6 Brain-Computer Interfaces: Current and Future Investigations in the Philosophy and Politics of Neurotechnology

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Contents

Abstract

Important insights have been generated by ethicists, philosophers, sociologists, lawyers, and representatives from other disciplines regarding the ethics of neurotechnology in general and of brain-computer interfaces (BCIs) in particular. However, since (medical) BCIs have yet to leave the laboratory and the context of clinical studies and enter the "real" world, many important normative questions remain unanswered. In this paper we summarize the main lines of ethical inquiry regarding BCIs, both from the general academic discussion and with a view on the results gained in INTERFACES, an interdisciplinary project on the

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O. Friedrich et al. (eds.), *Clinical Neurotechnology meets Artificial Intelligence*, Advances in Neuroethics, https://doi.org/10.1007/978-3-030-64590-8_6

normative dimensions of BCIs. Furthermore, we offer our perspective on future research and argue that the ethics of technology should explore decision-making processes by which communities and societies regulate emerging technologies, such as BCIs.

6.1 Introduction

The term “Brain-Computer Interface” (BCI) goes back to a paper from 1970 [1]. Ever since, this technology has seen a massive increase in research activity. However, the first 30 years after the term was coined only saw one or two dozen articles being published per year. This changed right around the beginning of the new millennium. As a brief search for the term “Brain-Computer Interfaces” on PubMed shows, the number of published works jumped from 28 in 2002 to 87 in 2003. A more or less steady increase in the number of articles published after 2003 led to 585 articles being published in 2019. In the early days, scientific research on BCIs prevailed. The first ethics papers did not appear until 2005. This is a well-known phenomenon: the ethical debate on emerging technologies typically sets in after a significant amount of scientific and engineering work has resulted in successful applications of a technology. To this day, important insights have been generated by ethicists, philosophers, sociologists, lawyers, and representatives from other disciplines. However, since (medical) BCIs have yet to leave the laboratory and the context of clinical studies and enter the “real” world, many important normative questions remain unanswered. Moreover, the question of what to do with results gained through work in philosophy and the social sciences is still open. We therefore find it necessary to summarize some relevant discussions and insights that have been generated so far, and to shed light on future issues within BCI research that require further attention. After a very brief overview of the technology known as “BCI,” we will lay out the main topics from the ethical assessment of BCIs. We will summarize existing work in applied ethics before summarizing the results from the project “INTERFACES” that has studied BCIs in a number of important ways. Finally, in the last section we offer our perspective on future research and argue that the ethics of technology should explore decision-making processes by which communities and societies regulate emerging technologies, such as BCIs.

6.2 BCIs: Technology and Applications

As Dennis McFarland and Jonathan Wolpaw put it, a BCI is “a computer-based system that acquires, analyzes, and translates brain signals into output commands in real-time” [2]. According to this generic definition, there are three elements that constitute a BCI. The first element is related to the generation (user side) and subsequent acquisition (technology side) of brain signals. There are many ways to generate and acquire brain signals, depending on (a) the type of BCI that is used and (b) the type of brain signal that is detected. The basic distinction divides BCIs into active, reactive, and passive BCIs [3, 4]. In active BCIs, the user has to perform a mental task, which is encoded with a pre-defined meaning (e.g., yes/no). Typically, the mental strategy uses motor imagery (moving one's arm or foot) and encodes the respective movement with a meaning [2]. Reactive BCIs, by contrast, require the user to direct his or her attention to a specific stimulus, which is related to a pre-defined meaning. The brain's reaction to the stimulus is measured and translated into the output connected to the stimulus [2]. Finally, passive BCIs monitor brain activity while the user performs any given task and measures when that brain activity has reached a certain threshold (e.g., drowsiness).

The type of signal that a BCI detects ranges from electric activity (e.g., EEG) to the flow of oxygen in the user's brain (e.g., fMRT). Both invasive and non-invasive methods are used. While invasive BCIs require an intervention, e.g., placing electrodes on top of the cortex, non-invasive forms do not require such an intervention. The electrodes are placed on top of the skull [5].

The second element concerns the measurement and analysis of brain signals [6]. Relevant features are extracted and the information that is needed is analyzed. BCIs often use machine-learning algorithms to obtain the relevant information (e.g., whether a certain mental activity has occurred).

Finally, the information is translated into an output that is used by an external device to perform certain actions (e.g., to pick a letter in an attempt to write something, or to direct a robotic arm) [6].

