1. Introduction

Humans have long sought to enhance themselves psychologically; for example, there is evidence of ingestion of herbal plants to enhance memory in Ancient Greece (Le Strange, 1977). As mind and brain sciences progress, more and more neurotechnologies for intervening in our brain states,
like pharmaceuticals and brain stimulation, become available. Similar to the use of pharmaceuticals for enhancement (Morein-Zamir & Sahakian, 2011; Smith & Farah, 2011), brain stimulation is not limited to use in experimental or clinical settings; due to its easy accessibility and ease of use, some are increasingly being adopted by individuals in a home setting (Fitz & Reiner, 2014; Wexler, 2016). Among neurotechnologies, transcranial direct current stimulation (tDCS) has drawn the most attention (Fitz & Reiner, 2015; Hildt, 2014; Jwa, 2015; Wexler, 2018). This home-based, self-administered form of brain stimulation is referred to as do-it-yourself (DIY) brain stimulation. In this chapter, I focus on the use of tDCS. Not only is tDCS the most common technique, but also numerous studies have been conducted that provide a characterization of the DIYers’ practice of tDCS (Jwa, 2015; Wexler, 2016, 2018; Wurzman, Hamilton, Pascual-Leone, & Fox, 2016). Even though this chapter centers on the use of tDCS, the analysis and discussion can be applied to the contexts of other methods such as the use of pharmaceuticals.

Comparing the use of brain stimulation in a home setting and in a professional setting brings to light a number of substantial differences. First, the former requires users to be equipped with a certain degree of knowledge and information in order to obtain and operate a device on themselves, including finding the tDCS montage and electrode positions, and applying the brain stimulation. One can rely on the professionals in the latter case. Second, home-based brain stimulation involves observation and management of a person’s own cognitive activities. During the process, one is required to pay attention to his or her experiences of, and changes in cognitive performance, as well as modify the mode of application based on these observations. Third, the expectations and motives of DIYers are likely to be more diverse than those of users in a professional setting. In addition, the means for measuring the effectiveness of tDCS in improving cognitive abilities in laboratory studies with a larger subject group and a control group cannot be replicated in a home setting with an individual user (Wexler, 2016).

This chapter aims to highlight the problems of measuring the effects of DIY brain stimulation and its ethical implications, given the characteristics of home users described above. The difficulty of assessing these effects risks undermining truthfulness and authenticity. Truthfulness concerns the understanding of the potential effects and uncertainties of using tDCS. It requires subjects being provided with full and honest information about tDCS and to be honest with themselves. Authenticity concerns the users’ identification with the actions they chose to perform given their
goal, and their understanding of how their goals can be achieved. The problem of uncertain effectiveness will be examined in consideration of these two issues.

The role of metacognition—the ability to monitor and control one’s cognitive functioning—will also be examined, as it is crucial for DIY brain stimulation. Whereas the use of brain stimulation to manipulate a person’s cognitive functioning can be seen as a kind of control, metacognitive monitoring contributes to users’ perceived effects and subjective judgments of the effectiveness of the stimulation. Taking the role of metacognition role into account to consider the ethical implications of the problem of uncertain effectiveness, the analysis highlights the importance of subjects being informed of and being capable to understand the effects and uncertainties of using tDCS in a home setting. I suggest that education and communication are important factors in addition to regulation (Maslen, Douglas, Kadosh, Levy, & Savulescu, 2015). Increasing neuroscience literacy can help to avoid some unwanted normative consequences.

In the following sections, I review the practice of DIY brain stimulation using tDCS, particularly how DIYers consider the effect and effectiveness of brain stimulation. The role of metacognition in DIY tDCS and the problem of evaluating the effects of brain stimulation are analyzed. Finally, I examine the issues of truthfulness and authenticity, considering the difficulty of assessing effectiveness, and discuss practical implications.

