

# ASSESSMENT OF NEUROTECHNOLOGIES: THE QUEST FOR SOCIAL AND PERSONAL SECURITY

Eng. Ivana Lacková Miroslava Kováčová<sup>1</sup>

<sup>1</sup>Faculty of Economics and Management – Slovak University of Agriculture in Nitra, Slovak Republic.  
mirkakovka@gmail.com

**Abstract:** *Neurotechnologies are devices that by integrated technical (neurostimulation, neuromodulation, and neuroimaging) means change activity of the human brain. There are many different types of neurotechnologies, such as neural-control interfaces, brain-machine interfaces, direct neural interfaces, auditory brainstem implants, retinal implants, predictive brain implants, deep brain stimulators, transcranial stimulators. These devices can in various degree monitor, coordinate and alternate brain activity and therefore neurotechnologies could fundamentally change the future of relationship between humans and technology. The article proposes new conceptual ramifications of neurotechnological devices, examines history of neurotechnological devices and points to possible threats and dangers of neurotechnologies for social and personal security.*

**Keywords:** NEUROTECHNOLOGIES, NEUROMODULATION, NEUROSTIMULATION, SOCIAL SECURITY, PERSONAL SECURITY

## 1. Introduction

Neurotechnological devices (for short NTDes) are brain computer interface technologies that can monitor, coordinate and change brain activity. There are many different types of NTDes, for example neural-control interfaces, direct neural interfaces, brain-machine interfaces. There are also many different devices, such as auditory brainstem implants, retinal implants, predictive brain implants, deep brain stimulators, transcranial stimulators, which all can be categorized as NTDes. There are also various administrative aspects of NTDes. The devices can administrate stimulation of electrochemical brain activity according to some external quantitative requirements (direct synchronization or desynchronization of brain activity). The NTDe can also administrate mediation of external qualitative transformations in coordination with the subject's brain activity (direct mediation of brain activity). Via advanced brain computer technologies NTDes could be also used for administrative enhancement of direct brain-to-environment and direct environment-to-brain purposes (direct coordination and enhancement of brain activity). It is therefore not surprising that NTDes are not only technologically sophisticated tools, but also represent new set of possible challenges to social<sup>1</sup> and personal security. In what follows I will therefore briefly sketch the history of NTDes, the modal operational classification of NTDes and the security implications of operational use of neurotechnologies.

## 2. Conceptual classification and history of neurotechnologies

The working mechanism of NTDes is crucially depended on various techniques that directly or indirectly monitor structures and reactions of the brain (neuroimaging), operationally classify and evaluate neuronal data (processing unit), and effectively modulate the nervous system's activity (neurostimulation). The success and operational use of NTDes is therefore the result of decades of technical and scientific advances in neuroscience, information science, electro engineering, biotechnology and medical sciences. For this reason there are many possible types and technologies of NTDes. The modern usage of NTDes is however mainly tied to the successful experimental and clinical use in neurological research.

### 2.1 First generation NTDes

The real world functional history of NTDes begins in the 1980s with the experimental and therapeutic use in the field of neural medicine. First generation NTDes were neurostimulators used mainly for deep brain stimulation in Parkinson's disease patients. In these kind of settings NTDes have been successfully used to treat

some of the symptoms of Parkinson's disease [2]. First generation NTDes were using neuromodulation techniques to directly alter brain activity in accordance with the respective quantitative therapeutic requirements (synchronization of brain activity). The goal was to effectively stimulate neuronal activity which could lead to a decrease or increase in brain, motoric or other functions (deep brain stimulation). This type of stimulation is regulated within the delivery of low-voltage electrical signals to a certain part of the brain. The exact mechanism of action of neurostimulation is not known, however it is believed that it can lead to desynchronization of abnormal oscillatory activity of neurons [3]. The neurostimulation is therefore mediated by an electrical signal, which is delivered by an electrode surgically placed in the respective part of the brain. The electrode is connected via a cable to the NTDes neurostimulator (internal pulse generator) as the source of stimulation. The neurostimulator is then usually implanted in the area under the skin near the collarbone, chest, or under the skin over the abdomen. The required range of electrical signals of the stimulation can be adjusted using another external computational instrument of the respective NTDe (access control device). Such adjustment is made by a researcher, physician. The variation is being determined according to the condition of the particular subject. In some cases, the subject maintains the ability to perform fine tuning of the actual adjustment on the access control device within the researcher, physician specified range of parameters. The targeted interference with a particular part of the brain therefore depends on the goals of the device. For example, in the case of Parkinson's disease, the most common target is the subthalamic nucleus, but interventions are also undertaken in other parts of the brain [4].