As this brief explication shows, there are numerous ways to realize a BCI [7]. Most of the current research efforts are put into finding new ways to acquire brain signals (e.g., using fNIRS), developing better algorithms to filter out the information needed, and creating new applications for BCIs. To date, BCIs are used in a number of domains. Medical BCIs were developed to restore lost capacities for communication and transport. Especially persons with physical impairments or patients who have suffered a stroke or spinal cord injury can benefit from the use of a BCI in order to enable communication and improve the rehabilitation process [8–11]. Outside of the strictly medical domain, BCIs are increasingly used in the consumer area [12, 13]. Examples include BCIs for gaming and entertainment purposes. In addition, enhancement through the monitoring of one's brain activity can also be seen as a consumer application.

Exploring the ethical, legal, and social implications of BCIs hinges, to a large extent, on the contexts of their use. There are, however, generic issues that transcend the contexts of use and have been the object of thorough work in applied ethics, to which we will now turn.

6.3 Ethical, Social, and Legal Implications of BCIs: State of the Art

6.3.1 Generic Issues

There are a number of surveys that summarize the views on BCIs by ethicists, BCI professionals, and lay people. Sasha Burwell et al. have studied what issues BCI ethicists raise [14]. In a scoping review, they analyzed a sample ($n = 42$) of bioethics articles and found that there are basically 8 areas of concern that ethics experts have voiced: user safety and risk-benefit analyses, humanity and personhood, stigma and normality, autonomy, responsibility, research ethics and informed consent, privacy and security and justice. Other issues that are regularly, but not as frequently, mentioned include novel domains of application (e.g., military), research funding policy and the need for regulation, as well as responsibility issues regarding the use of machine-learning algorithms.

BCI researchers' opinions on a number of issues regarding the technology have been examined in two studies that both take their data from surveys held at a stakeholder conference that takes place in Asilomar, California each year [15, 16]. Femke Nijboer and colleagues [16] asked experts about their views on issues such as the informed consent process with locked-in patients, risk-benefit analyses, team responsibility, consequences of BCI on patients' and families' lives, liability and personal identity, and interaction with the media. Expert opinion differs in the assessment of specific aspects of these issues, but a majority of them still finds it important to establish ethical guidelines for BCI research and use. Pham and colleagues [15] actually tested a proposal for such guidelines, again with participants from the Asilomar BCI conference. They found broad support for principles that emphasize care for subjects as the prime goal for researchers, modesty regarding the expectations tied to BCI research, a participatory approach to research, a broad, tolerant understanding regarding notions of disability and normality, an acknowledgement of the various relations BCI use might affect, justice with regard to access to BCIs and keeping in mind the broader social impact one's research has.

Lay persons' attitudes are the subject of a recent study by Matthew Sample and colleagues [17]. In the study that comprises answers from over 1400 participants, the authors found two factors that summarize people's concerns regarding BCIs. They call the first factor "concern for agent-related issues," which assembles worries such as "becoming cyborgs, redefining humanity, changing the self, doubting authenticity, defining normality, and enabling unfair enhancement." The second factor includes worries such as "enabling new forms of hacking, limited availability, risking surgical complications, seriousness of device failure, and media hype and inaccuracy" and is called "concern for consequence-related issues."

Some of these issues have also been studied in the project INTERFACES, in which a collaboration between ethicists, sociologists, and lawyers has produced a number of articles. Each of these articles deals with a specific issue and tries to shed light on conceptual as well as normative issues. We shall now turn to this work in more detail.

6.3.2 Results from Conceptual Research from the Project INTERFACES

When looking at BCIs, it is particularly exciting to note that in this neurotechnology we are dealing with a novel form of interaction between humans and machines. The changes people make in the world with BCIs are caused by brain activity alone and do not require any peripheral nerve or muscle activity. The latter can be bridged or replaced by a computer and technical devices [18]. The disembodied character of such a change in the world is the starting point for many philosophical-ethical questions that are related to agency, autonomy, and responsibility.

Another relevant starting point for philosophical-ethical investigations is the fact that the data obtained on brain activity must first be processed and interpreted in a complex algorithmic way in order to provide useful computer instructions. This fact also gives rise to a number of normative questions, such as autonomy, responsibility, and discrimination [19].

