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ORIGINAL PAPER

Bonding Brains to Machines: Ethical Implications of Electroceuticals for the Human Brain

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Abstract Novel neurotechnologies like deep brain stimulation and brain-computer interfaces promise clinical benefits for severely suffering patients. Nevertheless, such electroceuticals raise several ethical issues on different levels: while on the level of clinical neuroethics issues with direct relevance for diagnosis and treatment have to be discussed, on the level of research neuroethics questions regarding research and development of these technological devices like investigating new targets and different diseases as well as thorough inclusion criteria are dealt with. On the level of theoretical neuroethics more general questions are examined including anthropological considerations on "normal" human functioning as well as implications on personality, personal identity and authenticity. This paper presents a brief review on ethical issues of deep brain stimulation and brain computer interfacing and simultaneously introduces to this themed issue with thirteen contributions dealing from different perspectives with ethical implications of electroceuticals for the human brain.

Keywords Deep brain stimulation · Brain computer interface · Medical ethics · Research ethics · Enhancement

Introduction

Electroceuticals are defined as medical treatments based on electrical impulses [1]. While Kristoffer Famm and colleagues see a bright future for interventions which might target individual nerve fibres and modulate single action potentials, most of today's devices function less specifically. Current neurotechnology includes a broad range of devices which contact different sites of the nervous system. The contribution at hand focuses on the ethical aspects of currently available electroceuticals contacting the human brain. These neurotechnologies include devices for stimulating purposes as well as for recording purposes respectively. The ethical discussion usually concentrates on two technological approaches: deep brain stimulation (DBS) and brain-computer interfaces (BCI). DBS is the most frequently used therapeutic technology for directly stimulating the human brain and is especially applied in the treatment of end-stage Parkinson's disease. BCIs record signals from the brain to control external devices like computers or prosthetic limbs. This paper aims to present both, a brief review of the ongoing debate on the ethical implications of these neurotechnologies and an introduction to this special issue of thirteen papers covering a broad range of ethical implications the use of electroceuticals for the human brain currently raises.

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Neurotechnology brings up ethical questions on at least three levels: while on the level of clinical neuroethics issues with direct relevance for diagnosis and treatment are discussed, on the level of research neuroethics questions regarding research and development of the technology like investigating new targets and different diseases are dealt with. On the level of theoretical neuroethics more general questions are examined, including implications on personality, personal identity and authenticity as well as anthropological considerations on "normal" human functioning and the meaning of merging the human brain with technological artefacts. However, these levels are not strictly separated but overlap partially.

Ethical Implications of Deep Brain Stimulation

Deep brain stimulation (DBS) is a powerful treatment for motor symptoms in patients suffering from end-stage Parkinson's disease [2], Essential Tremor [3] and Dystonia [4]. Recently it was shown that well selected Parkinson patients could benefit from DBS even in earlier stages of the disease with respect to motor disability and quality of life [5]. On the one hand, many patients who had very limited medical options left benefit enormously from this technological approach. On the other hand, the great power of brain stimulation also causes side effects, which are sometimes severe. Weighing benefits against risk is common in every medical intervention. What are the specific risks of DBS? How should they be weighed against the benefits? Is there anything new in the ethics of this technological intervention? What can be learned for the ethics of DBS from more familiar brain interventions like pharmacological treatments?

For DBS electrodes are implanted into deep structures of the brain and stimulation has to be functionally integrated into neuronal processes. How is the self-concept of the human being as an embodied being influenced by the incorporation of technological devices into brain processes? Does chronic stimulation of the brain affect autonomous decision-making? What would be the consequences of acting under brain stimulation for holding someone responsible for his/her action?

Although the exact mechanisms of how DBS works are not known, the great successes in treating motor impairments encourage expanding DBS application to other diseases. Research on DBS in psychiatric disorders including major depression [6] and obsessive compulsive disorder [7] are well under way. Even Alzheimer's [8], obesity [9], minimal conscious state [10] and alcoholism [11] are under discussion as a target for DBS application. Further research directions are expected. How should one address ethical requirements for clinical research and innovation? These are central questions the evolving debate on the ethical implications of DBS focuses on [12–18].