The fundamental advantages of first generation NTDes are their functional simplicity and operational reversibility. The electro stimulation is operationally reversible, because the frequency and intensity of the neuromodulation are manually preprogrammed and controlled. Take away the preprogrammed signal and the stimulation stops. Functional simplicity means that the activity of this device is exclusively unidirectional and open, since the preprogrammed signal is directed only from the device to the respective brain region. First generations of NTDes are thus based on the classical open loop system scheme. The output stimulation has no direct influence or direct effect on the control action of the input signal of the respective NTDes. The stimulation automatically and constantly follows the input command preprogrammed by the definitions of the relevant goal. This approach can be successful in many administrative settings. First generation NTDes are nowadays medically used for treatment of Parkinson's disease, essential tremor, intractable pain, dystonia, obsessive-compulsive disorder and depression [4]. Current research is focused on possible clinical usage in treatment of anorexia, addiction and wide range of other psychological disorders [5]. However every technology has its price. In the case of first generation NTDes functional simplicity

<sup>1</sup> For definitions of social security see for example article by Wojnarowska-Szpuha S., Social security determinants [1].

limits not only the relevant modes of neurostimulation, but also control. A major disadvantage of any open loop system is its inability to respond to any relevant feedback. First generation NTDes cannot self-correct any errors of the electro stimulation output. The device is poorly equipped to handle dynamic disturbances or changes in the bioelectrical and biochemical conditions of the brain. This in many cases may reduce the ability to complete the desired goal. The brain is a dynamic system and therefore the appropriate technology should also be dynamic. This problematic aspect of first generation NTDes has led to research for new and innovative operational schemes.

## 2.2 Second generation NTDes

The second generation of NTDes reflects the dynamic approach to brain computer interface relations by incorporating aspects of the closed loop system. The neurostimulator sends different neurostimulation signals to the appropriate part of the brain. These signals are monitored by neuroimaging technologies (monitor). The information obtained from the neuroimaging tools is then analyzed by the predictive processing unit. The results of this analysis affects the transmission of the form and range of other signals (calibration). The activity of second generation NTDes is thus multidirectional (mediation of brain activity). Different forms of electro stimulation signals are directed not only from the NTDe to the respective part of the brain (first generation NTDes), but also from the brain to the device via neuroimaging (information) and the processing unit (calibration, second generation NTDes). This operational scheme based on the idea of a closed loop system therefore increases the information, calibration, and hence the administrative function of the respective NTDe.

Second generation NTDes are currently experimentally used mainly for the treatment of pharmacologically resistant epilepsy [6]. The reason is that epilepsy is a neurological disease characterized by recurrent seizures. Transient cerebral dysfunction (seizure) is caused by abnormal brain activity. Various internal causes (e.g., metabolic disorder), external causes (e.g., situational stress), or combinations thereof (e.g., injury) may cause abnormal brain activity. A specific feature of epilepsy is that these causes cause seizures only in some cases. Stimulation of certain brain activities may therefore decrease, but also increase the likelihood of transient brain dysfunction. For this reason the use of open loop NTDes (first generation) is not safe and therefore not suitable for this kind of stimulation. Second generation NTDes which are operating on the closed loop system scheme however can operationally calibrate the required neurostimulation and mediate various and different brain activity patterns. The monitor (neuroimaging) records normal and abnormal brain activity of the subject. For example, an integrated electroencephalograph (EEG) is used to record brain activity. The EEG sends information to an external processing unit. The processing unit predicts the likelihood of a seizure by means of specially programmed algorithm. This information is then transmitted to the implanted neurostimulation device. Neurostimulation on the basis of mediated or direct (processing unit) assignment performs appropriate (electrical) stimulation or inhibition (neurostimulator). The whole process is recorded by the monitor (neuroimaging) and the data is sent back to the predictive processing unit, thus closing the loop of the whole system (closed loop NTDe).