The disembodied character of BCI-related changes implies questions regarding the subjective perception of the users, as well as conceptual issues. It has not yet been conclusively clarified to what extent users perceive their effects with BCIs as their own actions and whether they feel fully responsible for them. First empirical results show, however, that BCI users experience themselves as self-determined actors and feel responsible for their actions [20]. However, it is necessary to further empirically investigate whether BCIs can lead to greater distortions of the sense of agency compared to conventional actions. *Sense of agency* usually refers to a pre-reflective or a reflective feeling of the subject that she is causing an action [21]. Errors in the sense of agency could occur in that not only the initiation of the action differs in BCI actions, but also the feedback mechanisms are different. This could lead to a situation in which users do not attribute BCI actions to themselves because they do not feel a sense of their own actions. Conversely, certain events may mistakenly be interpreted by BCI users as their own BCI-generated actions. The possibility of such errors has already been shown in several experimental situations without BCI use [22]. For BCIs, there could be an accumulation of such errors.

Besides such subjective misperceptions of the sense of agency, it is also relevant to discuss if BCI use might have consequences for philosophical concepts of agency and for the standard legal account of actions as bodily movements [23]. In a descriptive manner, active and reactive BCIs can be characterized as a hybrid of mental and bodily action, without involvement of the muscular system [23]. In those BCIs, we can describe a mental action, which is followed by a causal chain and by external effects [23]. Such a hybrid character of action has been shown to be a challenge for the law, as action theory in law is based on a bodily movement requirement [23]. An analysis of philosophical concepts of action and BCIs has shown that (active and reactive) BCI events are actions according to the standard (causal) theory of action, because the event is caused by the right kind of mental state (i.e., an intention) [23]. In contrast, those events that are mediated by passive BCIs cannot be called actions, as they are not caused by the right mental states [23].

While taking a closer look at three different forms of control that are relevant for actions (executory, guidance, and veto control), it can be stated that passive BCIs—contrary to active and reactive BCIs—completely lack executory as well as guidance control [23]. For passive BCIs, there is a conceptual similarity to automatism in everyday life, in which movements are not initiated by a conscious executory command and the person has no conscious guidance control during the movement [23]. It remains an issue for future research, if an installed veto control for the user, which she can operate consciously, would change the conceptual evaluation of passive BCI events from no-action to action.

BCI applications, which do not guarantee conscious action initiation for the user, could be very helpful in making automated processes such as driving a wheelchair easier. For this purpose, it is necessary that the BCI system can predict the intended actions of users with high probability by interpreting brain activity and using machine learning (ML). However, BCIs not only involve algorithms in automated processes, but always require algorithms at relevant operating points (e.g., the extraction and classification of relevant features; transmission of the relevant information to an external device) [19].

Using algorithms and ML in BCIs results in many normative concerns. The inscrutability of the decision-making process and the algorithmic opacity decreases user oversight, comprehension, interpretation as well as control and thus, also trust in algorithms [19, 24, 25]. If a user is unable to understand and to interpret an algorithm and its decision-making logic, the person loses her capacity to control the outcome, which has implications for autonomy [19]. The person will suffer a decrease in autonomy without sufficient knowledge of certain processes of decision-making and without control over data, data acquisition and processing [19]. Discrimination is a further problem related to the inscrutable and inconclusive character of algorithms, as those characteristics make it harder to detect biases, resulting in shortcomings in the decision-making process [19]. Discrimination can lead to less opportunities and less autonomy among discriminated groups and persons and thus, to more or new inequalities in society [19].

BCI use can raise the question not only of agency, but also of the extent to which its use increases or limits the realization of user autonomy. In the medical field, a (re-) opening of (new) possibilities of action seems to be connected with an obviously improved enabling of autonomy, for example by enabling patients to (re-) communicate or to operate a prosthesis independently. There might also be further positive effects though. More or new information about their brain activity could also have a positive effect for users on the realization of autonomy, e.g. if BCI users use the information about their affective states to re-evaluate or re-formulate reasons. Theoretically, positive consequences in the realization of autonomy could also occur, if executory control in action is transferred to the machine after action initiation, thus preventing disturbing influences of human action control from unfolding [26].

However, the modified mode of interaction in BCIs can also lead to the fact that realizing human autonomy becomes more difficult. It is precisely this aforementioned stronger machine control in actions as well as the opaque or even manipulating influence of the machine on human decision-making that can lead to the fact that humans are no longer able to sufficiently realize their autonomy. Especially when recurring information about the user's brain activity in certain situations is algorithmically processed by the computer and presented in similar situations in the future, so that the user only has limited decision-making options, resulting in the possibility of immense losses for the realization of autonomy [26]. The user has less choices and his future is automatically and technologically fixed to his past.