It is worth noting that the concept of a DIYer is sometimes used specifically to refer to users who build a brain stimulation device on their own, instead of purchasing from direct-to-customer manufacturers (e.g., Wexler & Reiner, 2017). This distinction is not important for the purposes of this chapter. Therefore, a broader concept is adopted here to include users who use brain stimulation at home rather than in a professional setting. Furthermore, as the normative concerns with regard to the problem of potential ineffectiveness may differ when targeting a medical condition, the discussion in this chapter is limited to DIY brain stimulation used for cognitive enhancement. However, analysis of the difficulty of measuring the effect of an intervention is also applicable to DIY brain stimulation used for therapeutic purposes.

2. Do-it-yourself brain stimulation

This section outlines DIYers’ practices, particularly how users consider the effects of brain stimulation using tDCS.
2.1 The practice of DIY tDCS

DIY brain stimulation refers to lay individuals’ use of devices to stimulate their brains for treatment or enhancement outside of professional academic or medical settings. One of the most popular brain interventions is tDCS: a neural modulation technique that directs a low amplitude electric current through scalp electrodes to stimulate specific parts of the brain. As it is non-invasive, portable, inexpensive, painless, easy to administer, and relatively safe, tDCS can be used in home and everyday settings and has thus been adopted by DIY communities. There are several ways in which DIYers can obtain a brain stimulation device despite the fact that most DIYers are not qualified to purchase professional devices from medical device companies. One can choose to buy direct-to-consumer products (e.g., foc.us headset), device kits, or an iontophoresis device and modify it. Building a tDCS device from material available in hardware stores is another option. Product reviews and tutorials about how to construct such devices are shared and accessible on forums and websites (Wexler, 2016).

The main reasons for using DIY tDCS are cognitive enhancement and the treatment of medical conditions. Concerning the former, the cognitive functions that are primarily targeted by DIYers are attention, learning (e.g., motor, verbal, and numerical learning), working memory, long-term memory, and perception (e.g., visual, somatosensory, and auditory perception) (Jwa, 2015). Other reasons include curiosity, novelty, and/or self-experimentation (Wexler, 2018). Researchers have noted that there can be more than one reason for a DIYer to use tDCS (Jwa, 2015; Wexler, 2018).

When applying tDCS, DIYers rely on scientific articles and information shared by other DIYers on websites and blogs. Without any standard protocol, DIYers often follow the standardized electrode placement and the maximum of 2 mA of current used conventionally in scientific studies (Wexler, 2016). However, to attempt to increase effectiveness, DIYers experiment on different methods of application (e.g., frequency, montages) beyond those reported in the scientific literature. For instance, while single sessions tend to be used in scientific studies of cognitive enhancement effects on healthy subjects, and 5–15 sessions in studies on clinical effects, Wexler (2018) found that more than 40% of tDCS DIYers had self-administered more than 20 sessions. This raises safety concerns while

---

4 The standard 10–20 system is an internationally recognized method used in electroencephalography (EEG) to describe and apply the location of scalp electrodes as well as compare electrode positioning between subjects.
the effects of tDCS are unknown, especially considering the lack of research on its long-term effects.

2.2 Considerations of the effects and effectiveness of DIY tDCS

How does an individual DIYer assess the extent of the achieved effects of tDCS? In scientific studies, researchers have found tDCS to affect working memory (Fregni et al., 2005; Hill, Fitzgerald, & Hoy, 2016; Mancuso, Ilieva, Hamilton, & Farah, 2016; Ohn et al., 2008), episodic memory (Manenti, Brambilla, Petesi, Ferrari, & Cotelli, 2013; Penolazzi et al., 2010), attention (Coffman, Clark, & Parasuraman, 2014), decision-making (Fecteau et al., 2007; Hecht, Walsh, & Lavidor, 2010), and other cognitive abilities. Even though the effectiveness of tDCS has been reported, the same assessment methods cannot be used to measure effectiveness on a single individual, since DIY users at home cannot replicate experimental conditions, which often involve a larger number of subjects, a control group (i.e., sham stimulation in tDCS), and a blind design. Without any scientific method of determining the effectiveness of their tDCS use, some users attempt to quantify the effectiveness by tracking their improvement in cognitive tasks (Wexler, 2016), while other members of the DIY community rely mainly on subjective judgment or feelings of improvement (Jwa, 2015; Wexler, 2016).

