейротехнологии, этика✉ **Для корреспонденции:** Михаил Юрьевич Котловский  
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Today, neurotechnologies are defined as an area of technical devices and procedures used to obtain access to, monitor, examine, assess, manipulate and (or) emulate structures and functions of the neural systems of animals or people [1]. Meanwhile, neurotechnologies are at the junction of several disciplines such as chemistry, neurology, neuropsychology, informatics, biological engineering, computer science, material science and medical technologies. Neurotechnologies cover not only direct registration of human brain activity and direct influence or modification of brain activity. They also concern any device or application including services and interfaces based on AI and big data which can extract data from human brain activity or produce a modifying effect hereon.

It is obvious that the list of technologies has a significant potential in relation to a wide specter of diseases and disorders of the nervous system. Electronic chips implanted into the nervous tissues or wearable devices display serious potential in relation to diagnostics, treatment and prevention of neurological and mental disturbances and perspective of their use among children with limited capabilities [2].

For instance, a breakthrough method was developed in 2023. It allows people with traumatic damage to the spinal cord to move in a natural way. For this, a wireless digital interface (brain-spine interface) that transmits signals in real time should be used [3].

It should however be noticed that the area of using neurotechnologies goes far beyond the sphere of medicine and covers scientific research, education and even daily life of ordinary people. For instance, decisions based on the use of neurotechnologies can improve the process of education, acquisition of skills and increase concentration [4].

Today, neurotechnologies can reveal the human nature, secrets of the human biological basis and nature of social, ethical and, as a consequence, legally significant decisions produced by the human brain.

Owing to current perspectives, neurotechnologies attracted significant attention on the part of governments and private business. In modern times, they were considered from the perspectives of investment attractiveness [5].

Based on the International Brain Initiative (IBI), research financing has been steadily increasing during the last 10 years. It leads to the growth of large-scale government programmes aimed at advance in the technology of intervention in the human brain [6].

Starting from 2013, such national initiatives as brain research due to advance of innovative neurotechnologies in the USA (BRAIN) and European Union (HBP), and large national initiatives of China, Japan and South Korea were initiated in significant financial support of respective national governments [6–8]. The Canadian strategy of brain research, which initially acted as a multilateral coalition of involved parties in this area of research, is actively searching for financial state support to be transformed into the national research initiative [9]. A similar offer is also considered in case of the Australian Brain Alliance, which calls for initiation of the Australian National Initiative of Brain Research [10].

According to the approximate assessment of state investment into these technologies, over 6 billion US dollars were invested into this trend starting from 2012 (USA). State support is complemented by a steady growth of private investment into neurotechnologies. From 2010 to 2020, the scope of investment into the company data is increased from 331 bln to 7.3 bln US dollars (by 22 times). Meanwhile, the total scope of investment to neurological companies has achieved 33.2 bln US dollars by 2020 [11].

The pronounced surge of private investment reflects the growing market demand and expansion of implemented solutions based on these technologies. It is predicted that neurotechnologies will turn into a large area capable of yielding significant social and economic dividends in the nearest future. According to previously made prognosis, the scope of the market will account for over 17 bln US dollars by 2026 already [12]. Later studies have shown that the market of neurotechnological devices can be increased from 11.3 bln US dollars in 2021 to 24.2 bln US dollars in 2027. Meanwhile, the predicted aggregate annual growth rate during the considered period will constitute 14.4% [13].

Rapid development of neurotechnologies naturally raises a number of important ethical issues in many areas. Unlike other technological investments, neurotechnologies most frequently interact with the human brain and produce an effect hereon. This may entail deep consequences for the fundamental aspects of the human existence. They include mental integrity, inviolability of the person, human dignity, personal identity, freedom of thought, autonomy and personal privacy. This raises the questions associated with accessibility and potential use of neurotechnologies to improve the human nature. It can produce a deep effect both on certain people, and the entire society [1].

It should be noted that mental integrity of a human being means that the person can handle the mental condition and brain-related data so that nobody could have a right to read, distribute or change the condition and mentioned data without the person's consent [14].

