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THE NEUROENHANCEMENT OF HEALTHY INDIVIDUALS USING tDCS: SOME ETHICAL, LEGAL AND SOCIETAL ASPECTS

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ABSTRACT

Over the past two decades there has been increasing scientific interest in Human Enhancement, that is, the possibilities of expanding and enhancing the capabilities of healthy individuals with direct technological interventions into the body. The (sub)field of neuroenhancement, which explores attempts to technologically increase attention, memory, perception, learning and other cognitive capabilities, as well as alter mood and emotions, has become especially prominent. Recently, transcranial Direct-Current Stimulation (tDCS) has emerged as a possible method for enhancing cognitive abilities in healthy individuals. The article provides a short overview of the concept of neuroenhancement and of the cognitive enhancement effects that tDCS has demonstrated in the scientific literature. It further focuses on the (neuro)ethical, legal and societal implications of such a practice, and points out issues and questions that especially require further research and investigation, both from a neuroscientific and from a social sciences and humanities perspective. tDCS could become another addition to the increasing set of Human Enhancement Technologies, but it requires further rigorous studies and trials in order to properly assess its potential risks and benefits.

KEY WORDS

tDCS, transcranial direct-current stimulation, neuroenhancement, cognitive enhancement, neuroethics

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INTRODUCTION

Human Enhancement, the idea that the physical and mental capabilities of healthy people can be expanded or increased through direct technological interventions into the body, especially the brain, has become a subject of increasing discussion and investigation in the scientific community over the course of the last twenty years [1, 2]. While there are still many conceptual and normative disagreements about the notion itself, Human Enhancement can be generally expressed as meaning "an intervention that improves the functioning of some subsystem of an organism beyond its reference state; or that creates an entirely new functioning or subsystem that the organism previously lacked" [3; p.179]. The reference state can be taken as the normal, healthy or average functioning of an individual's specific ability or trait, or as referring to the species-typical or average range of an ability or trait. An entirely new functionality would be one that no member of the human species has previously possessed, for example infrared vision or controlling a machine with thoughts. In this way, enhancement can be seen as different from therapy, although the attempts to turn this differentiation into a normative one have proven unsuccessful, especially considering the changing nature of norms, values and medical goals in contemporary societies. There is a wide range of technologies and applications, some already in use, some still experimental, others only theoretical, that have been discussed as potential Human Enhancement Technologies. These range from prescription pharmaceuticals, such as methylphenidate (Ritalin) and steroids, through gene and stem cell therapies, to cybernetic implants and brain-computer interfaces. The application fields of Human Enhancement Technologies can be roughly separated into healthy lifespan extension/anti-aging therapies, the enhancement of physical capabilities, and neuroenhancement, although there is also considerable overlap between these fields, as the enhancement of some specific system can have simultaneous effects in more than one of them.

The field of neuroenhancement can be further divided into at least three subfields, namely Cognitive Enhancement [4], Mood and Affective Enhancement [5], and Moral Enhancement [6]. Cognitive enhancement is usually seen as aimed at improving the cognitive capabilities of healthy individuals, such as attention, memory, wakefulness and executive function [7], mood enhancement targets emotional processing and subjective emotional states, while moral enhancement is focused on improving altruistic, cooperative and virtuous behavior. The enhancement of such capabilities is most often explored through the use of prescription pharmaceutical and experimental psychopharmacological substances, and while Pharmaceutical Cognitive Enhancement (PCE) has been the main focus of research and debate in this field [8] over the last two decades, newer methods for potentially enhancing cognitive capabilities have opened new possibilities and new dilemmas in recent years.

These newer neuroenhancement methods are enabled by non-invasive brain stimulation (NIBS) devices, such as Transcranial Magnetic Stimulation (TMS) and Transcranial Current Stimulation (TCS), the latter most notably as transcranial Direct-Current Stimulation (tDCS) [9]. Such tools promise to be less invasive and without as many systemic side effects as the use of pharmacological substances, while still facilitating similar enhancement effects. For the time being, TMS remains costly and (relatively) complex due to its hardware requirements, while tDCS with its technically simple, readily available and cheap hardware has been rapidly adopted in scientific and medical research and clinical trials, and has also quickly spread among the amateur community of Do-It-Yourself (DIY) technology enthusiasts and neuroenhancement (self)experimenters [10, 11]. And although there are still many open and pressing technical (pharmacological), ethical, legal and societal issues connected with PCE [12, 13],

some of which are shared by tDCS use, the latter brings with it its own issues and challenges, as well as opportunities.