It is particularly important to note that the data obtained through BCIs will probably not be the only data that influence users' decisions. In addition, a wide range of other data (from mobile phones, etc.) about the person is simultaneously collected and could be correlated with each other. This enables complex user profiles. These not only affect the decision-making possibilities and influences on users, but also another aspect of autonomy, namely privacy. Therefore, a further risk of creating such personal data and profiles can be seen in the potential interest of these data by a wide range of institutions, followed by the risk of hacking, violating privacy, and misuse [25].

The previous descriptions make it clear that there are also various questions to be clarified with regard to responsibility when developing and applying BCIs. Following the comments on privacy, it is important to ensure that the individual user or group data on brain activity and correlated mental states obtained via BCI do not fall into the wrong hands and are not used for purposes that the user has not approved or to discriminate against people. However, it should be noted that many people are involved when it comes to ensuring data security and the responsible handling of data. The attribution of responsibility is by no means easy in this context, so that complex regulatory issues must be discussed for this technology. In addition to the question of how to ensure the responsible and secure handling of the data obtained, it must also be discussed whether the users themselves are responsible for the results of their interaction with the machine.

A user can be seen as responsible for possible outcomes with BCIs in terms of legal liability within tort and criminal law [27]. A user can be liable for BCI-mediated actions, but also for omissions that would prevent potential harm [27]. The difficulties of talking about actions and thus responsible actions in some BCI-mediated events were presented before. Further, it can be difficult or even impossible for users to foresee and to prevent many harmful events that the machine causes, as ML and related errors are hard to come by as a human.

An extensive analysis shows, however, that there are no principled objections to imposing civil liability for BCI use that results in foreseeable and non-foreseeable damages to third-parties [27]. However, there might be a bigger epistemic gap in criminal responsibility, due to the disembodied character of BCI use and the difficulty of identifying the primary cause of a BCI movement [27]. Such an epistemic gap might cause further difficulties for the presumption of innocence [27].

6.4 A Look Ahead: Focusing on Procedures in the Ethics of BCIs

Assessing BCIs through the ethics lens reveals a number of important issues that are often said to be in need of clarification before BCIs can enter the market. However, it is unlikely that early and far-reaching agreements will be gained concerning these questions. As the academic debate itself shows, there is widespread and continuing disagreement regarding almost all of the issues discussed above. Moreover, when persons outside academic ethics, such as BCI professionals and the public are interviewed, ethical pluralism can be expected and was already shown [17]. In addition to prevailing pluralism in moral concepts in society and among ethicists, the problem of normative assessments of BCIs lies in the inconclusiveness of BCI effects for users and for human action, autonomy, and responsibility. The latter difficulty is partly due to the fact that technology is developing steadily and is not yet fully assessable. In addition, further empirical and philosophical work is needed to better understand and assess the novel interaction between neurotechnology, AI, and humans. Only then can more reliable normative assessments be expected. Parallel to these efforts, it may be useful also to focus on procedural elements in the ethical discussion, especially in times of uncertainty regarding results in technology use.

When it comes to procedural aspects, there are quite a few philosophical precursors to consider. Philosophers in the wake of John Rawls have used an approach in which a procedure is devised whose goal is to find those solutions that no one can reasonably deny, no matter which ethical standpoint they represent. Other ethicists develop their work in close cooperation with practitioners, so that the action-guiding nature of their work is self-revealing. Similarly, some base their work on principles that are well entrenched in our practices or common sense, so that the results reached are thought to be directly action-guiding. However, these solutions will certainly face questions from more theoretically oriented ethicists, and in any case, pluralism and disagreement will remain.

Focusing on procedural elements and considering pluralism as well as continuing disagreement regarding the results of certain technology use, can also mean exploring (political) processes by which varying ethical views can and should come into play.