In this issue *Martje Schermer* presents a clinical case of a patient suffering from Obsessive Compulsive Disorder (OCD) who felt very happy after DBS surgery although the OCD symptoms were not reduced [19]. This case is theoretically and clinically of utmost relevance, since it links the rather theoretical questions of human enhancement to concrete clinical approaches. Usually neuro-enhancement is discussed as the application of a medical intervention to improve a healthy person's cognitive capacities beyond the normal range. In the case presented by Schermer the rationale of the DBS intervention was to treat the OCD patient. However, the symptoms remained, but the patient experienced an improvement in her mood: she felt much happier than before the DBS intervention. Schermer discusses the question whether to continue the stimulation although there is no therapeutic effect on the OCD symptoms. Or should the stimulation be terminated because its original therapeutic aim could not be reached? She addresses these questions against the backdrop of the goals of medicine, to treat and not to enhance, and questions if mood enhancement through DBS really improves the well-being of this person.

While DBS is usually limited to adult patients, there are some cases where it also is applied to treat children with neurological (Dystonia) or psychiatric (Tourret Syndrome) disorders. *Farah Focquaert* addresses issues of parental authority in consenting for DBS interventions in children [20]. She questions exclusive parental authority and argues in favour of strengthening the children's autonomy. To give children's decisions more weight she proposes a process of shared decision making where the child's assent is mandatory. There should be no treatment against a child's will unless the untreated child would face harm and DBS treatment would be beneficial.

Veronica Johansson and colleagues focus their paper on DBS applied for treatment resistant depression (TRD) [21] and argue for a well balanced evaluation.

Decisions on DBS for TRD should neither be based on blind optimism nor on unfounded fears, since both face the risk that patients will not benefit from those decisions. They encourage identifying and being aware of potential biases in the ethical evaluation of DBS. E.g. presenting side effects caused by DBS as ethically problematic without even mentioning unintended adverse effects of alternative treatments like antidepressant drugs seems to be based on a technology bias that the use of new technological devices might be more problematic compared to pharmaceuticals already known for years.

Frederic Gilbert presents a case report on DBS for a patient with TRD who after five month of remission faces the return of depressive symptoms and finally self-estrangement, impulsive aggressive behaviour against himself, and suicide attempts. While suicide cannot be directly linked to DBS Gilbert shows that postoperative feelings of self-estrangement, suicidal ideation and impulsive-aggressive behaviour should be seen as indirect medical harm which may lead to suicidality. Since self-estrangement is directly related to suicidal risk in adolescents Gilbert recommends careful patient selection and questions the permissibility to use DBS in TRD patients with a history of self-estrangement, suicide attempts and impulsive-aggressive behaviour.

Closely linked to questions of self-estrangement *Felicitas Kraemer* focuses on DBS with respect to personal authenticity and possible alienation through brain stimulation [22]. She takes both as opposite felt mental states which can be expressed as feeling like oneself in case of authenticity or as not or no longer feeling like oneself in case of alienation. Since authenticity is desirable and alienation has to be avoided, both are not neutral terms but have normative impact. In referring to three cases presented in Schuepbach's landmark paper on DBS outcome [23] Kraemer shows that some patients report alienation through DBS, which is ethically problematic in her view, while others become more authentic in her interpretation. However, interpreting these cases with respect to alienation and authenticity gives a more nuanced and perhaps more adequate understanding than just thinking of them as mal-adjustments.

Karsten Witt and colleagues refer to the same paper and try to interpret the reported changes after DBS in the light of a concept of identity [24]. Their concept of individual identity focuses on core attitudes which have to be distinguished from more peripheral ones. While they claim individual identity matters for ethical evaluation, the authors point to the problem of measuring changes of identity and recommend developing instruments for detecting such changes.

Francoise Baylis understands personal identity in dynamic, narrative and relational terms and is much more critical with regard to its normative impact on evaluating interventions like DBS [25]. While agreeing that DBS may result in profound changes of mood, behaviour and cognition, she holds that the claim that DBS is a threat to personal identity is deeply problematic. This claim is either false on the basis of a wrong conception of identity; or it is misdirected as the real threat to identity is not DBS but attitudes and behaviour of others towards DBS patients; or it is trivially true in a sense that every major life event or dramatic experience results in a threat to the individual's identity.