The primary focus of this article will be on the potential use of tDCS as a method for enhancing the cognitive capabilities of healthy adults and on presenting some of the (neuro)ethical, legal and societal implications of such a practice. The article will also briefly touch on some possibilities and aspects of using tDCS in the other two neuroenhancement subfields, namely mood enhancement and moral enhancement.

COGNITIVE ENHANCEMENT AND tDCS

Cognitive Enhancement in the context of Human Enhancement usually refers to attempts to increase human cognitive abilities or functions that are already considered to be in the normal or healthy range, through the use of technological means that directly target the underlying neurophysiological mechanisms. In this way, the Nuffield Council on Bioethics defines cognitive enhancement as "the use of interventions to improve cognitive functioning and performance, where these are not impaired in clinically significant ways … such as attention, understanding, reasoning, learning, and memory … loss of painful memories might equally be viewed as a functional improvement" [14; p.164], and Galert and colleagues as "improvements in cognitive performance, which are not intended to pursue therapeutic or preventative goals, and which employ pharmacological or neurotechnical means" [15; p.40]. The targeted cognitive abilities usually encompass perception, attention, memory, motor abilities, language skills, visual and spatial processing, and executive functions [7], although some definitions entail a broader scope of mental states and functions, including emotions, mood and non-ordinary states of consciousness.

For the purposes of this paper, the technological means of cognitive enhancement under scrutiny are tDCS devices. These are technically simple, composed of a battery-powered device, which delivers the electrical current, and of two electrodes (one positive and one negative) that are placed on specific areas of the head, whereupon a weak direct current is sent through the cortical brain matter for a short time. This leads to increases or decreases of neuronal excitability in the target area, and to changes in the functioning of the underlying mechanisms [9]. As influencing a specific ability or system requires a quite exact placing of the electrodes, an accurate mapping of sites on the scalp that correspond to individual cognitive functions is one of the requirements for further progress in this area. Although the precise functioning and structure of the mechanisms involved in various cognitive functions are not yet fully known, this is not necessary for eliciting enhancing effects, which can be gauged through experimentation. While the technique of transcranial electrical stimulation itself has a long history [16], with widespread unregulated commercial use between 1740 and 1930 in depressive patients and in various attempts to increase wellbeing and enhance performance in the healthy, tDCS has only been rediscovered as a research tool in neuroscientific investigation and a therapeutic method for various disorders and diseases in the last decade. Its applicability as a tool for cognitive enhancement has only come to be recognized over the past few years, with the discovery of enhancing effects in healthy individuals [17].

The cognitive enhancement effects from medical and neuroscientific research include improvements in attention [18], memory [19], facilitation of insight in problem solving [20], improvement of numerical abilities [21], enhanced learning of novel and challenging motor skill tasks [22], and of language acquisition skills [23]. In many instances, tDCS seems to increase the learning capability of the brain, and is especially effective when stimulation is combined with training and learning activities. Regarding mood, tDCS did improve (positive) emotional processing, but did not influence subjective emotional states in healthy people [24].

More precisely, this means that the subjects perceived the facial expressions of other people as more positive and friendly, while their internal mood or emotions did not become more positive than they already were. While the duration of such enhancing effects is usually short-lasting, they can be increased through greater time length and current intensity of the stimulation. It should also be noted that improvements in one capability or faculty often lead to diminishment in another [25], and that improvements in processing in one hemisphere often impair processing in the other [17], therefore the trade-off nature of such enhancements needs to be taken into account. Similar effects have been observed in PCE, where there was also a diminishment in general capabilities with increasing dosages. The latter has not yet been observed with increasing current intensity and duration of tDCS, although there are at least some (anecdotal) reports of short-lasting mental blackout caused by personal experimentation outside of established parameters.

Apart from use in the research and clinical setting, such devices are now commercially available for purchase over the internet [26, 27], and their potential enhancement use and benefits, in no small part driven by the DIY tDCS community, have become popular and often strongly magnified in the media [28]. In this way, the trend of amateur enhancement and experimentation use of tDCS can be predictably expected to continue and grow in the coming years.

ETHICAL, LEGAL AND SOCIETAL ASPECTS

There are numerous open ethical, legal and societal issues connected with the various aims and means of improving human performance in the context of Human Enhancement [29]. In the scope of tDCS used for cognitive enhancement purposes, as with other technologies, the primary considerations are safety and efficacy. The application of tDCS use is generally considered safe, having been conducted in thousands of subjects, usually with only mild, benign and transient side effects [30]. Thus it appears to be safe within established research protocols, although long-term and persistent use could have unwanted side-effects, especially when greater duration and intensity of stimulation is used, which is a salient concern in the DIY and amateur use of such devices. Also, enhancement uses should require a higher safety threshold than more clearly therapeutic uses, and tDCS seems to fulfill this requirement, in contrast to most current PCE substances. Thus it might prove to be a safer (and less expensive) alternative to at least some psychopharmaceuticals currently used (off-label) for cognitive enhancement by individuals in various demanding fields, including the military, medical research, academic and entrepreneurial spheres. Further safety concerns pertain to considerations of tDCS application on children and teenagers, as it might have completely unknown physiological and psychological effects on developing brains that were not present in healthy adults, and potential enhancement use opens many questions concerning the rights and obligations of parents [31]. This presents a special concern when such devices are commercially available to parents of children with actual or perceived neurophysiological developmental problems outside of any professional (medical) supervision and counseling.