The main advantages of second generation NTDes are their stability and operational flexibility. This means, that this type of NTDe doesn't require continuous control and manual calibration of the system. If the system works, than the external interference is limited. The second generation NTDes are however also potentially very flexible. These types of NTDes can be used not only for the treatment of epilepsy, but also for many other means and purposes. In theory any attribute caused by recognizable (neuroimaging) and changeable (neurostimulation) brain activity can be administered (predictive processing unit) by this device. In this sense it is therefore not surprising that for example in the United States, Italy, Spain and Poland second generation NTDes are already being experimentally used to limit impulsive aggressive behavior of

subjects with severe psychiatric disorders [6]. There are also descriptions of NTDes schemes that could be used in the administration of various other social and personality characteristics and disorders [7].

Stability and operational flexibility comes with a tax. Second generation NTDes are prone to disadvantages which are derived from the functional specialization of these types of NTDes. Effective administration is linked to the specific problem for which the respective NTDe is used. This means that second generation NTDes are theoretically multi-operational, but more or less unfunctional systems. The system can learn (predictive processing unit) to adapt to only one specific task at a time. This means that the learning process is internally closed only to the use of the respective closed loop functionality (e.g. treatment of epilepsy). There are many beneficial uses for this kind of neurotechnology, however there are also many uses that are out of reach for this kind of NTDes. The brain is a multifunctional system and therefore some of the appropriate technologies should be also multifunctional.

## 2.3 Third generation NTDes

Research into the third generation of NTDes is focused on the problem of multifunctional use of NTDes. The problems of second generation NTDes are dependent on the limitations of the learning input and output [8]. The solution is therefore theoretically pretty straightforward. Artificial intelligence has synergic effects [9]. Artificial intelligence could be used to adapt the NTDe not only to the specific brain (electrochemical brain patterns) but also to the environment as a whole. This could greatly enhance not only the learning ability of the respective NTDe, but also the potential multifunctional ability of NTDes and the brain (coordination and enhancement of brain activity). Third generation NTDes would utilize neurostimulation characteristics of the classical or advanced neurostimulator devices. Neuroimaging technologies would monitor different types of (environmental) inputs which could be than processed through the processing unit connected to the (real or virtual) environment. Adaptive deep learning algorithms (artificial intelligence) of the processing unit would link the environmental factors in the right interpretational language, which could be than used to transfer instructions to the neurostimulation device. This scheme would therefore mediated a direct brain-to-environment and direct environment-to-brain connection. Third generation NTDes could therefore enhance usability by mirroring functionalities (mirror system) of the brain and environment (brain signals, environmental signals), thus bridging the gap between (in philosophical terms) mind and matter and potentially leading to the so called age of transhumanism [10, 11, 12].

At present time third generation NTDes are partially only theoretical devices. There isn't currently any prototype that could be classified as a safe and functional full third generation mirror system NTDe. The successful use of first generation NTDes, promising results from the experimental use of second generation NTDes and some predictions about advances in biotechnological research are giving hopes for the possible technical functionality of third generation NTDes. Some expected breakthroughs in material sciences, informational science, computational science and neuroscience therefore could lead to technologies, which are required for the necessarily multifunctional ability of third generation NTDes. This isn't just an academic and futuristic speculation. The talks about robust brain computer interfaces (third generation NTDe) are nowadays step by step going mainstream. The most vocal popular proponent for this generation of technologies is for example E. Musk with his Neuralink project [13]. There are also many other companies, institutions and countries that bet on the possibility of a real world, real time brain computer connection. Projects for third generations of NTDes are on the way for example in Facebook [14], Emotive [15], DARPA [16] and EU [17]. This economical and research investment is proportional not only to the so called new tech hype, but also to the many possible uses of NTDes. Third generation NTDes will be multifunctional devices and therefore could (in principle) be used

for medical, therapeutic, industrial, informational, defense and other purposes. The possibilities of a direct fusion between brain and environment via computer are almost endless. The brain could directly manipulate with almost any kind of environment and the environment could directly mingle with almost any kind of brain (direct brain-to-environment and direct environment-to-brain connection, coordination and enhancement of brain activity). Some authors therefore even speculate that third generation NTDes could effectively merge biological and artificial intelligence and lead to super-intelligence, or the so called singularity [18, 19]. At the moment this scenario seems to be farfetched, but this doesn't change that fact, that there could be many different exciting and interesting possible uses for NTDes.