The use of brain-computer interface (BCI) is an example of ethical issues associated with the mental integrity. The devices read signals from the human brain and transform them into commands for machines. It seems that the interfaces can help people with motor disturbances or paralysis [15]. If we admit that the devices can be hacked or manipulated by fraudulent third parties, this can produce an effect not only on the physical personal autonomy but will also result in the breach of psychological integrity of persons and their right to control own thoughts and actions.

The concept of psychological integrity also means that human dignity including body integrity and respect for the principle of equality is recognized. Article 1 of the Universal Declaration of Human Rights (UN, 1984) states that all people are born free and equal in relation to dignity and law [16]. They are endowed with intelligence and consciousness. Thus, the integrity of a human body including brain and mentality should be recognized, respected and protected from any forms of neurotechnological changes. Meanwhile, illegal modification or manipulation should be perceived as violated human dignity [1].

Neurotechnologies can influence the personal identity which is related to the ability of people to think and feel on their own [1]. Thus, deep stimulation of the brain (DBS) is an example of neurotechnology that causes ethical problems associated both with human dignity, and personal identity. Deep brain stimulation is a surgical procedure when electrodes are implanted into certain areas of the brain to regulate abnormal impulses. They are often used to treat such conditions as Parkinson disease, dystonia and obsessive compulsive disorder [17]. However, DBS can change a human behavior in an ambivalent manner by decreasing positive personal capacities as well. For instance, human artistic creativity can suffer, too. A patient's memory about the past events can be distorted. In such cases, human dignity and personal identity that make people unique can be violated [18].

Growing capabilities launched by neurotechnology-associated developments including monitoring, tracking and manipulation with cognitive functions can prevent cognitive processes, especially in respect to freely taking decisions. It is of primary importance for the autonomy of an individual's will. This includes the human ability to produce independent actions that correspond to criteria of intentionality and awareness. They should be free from external effects aimed to control or determine human actions [19]. The autonomy of a will is closely interrelated with the concept of informed consent. In this respect, article 6 of the United Declaration of Bioethics and Human Rights (UDBHR) states that any preventive, diagnostic and therapeutic medical intervention, and research should be carried out based on preliminary, free, clearly expressed and informed consent of the involved person [20]. At the same time, neurotechnologies deal with additional problems associated with applicability of the informed consent principle as risks and benefits related to the use of these technologies are still to be evaluated. At the same time, respective information is currently knowingly incomplete or totally inaccessible for a patient.

Ethical issues which are connected with the autonomy of will and informed awareness can be caused, for instance, by methods of neurovisualization such as functional magnetic resonance tomography (fMRI) [21]. Neurovisualization can identify the individual thinking models and even predict human behavior. For instance, an employer can use the methods of neurovisualization to assess whether the considered applicants are suitable for employment. However, this would cause ethical issues associated with whether candidates can comprehend the consequences that can occur when brain scanning can find potential incorrect use of these data. For instance, unjust assessment of qualities that are not associated with work or disclosure of deep personal information such as susceptibility to certain mental diseases. In these cases, informed consent validity is undermined.

As neurotechnologies can record and transfer brain-related data and digital information associated with the brain activity,

they can intrude a human private life as well. The last concerns obviously violated protection of an individual from unauthorized intrusion of third persons into their mental data and from unauthorized collection of personal data.

Brain personal data, which are also known as neural data, include data associated with the brain functioning or structure. People unconsciously generate a significant amount of neural data. It means that individuals can unconsciously or unintendedly share data which they would never disclose to third persons otherwise [1].

Collection and treatment of data from a neurodevice can be used to identify certain people or brain activity especially in relation to stigmatization of neurological or mental health. These are the prerequisites of discrimination practice. It should be added that emotional reactions of consumers associated with individual preferences and risks can be traced not only within a medical sphere but also with neurotechnologies such as neurovisualization. Similar ownership of neuronal data can promote building more exact market-level predictions than possession of traditional behavioral data does [22].