The studies listed in the previous section show that the cognitive enhancement effects of tDCS, although transient, are tangible. Nevertheless, the outcomes are not always consistent, even when identical protocols are used. This variation seems to be due to anatomical differences between individuals, especially those with atypical brains [32], and would need to be considered in future research and application. Given that a firm and defensible normative distinction between therapy and enhancement uses remains elusive [12, 13], much of the debate about the ethical, legal and societal implications of tDCS enhancement use will revolve around its costs and benefits.

The potential positive implications for individuals and societies could for example entail societal savings from decreased numbers of accidents and errors at work and in personal life due to enhanced attention, decreased costs and losses due to better memory and increased social productivity due to enhanced cognitive capabilities [33]. Especially important might be decreases in costs due to the reduction of the time and resources needed for general learning, education and acquisition of skills and knowledge, as well as reduced personal costs and frustration involved in difficult and unsuccessful learning attempts.

The weight of potential benefits strongly depends on extensive further study of the enhancement effects in healthy adults, with proper and rigorous interpretation of empirical data, leaning strongly on the optimization of research frameworks and stimulation protocols and standards, as well as results from the study of therapeutic uses. Unrealistic expectations of enhancement effects, often overhyped by the media and enthusiastic amateur users, especially need to be moderated by such empirical investigations.

Further important questions are concerned with the impact of tDCS use on personal identity, autonomy and authenticity. Enhancement through tDCS could result in changes in personal identity, and questions of whether these are ethically acceptable, especially if they foster a sense of wellbeing and autonomy [34] have been raised. In this regard, it would not be imprudent to assume that increases in wellbeing that also contribute to increased autonomy and engagement with the world can be regarded as personally positive and ethically acceptable. Authenticity has been often discussed in PCE, especially whether such means constitute a form of cheating, and there are good arguments that enhanced minds can be authentic [35]. Namely, if an individual uses tDCS to strengthen their abilities in attaining specific personally important goals, then it cannot be claimed that such a strengthened pursuit is inauthentic, no more than any technological shortcut makes any endeavor inauthentic. Furthermore, the use of tDCS does not mean that there is no longer any need to perform the learning or practice, only that these can be more effective with the application of tDCS, while an individual still needs to bring forth the effort required to engage in study or practice. The notion of cheating is closely tied to issues of distributive justice and access, which are, due to the inexpensiveness and simplicity of TDCS devices that can easily be assembled at home from inexpensive components, much less of a concern than in the case of expensive pharmaceuticals and other emerging neurotechnologies, which might exacerbate the capabilities gap between the rich and the poor. In case the benefits turn out to be large and the risks negligible, society might also opt to specifically promote such means, for example through subsidized access. Significant benefits to users and wide societal acceptance usually entail indirect coercion even of those who would otherwise not choose to use the technology, in order to stay competitive at the workplace or in school. The availability of proven and safe methods for cognitive enhancements also leads to considerations of expanding duties for specific professions where increased cognitive capabilities are important, such as pilots, surgeons, firemen, etc., leading to arguments that such professionals might have a duty to engage in cognitive enhancement [36]. Some authors have suggested that emerging neurotechnologies could also be used to promote virtuous behavior, increase happiness and suppress vice [37], thus enabling individuals to more easily attain desired personal characteristics or enable society to produce better citizens, which again opens many questions concerned with autonomy, authenticity and coercion. Further, tDCS might be used to elicit non-ordinary or mystical experiential states, including euphoric experiences. This raises questions of whether states elicited by tDCS are qualitatively comparable to "naturally" elicited ones and whether such shortcuts carry their own costs. They might also raise questions connected with drug policy, especially if the triggering of euphoric states has negative neurophysiological effects and changes comparable to those of illicit drugs, but also

about tolerated use if it proves to be less harmful. The ability of tDCS to trigger behavioral changes in individuals, such as reducing the propensity to punish unfair behavior [38] or influencing compliance with socially constituted sanctions [39], poses strong concerns regarding the abuse potential of triggering (nonconsensual) manipulative changes in individual behavior. Further concerns, as with practically any technology, are its military uses, for example in augmenting the perception, alertness and other cognitive capabilities of soldiers, as well as pilots and other combat operators, thus improving their performance on the battlefield. In this regard, the effectiveness of tDCS in reducing sniper marksmanship training time has already been demonstrated [40]. But the question of the (un)ethical (ab)uses of new technologies is ultimately a question of proper societal regulation, not of the technology itself being intrinsically either good or bad.