### 3. Personal and social security of neurotechnologies

Every application of new technologies comes not only with different sets of opportunities, but also with new and different sets of problems. As in every technology the successful use of NTDes is dependent on the security of the relevant technology. The operational use of NTDes is however closely linked with the idea of a direct and intimate integration of this technology with human subjects. In this sense NTDes are not only interesting because of the technological security, but also on the ground of social and personal security.

In their simplest analytical form NTDes are devices that can (or could) monitor, coordinate and change brain activity. Based on this, we can then define three functions relevant to the problem of social and personal security: The information function, the predictive function and the automation function of NTDes. The information function of NTDes is used to record unchanged and altered (after impulse) brain activity (information). It is characterized by different ways of obtaining, recording and disseminating the necessary information (neuroimaging). The predictive function is used to process and evaluate information. It is characterized by a classification of activities that can alter brain activity (predictive processing). The automation function is used to process information and implement results that were obtained and based on the prediction (neurostimulation). The automation function is therefore characterized by an operation that changes brain activity. This change can occur autonomously and automatically (closed loop, mirror system).

It's not surprising, that the automation function of NTDes is of particular concern here, because it could have direct implications for personal security, social security and the problem of human autonomy [6]. For example, it is conceivable that the automation function of NTDes could limit, completely prevent, or override subject's free decisions. It is therefore understandably that such real, or just hypothetical usages would not only drastically decrease the operational employment of NTDes, but also increase public distrust in the safe and secure use of NTDes. If NTDes had just such uses and purposes, than it is certain and right that their public evaluation would be negative, or rather straightforwardly dismissive. The so called slave to the machine problem, however, has its limits. Every sincere technology assessment should focus not only on failures, but also opportunities. Focusing only on catastrophic consequences can lead to two problematic aspects, which could make it impossible to adequately assess the case of NTDes. The first problem comes with the potentially dangerous ignorance about the many beneficial uses of NTDes. The second problems consist in the potentially perilous unawareness to other possible negative aspects of NTDes.

#### 3.1 The problem of force

It should be assumed that, if NTDes are (or will be) used to directly manipulate the brain activity of a subject who doesn't agree with the procedure (or may reasonably be expected to do so), than such use of NTDes is an unacceptable case of a threat to personal and social security. However this doesn't mean that the automation which comes with NTDes is always unacceptable and unsafe.

The classical line of reasoning against the automation function of NTDes is the argument, that all automated interventions of NTDes are potentially dangerous, because they may in some direct sense conflict with the subject's decisions. The main problem with the automation function of NTDes is that it reduces the subject to a passive recipient. This passivity prevents the subject from realizing his own will even in potentially beneficial cases. Thus, NTDes would ultimately undermine personal and social security.

The main problem with this popular argument against NTDes is the misunderstanding that automation necessarily implies coercion. In some cases automation doesn't necessarily imply a disagreement of the subject with the intervention. Criticism of NTDes sometimes operates by confusing meanings between automation, force, coercion and disagreement. These terms are neither linguistically synonymous nor necessarily linked. Automation itself is neutral in nature. Neutrality subsists in the fact, that automation does not necessarily imply subject's disagreement with the correct procedure. There are conceivable situations where, for good reasons, the subject agrees with the automated intervention of technologically secure NTDes. Such situation may be, for example, the automatic administration of pulses and brain activity that ensure a continuous good and beneficial medical condition of the subject (e.g. treatment of epilepsy). However, there are also conceivable situations where the subject disagrees with some kind of automation, for some other reasons. Nevertheless, this doesn't change the fact that the automation automatically doesn't lead to coercion. The problem of the security of the closed loop NTDes is therefore not in the problems of the device (and function) itself, but only in the real and objective assessment of the concrete situation.

#### 3.2 The problem of prophecy

Argumentation for some of the aforementioned negative and positive aspects of the actual automation use of NTDes doesn't mean, that the other functions of this device may be automatically socially and personally secure and without a problem. The predictive aspect of NTDes doesn't lead to the problem of the automated control. The predictive part of NTDes simply gives a choice to the subject. However, in some cases, the prediction may fail. A broken or corrupted NTDe could provide the subject, or the implementation part of the NTDe, with information that are false. Acting (or not acting) according to false information is manipulation of the subject and therefore dangerous to the subject and his environment. This situation could also represent a serious threat to social security and public trust for NTDes. This type of problem is mainly technological in its nature. The solution consists in adequate design practice and appropriate technical regulations.