It should be noted that effect of neurotechnologies on vulnerable population groups including children and adolescents deserves special attention. The category of people is more susceptible to potential adverse effects or unintentional consequences of neurotechnologies taking into account their continuing development of the nervous system and brain plasticity [23]. Admitting the fact that the school implemented the program within the frames of which students use BCI interfaces to increase their susceptibility to education can create some ethical issues. On the one hand, excessive dependability on BCI during the learning process can produce a negative effect on other cognitive skills of students including creativity or skills to solve problems independently. On the other hand, integration of neural devices and brain-computer interfaces during the critical development stages of the nervous system can hamper differences between personality traits and behavior.

Considering everything that was said above, in 2020 UN member states urged for the preparation of guidelines, which would promote the common agenda for all countries and reaction to the current and future human challenges (A/RES/75/1) [24]. They included digital technologies and potential ability to provoke disagreements in countries, diminish safety, undermine human rights and exacerbate personal inequality. In 2021, UN Secretary General read a report where neurotechnologies was presented as a boundary issue in the area of human rights. It had to be explained as far as the applicable frames and standards go to prevent harm in digital or technological space [25].

Currently, UNESCO plays a significant role in neurotechnologies by using its mandate and experience in bioethics. A report for the year of 2021 published by UNESCO presented an extensive review of ethical, legal and social consequences of using neurotechnologies and contained certain recommendations about possible ways of their implementation into practice [1]. Apart from guidelines of international discussions on this issue and discussions in the UN system, UNESCO raises community awareness and focuses on better political efforts in relation to neurotechnologies.

Report on risks and challenges associated with neurotechnologies in relation to human rights was published by UNESCO in 2022 in collaboration with the University of Milano-Bicocca and New York State University [26]. The report

has shown a global landscape of neurotechnologies, presented data about the key participants, their development area and basic achievements.

The International Committee on Bioethics, which is an expert and consultative body of UNESCO, believes that the 'neurorights' cover certain human rights, which have already been admitted in national laws, international law and international documents on human rights. These rights are based on recognition of basic human rights to physical and mental integrity, integrity of private life, freedom of thoughts and free will, right to use the benefits of scientific progress, recognition of the necessity to protect and encourage these rights in relation to application of these neurotechnologies. They also include the right to take free and responsible decisions on the issues associated with the use of neurotechnologies without any discrimination, intimidation or violence.

Regulatory acts that protect mental health or neurodata as personal data have currently been taken at the state level in some countries only [26]. The constitutional reform conducted in Chile, Charter for the Responsible Development of Neurotechnology of the Government of France and Charter of Digital Rights of the Government of Spain can serve as examples [27–29]. The cases offer various approaches to regulation and protection of basic human rights in relation to neurotechnologies. Great Britain is currently examining the circumstances in which neuronal data can be considered as a special category of data within the general system of personal information [30].

## CONCLUSION

It should be admitted today that ethical regulation of science and technology development is always late if it is based on a simple reaction to certain situations which are generated using the available or even widely applied technologies. Thus, it is necessary to predict the consequences of neurotechnology implementation beforehand by using the scenarios where society, science and technology of the future and the way they are going to interact are being reflected. Just like in case with all newly arising technologies, development of neurotechnologies requires a highly organized approach on the part of human ethics and morality. These provisions should be further fixed in legislative and regulatory acts.

Responsible innovations in neurotechnologies should constitute a result of science and society cooperation. While neurotechnology are developed, it is essential to take into account the perspectives, needs, concerns and experience of people who could use them. The educational work which is associated with what a neurotechnology is and which effects can be seen due to its development and application constitute the basic need of the today's society.

Progress in neurotechnologies needs an active interaction with the society. It is also important to ensure bilateral exchange of information and not just transfer of data from developers to users. Thus, we should strive to inclusivity by integrating interests and values to the process of creation and development of these neurotechnologies.

Attracting society attention is essential for building user's trust. This will promote a more exact adjustment of novel technologies to the needs of those who could use them. This will allow to avoid unreasonable expectations, which can produce a negative effect on public confidence in technologies and artificial intelligence.



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