The primary implications for public policy in regard to tDCS use for cognitive enhancement entail considerations of whether access and use by healthy individuals should be supported and possibly encouraged for specific uses by specific populations, or even generally, whether governments might impose certain restrictions. Further considerations include how vulnerable groups and populations that would be unwilling to engage in such practices could be protected from harm. In this regard, the DIY or amateur self-experimentation use poses some pressing challenges for regulation, and some experts have called for regulatory frameworks that would regulate commercial tDCS devices as medical devices, ensuring quality and safety standards, and use by skilled operators, in order to prevent threats to public health and vulnerable populations [41]. Such considerations would of course need to be supported by expert ad stakeholder opinions and by empirical research data in order to produce a well-informed and evidence-based policy. A good policy would ultimately engage regulators, scientists and the DIY community in crafting policy proposals that ensure public safety while still supporting (DIY) tDCS innovation [42].

CONCLUSION

Much of the debate concerning neuroenhancement has until now been focused on the off-label use of prescription pharmaceuticals, but the growing body of knowledge and experience with tDCS, as well as its DIY spread, is showing the need to discuss such issues with a focus on tDCS. A balanced policy promoting safety and innovation will need to consider both the requirement of ensuring public health and protection of vulnerable groups, and the fact that adults will employ such easily accessible neurotechnologies in pursuit of their own goals regardless of regulation. In this regard, DIY tDCS users might consider that the enhancement uses of tDCS could be employed strategically, to complement other techniques and approaches according to ones goals and needs at specific times, while following tested protocols and guidelines. They should also keep in mind the comparative cognitive enhancement effectiveness and additional benefits of more traditional and established non-invasive interventions, such as proper nutrition, exercise, sleep, rest, relaxation, mind-training, meditation, etc. [43], which can all contribute significantly to achieving an individual's optimum (biological) state. Furthermore, the DIY tDCS community represents a rich source of experimental information, which, although not rigorously controlled, van nonetheless provide valuable insights into personal experiments and experiences, both from a neuroscientific and a sociological viewpoint [44, 45]. Even if tDCS fails to provide consistent enhancement effects for the general population, it might still prove useful as a tactical tool for some individuals and for some occasions when ones ordinary capabilities are below average, for example due to (mental) exhaustion or lack of sleep. In this way it might prove to be another step in achieving rapidly flexible mental states that are demanded of us in today's increasingly high-speed and complex society. Of course, as has

been stressed before, safety considerations need to remain a priority where enhancement practices are concerned.

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NEUROPOJAČAVANJE ZDRAVIH INDIVIDUA PRISTUPOM TDCS: NEKI ETIČKI, ZAKONSKI I DRUŠTVENI ASPEKTI

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SAŽETAK

Tijekom zadnja dva desetljeća raste znanstveni interes za ljudsko pojačavanje, tj. za mogućnost proširenja i pojačavanja sposobnosti zdravih individua izravnom intervencijom u tijelo. Metode neuropojačavanja koje istražuju mogućnosti tehničkog povećavanja pažnje, pamćenja, percepcije, učenja i drugih kognitivnih sposobnosti, kao i mogućnosti utjecanja na volju i emocije, izrazito su istaknute. Metoda transkranijalne stimulacija istosmjernom strujom (tDCS) u novije vrijeme javlja se kao moguća metoda pojačavanja kognitivnih sposobnosti zdravih individua. Ovaj rad daje kraći pregled znanstvenih rezultata o konceptu neuropojačavanja i kognitivnog pojačavanja metodom tDCS. Nadalje, rad se fokusira na (neuro)etičke, zakonske i društvene posljedice takve prakse te ističe probleme i pitanja koja posebno zahtijevaju daljnja istraživanja s neuroznanstvenog stajališta i sa stajališta društvenih i humanističkih znanosti. Metoda tDCS može postati dodatak rastućem skupu tehnologija ljudskog pojačavanja, ali to zahtijeva daljnja rigorozna istraživanja i provjere zbog pravilnog izvrjednjavanja potencijalnih rizika i koristi.

KLJUČNE RIJEČI

tDCS, transkranijalna stimulacija istosmjernom strujom, neuropojačavanje, kognitivno pojačavanje, neuroetika