The problems of predictive function of NTDes may also occur if the device is functioning properly. The predictive function of NTDes would seem to increase the subject's information capabilities. In some cases, however, the quality of the information does not necessarily lead to more correct decisions. People simply don't make only rational decisions. The reason for this is not only incorrect information, but also the human nature of information processing [20, 21]. Sometimes information processing can be random or arbitrary. The randomness of this process is increased by the number of steps (operations) that lead to a certain decision. Increasing the number of decision-making steps increases the likelihood of a decision being random. Randomness can subsequently lead to the possibility of an incorrect decision. The information paradox is also confirmed by some studies on decision theory [6]. Some subjects that cooperate with artificial information assistants achieve in some cases statistically worse decision-making results, than subjects that do not cooperate with the assistant at all. But it's not the technology's fault. The results of some subjects cooperating with the assistant are even statistically worse than some of the proposed solutions of the artificial information assistant itself. The randomness of human behavior leads to the fact, that people can make bad choices even with the right incentives and information. The more this right information is conveyed the greater is the risk, that it will not be properly evaluated and implemented by

the subject. This in turn means that a better effect would be achieved if NTDes were not used at all, or if these devices were fully automated. Thus, in some cases, predictive function of NTDes may not increase personal security. In some cases open and transparent predictive information may lead to decisions that are incorrect for the subject, his environment and society.

### 3.3 The problem of secrecy

The last function of NTDes is the information function. On its own this function prescribes nothing, but only informs. The information just ensures that the subject and the NTDe are "aware" of their condition and functions. Information increases knowledge of the subject and the operational functionality of the NTDe. The relevant information therefore increases the possibilities for the right kind of procedure. If the relevant procedure is the main goal, then the information function of NTDes doesn't seem to be problematic. Other problems arise when we concern other aspects of the whole situation. The main problem could be privacy and new privacy standards. The efficient information function of NTDes will fundamentally change some of our assumptions about relevant privacy settings. For some technological and other research reasons NTDes not only use, but also record information. This recording is used for the right kind of calibration of the entire loop of the respective NTDe and for the classification of other future uses of different kinds of NTDes. The successful use of NTDes therefore requires that some of the information about the subject's brain activity are not, in the strict sense, private anymore. Thus in some cases the NTDes may significantly undermine the subject's own privacy.

The problem isn't only the possibility of invasion of the subject's privacy, but mainly the possibility of exploiting personal data which are of a completely new and different kind. This data and information are integral parts of every subject and therefore essential characteristic of everyone's personal and societal security. Recognizing this fundamental qualitative difference of NTDes can help us to understand the new qualitative aspect of protection that this exciting technology requires.

### 4. Conclusion

NTDes compromise promises for technologies that could fundamentally challenge and change the relationship between the human brain and the human world [22]. NTDes therefore represent novel cognitive tools, which could revolutionize not only many aspects of scientific inquiries, but also some new aspects of anthropological self-understanding. First and second generation NTDes are now successfully used in the treatment of many serious and chronic diseases, psychological disorders and personal disabilities. We should therefore not assume that the current scientific research is focused only on some theoretical, hypothetical and controversial applications. Too much focus on some negative visions makes it impossible to see that NTDes are (and could be) used to help many people, which are in great need. However, this doesn't mean that NTDes are entirely unproblematic. NTDes belong to technologies with high security ramifications. Concerns about the security of machine-driven behavior are understandable, but automation and prediction doesn't automatically mean negative and false personal coercion. The automation and predictive function of NTDes is crucially determined by the information function of NTDes. Without a critical amount of the necessary information, neither prediction nor automation is possible. The sensitive nature of this information implies that the solution should consist in the critical analysis of the information security of NTDes. Neurotechnology of brain activity isn't only a quest for knowledge, but also a quest for social and personal security of knowledge.