This proposal implies that, apart from the ethical implications of a certain technology, the processes by which real-world agents debate and find consensus on what to do with this technology need to be explored. This includes a strong focus on processes by which people decide on the ethical nature of using (researching, developing) technology, at least as long as there is a high amount of uncertainty concerning certain outcomes of technology use. In addition, particular decision-making processes for specific questions should be embedded within the larger context of social and political institutions that regulate how societies deal with the impact of emerging technologies. Ethicists should thus reason about how to organize the social and political system in which new questions (and old ones, too) come to the fore and are picked up by relevant institutions. The whole organization of societal, institutional living should be addressed within the ethics of technology as a way to reflect on mechanisms by which innovation on the one hand, and protection of basic values on the other hand are balanced and decided upon. In other words, technology ethics should also be involved or integrated into political and institutional ethics. Heath and colleagues [28] have pursued a similar approach in their attempt to understand business ethics as political philosophy. Another point of reference could be the discussion about "technology governance" that sociologists of technology typically lead [29, 30]. Interrelations between these two fields need to be explored and worked out.

It could appear as though this proposal is based on the idea that it is easier to find common ground on how to shape decision-making processes than on finding the right ethical action-guidance. It might be objected that there is a contradiction involved since one cannot claim that there is insurmountable pluralism regarding ethical evaluations of technology, but not regarding the ethics of institutions. Though we agree with this objection, some arguments can be put forward in favor of putting more efforts into exploring procedural aspects at the current stage of BCI development. First, the suggestion is not meant to substitute work on finding the right ethical action-guidance in BCI use, but rather as an addition in times of uncertainty regarding the results of BCI use. Second, as Stuart Hampshire argues, there might simply be a better chance of finding a consensus on procedures rather than on principles [31]. Third, empirical research on procedural justice has revealed surprising results regarding the power of fair procedures to contain evaluative disagreement. Tom Tyler's work on fair procedures in policing and other domains, for instance, shows how procedural fairness leads to beneficial outcomes, such as cooperation [32] (for an overview, see [33]). Creating fair procedures, by which even normatively disagreeing parties on uncertain technology developments can come to an agreement, remains a promising focus even if uncertainty remains with regard to ethical evaluations in exploring novel technologies like BCIs.

Fair procedures are thus a distinct place of ethical concern, as Ceva thinks [34]. In addition, fair procedures are also constitutive to the acceptability of X and they might also help with the problem that work in applied ethics often lacks action-guidance. Focusing on proceduralist accounts can therefore shed new light on the ethics of BCIs. This line of research can very well be supported by empirical studies on procedural fairness. As mentioned above, fair procedures appear to have a strong influence on people's willingness to accept decisions. In many domains, from the workplace to policing to environmental policy, fair procedures enhance the legitimacy and acceptance of decisions made by authorities. Fair procedures can be considered as realizing demands that the political philosophers have posited as normative requirements. The philosophical exploration of empirical features, by which fair procedures appear to be constituted, remains an open task. At the same time, an application of fair procedures to the question of technology regulation should complement this endeavor and lead to a fruitful trans-disciplinary examination of how technology regulation can be improved.

6.5 Conclusion

In this article we have summarized the main philosophical and ethical aspects of BCIs that previous work in academic ethics has revealed. Issues such as agency and autonomy are important aspects where BCI use can potentially have beneficial as well as detrimental effects. The evaluation hinges on many technological details, such as whether the BCI is active, reactive, or passive. The danger of misattribution of agency, as well as the legal grasp of actions are factors that depend, to a large extent, on the nature of the BCI. Whether BCIs enhance or hamper autonomy is partly a technological issue (e.g., whether there is a mechanism to establish action control), and partly a conceptual one. Closely related to agency and autonomy is the question of responsibility. Discussing legal responsibility in terms of either civil or criminal law has a huge impact on how we assess the forms of responsibility that the legal system allows. Moreover, both the notion of responsibility and the general problem of empirically assessing future developments and outcomes of BCI use, as well as ethical disagreement regarding those outcomes lead us to the necessity of finding processes by which pluralist views can be reconciled. As a result, we propose a stronger focus on proceduralist aspects, where a focus on fair processes could help overcome times of uncertainty in technological development and its ethical evaluations, and by which ethical disagreement can be contained to a certain extent. In summary, even though the debate on BCIs has seen a lot of progress over the last years, there are many avenues for future work, both within an ethical approach, narrowly understood, and a broader political-regulatory perspective.

Acknowledgments Work on this paper was funded by the Federal Ministry of Education and Research (BMBF) in Germany (INTERFACES, 01GP1622A) and by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)—418201802. We would like to thank Dorothea Wagner von Hoff for proofreading the article, Meliz-Sema Kaygusuz and Bernadette Scherer for formatting.

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