Laura Klaming and Pim Haselager discuss unintended side effects of DBS which might affect the patient's psychological continuity and pay special attention to questions of responsibility and autonomy [26]. The authors claim that the adverse effects in question are similar to some situations in the use of antidepressants and in dissociative identity disorder (DID). They draw parallels and claim that questions of responsibility and legal liability could be solved in similar ways.

Ethical Implications of Brain Computer Interfacing

Brain-computer interfaces record neural activity, decode and interpret these signals through computational algorithms and create output signals for directing an external effector. BCIs differ in recording technology, decoding algorithms and output devices [27]. Possible clinical applications range from restoring communication through spelling devices for patients with Locked-in-Syndrome (LIS) [28] to motor-prosthetics for paraplegics [29] as well as neurofeedback systems for attention deficit hyperactivity disorder [30] and studies with criminal psychopaths [31].

Again, safety issues come to mind: do patients face any unacceptable consequences especially when electrodes have to be implanted into the cortex? Are the medical risks justified by the health benefits? On top of these standard considerations ethical issues discussed with respect to BCIs focus on the building structure of the devices. Since external effectors are in the end controlled by computational algorithms, questions of shared decision-making and responsibility arise [13, 32–34]. Who would be responsible for a prosthetic's movement based on erroneous computational predictions? While some recognize a principle responsibility gap [35], others hold BCIs do not present any challenges with respect to responsibility [36].

With respect to BCI research in Locked-in Syndrome, end of life decisions come to mind. Is it really justified to enrol these patients in research studies or wouldn't it be better to just let them die [37]? Since self-assessed quality of life is much better than assumed from the outside [38], underestimated quality of life might not be a convincing argument for withholding BCI training [39].

In this issue *Femke Neijboer* and colleagues present results of a survey on the ethical issues of brain-computer interfaces. They conducted this inquiry at the 4th international BCI conference in Asilomar, California 2010 [40]. This study surveys stakeholders' opinions from within the BCI community. Interestingly, even the experts in this field disagree significantly on the question which device should count as a BCI and which not. Nevertheless, these results include valuable information about the ethical issues BCI technology may raise from the perspective of the BCI scientists themselves. This might help to bridge the somewhat separate discourses on the science and the ethics of these innovative electroceuticals.

Miriam Kyselo focuses on a specific BCI application, namely its use for patients with Locked-in Syndrome (LIS). Her philosophical reflections aim to identify the right theoretical framework for interpreting these clinical attempts to increase severely paralysed patients' abilities to interact with their environment [41]. She critically discusses an interpretation based on a theory of extended cognition [42] and holds that an enactive approach would be more accurate, since the latter focuses on a socially and linguistically embedded understanding of autonomy. BCIs function as a body's substitution for enabling social exchange and thereby sustaining LIS-patients' autonomy.

Tom Buller takes BCI technology as a starting point to discuss the criterion of invasiveness [43]. He understands human beings as embodied persons and therefore argues that the skin-and-skull boundary matters normatively. Invasions of this boundary are ethically relevant. This is not contradicted by the extended-mind hypothesis that human minds and cognition can be extended technologically beyond the brain and its surrounding skin-and-skull.

Gregor Wolbring contrasts the typical notion of enhancement as a medical intervention in healthy human beings without therapeutic need with an empirical analysis [44]. His results of a survey among the members of the World federation of the Deaf show that wearable assistive devices might more easily pave the way for human enhancements. Devices developed for restoring species-typical functioning, e.g. the cochlea implant for the hearing impaired, will probably allow the user to outperform species-typical body abilities. In this notion enhancement is no longer solely an off-label use of some therapeutic interventions but a development to be observed within the original target group. Wolbring concludes that a broad discourse within the disability community on possible enhancements is desperately needed to develop guidelines and discuss the goals that drive enhancements.

Karim Jebari discusses ethical concerns of the widespread use of brain-machine interface in everyday life [45]. He focuses on the aspects of privacy and autonomy and identifies both the potential to undermine and to enhance privacy as well as autonomy. Therefore he calls for thorough regulations to prevent unwanted effects while promoting the ethically desirable.

Acknowledgment This special issue traces back to the panel "Bonding Brian to Machines" at the World Congress for Bioethics in Singapore 2010. A call for abstracts on ethical issues in DBS and articles submitted independently to this journal completed the contribution at hand. The author wants to thank all speakers at the Singapore panel and all contributors to this special issue.

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