### 5. References

- [1] Wojnarowska-Szpucha S., Social security determinants, *Security & Future*, 2 (4), 2018, pp.158-162.
- [2] Miacinovic, S., Somayajula, S., Chitinis, S., Viterk, J. L., History, applications, and mechanisms of deep brain stimulation, *Journal of the American Medical Association neurology*, 70 (2), 2013, pp. 163-173.
- [3] Popovych, O. V., Tass, P. A., Control of Abnormal Synchronization in Neurological Disorders, *Frontiers in neurology*, 5 (268), 2014.
- [4] Odorčák, J., Hĺbková mozgová stimulácia, identita a perdurantizmus, *Filozofia*, 69 (6), 2014, pp. 472-481.
- [5] Gardner, J., A history of deep brain stimulation: Technological innovation and the role of clinical assessment tools, *Social Studies of Science*, 43 (5), 2013, pp. 707-728.
- [6] Odorčák, J., Neuroadministratívne zariadenia a autonómia subjektu, *Filozofia*, 73 (6), 2018, pp. 449-457
- [7] De Ridder, D., Langguth, B., Plazier, M., Menovsky, T., Moral Dysfunction: Theoretical Model and Potential Neurosurgical Treatments. In: Verplaetse, J., De Schrijver, J., Vanneste, S., Braeckman J., (eds.) *The Moral Brain. Essays on the Evolutionary and Neuroscientific Aspects of Morality*, New York: Springer, 2009, pp. 155-183.
- [8] Valuch, J. M., *Neurotechnologie, mozek a souvislosti*, Praha: Galaxy, 2006.
- [9] Radulov, N., Artificial intelligence and security. *Security 4.0, Security & Future*, 3 (1), 2019, pp. 3-5.
- [10] Bobryk, J., Transhumanizm, cognitive science I wyzwania, *Studia Socjologiczne*, 3 (214), 2014, pp. 9-27.
- [11] Klinec I., Transhumanizmus. Budúcnosť človeka v 21. Storočí. (Available online) <http://www.akademickyrepozitar.sk/sk/repozitar/transhumanizmus-study-text.pdf>
- [12] Odorčák, J., Kritika transhumanistickej kritiky Friedricha Nietzscheho, *Filozofia*, 65 (6), 2010, pp. 552-556.
- [13] Musk, E., An integrated brain-machine interface platform with thousands of channels, *BioRxiv*, 2019. (Available online) <https://www.biorxiv.org/content/10.1101/703801v1>
- [14] Facebook, Imagining a new interface: Hands-free communication without saying a word. (Available online) <https://tech.fb.com/imagining-a-new-interface-hands-free-communication-without-saying-a-word/>
- [15] Emotive, The Introductory Guide to BCI, (Brain-Computer Interface). (Available online) <https://www.emotiv.com/bci-guide/>
- [16] Miranda, R. A., Casebeer W. D., Hein A. M., Judy J. W., Krotkov E. P., Laabs T. L., Manzo J. E., Pankratz, K. G., Pratt, G. A., Sanchez, J. C., Weber, D. J., Wheeler T. L., Ling G. S., DARPA-funded efforts in the development of novel brain-computer interface technologies, *Neurosci. Methods*, 244, 2015, pp. 52-67.
- [17] Bauernfeind, G., Brunner, C., Müller-Putz, G., Steensel, M., Otal, B., Pichiorri, F., Schettini, F., Real, R., Blefari, M., Höhne, J., Poel, M., D1.4 - BNCI Horizon 2020 – Roadmap, 2015.
- [18] Vinge, V., The Coming Technological Singularity: How to Survive in the Post-Human Era, In: Landis, G. A. (ed.) *Vision-21: Interdisciplinary Science and Engineering in the Era of Cyberspace*, NASA Publication CP-10129, 1993, pp. 11-22.
- [19] Odorčák, J., Kopírovanie zabíja identitu osoby, *Filozofia*, 70 (5), 2015, pp. 367-377.
- [20] Mráz, M., Urbanovičová, O., Findura, P., Prístavka, M., Use of information systems to support decision making according to analysis machines, *Mechanization in agriculture & Conserving of the resources*, 65 (2), (2019), pp. 59-62.
- [21] Szyłkowska, M., Human factor in the proliferation of threats, *Security & Future*, 2 (2), 2018, Issue, pp. 55-57.