The outcome of the use of tDCS has been reported as either positive or neutral by DIYers who seek cognitive enhancement or self-treatment. According to a study by Jwa (2015) that used an online questionnaire survey, when users were asked to rate the success of their use of tDCS on a scale of one to five, from “totally unsuccessful” to “extremely successful,” most of the 121 respondents scored four or five (44%) or three (41%). In addition, when asked if they would continue using tDCS, a large proportion of them (92%) replied positively. Nearly half of the respondents (46%) were willing to recommend using tDCS to family or friends with similar conditions or enhancement goals. The results suggest that around half of the respondents found tDCS helpful in improving their conditions or achieving their aims.

Using an online survey, a study by Wexler (2018) targeted users who had purchased devices from manufacturers for treatment, restoration, or enhancement purposes. According to this study, almost half of the participants reported that they did not attempt to measure the effects, while about a fifth (19.5%) reported that they measured the effects based on self-observation and self-reflection. A smaller number of users (12.3%) took
measurements using self-developed tests. In the results reported in the study, examples of these personal tests included comparing memory encoding and retrieval tasks with or without brain stimulation, using cognitive tasks to track their performance, and self-evaluation of a skill (e.g., “I pay attention to if my guitar playing sounds better and it’s like I’ve made a breakthrough or leap to another level” (Wexler, 2018:125)). The participants were also asked to rate the extent to which they felt tDCS was successful. The majority of participants (52.4%) reported their impression to be positive (somewhat or totally successful), whereas 29.9% of users were not sure.

In the studies previously reviewed (Jwa, 2015; Wexler, 2018), DIYers’ impressions of the success of the use of tDCS was investigated. However, the implications of these results are vague. First, it is unclear, from the DIYer’s point of view, what success would consist of; that is, it is not clear what criteria the DIYers who completed the questionnaire used to determine their rating. Many factors—such as users’ goals, expectations, criteria, and awareness of improvements—can influence how an individual evaluates the success of the practice. Therefore, it would be interesting to obtain a deeper understanding of what constitutes the success of tDCS administration for DIYers and to understand how the perceived effect is weighed.

Second, Jwa (2015) interpreted DIYers’ ratings of success concerning the use of tDCS as their ratings of the “perceived effect” (pp. 310–311). Nevertheless, because of the variety of factors that might be involved in the rating, rating of success cannot be equivalent to the rating of perceived effect. That is, to perceive tDCS as more successful does not necessarily relate to a positive or significant effect. For example, successfully self-administering tDCS may lead to the higher rating of success but not the perceived effect. To date, there has been no study that focuses on the DIYers’ perceived effect of the use of tDCS. Empirical studies on the subjectively perceived effects of DIY tDCS will allow researchers to access users’ perspectives on the perceived effects as well as learn more about relevant perceived effects. Such studies will help to understand the motivation behind using, or ceasing to use, tDCS, as well as what self-administering brain stimulation means to the users.

3. Metacognition in DIY brain intervention

Having reviewed the use of tDCS and the issue of measuring its effectiveness, this section highlights metacognition and the role it plays in the practice of home-based tDCS.
3.1 Metacognition

Metacognition is defined as thinking about thinking, or the cognition of cognition (Flavell, 1979). Such a conceptualization of metacognition presumes two levels of function (Nelson & Narens, 1990). The first is object- or cognitive-level processing, where cognitive functions—such as memory, attention, and learning—occur. It is the target level of cognitive enhancement. The second is the meta, or metacognitive, level, which governs operations at the object level by monitoring and applying top-down control. For example, if anomalies in cognitive activity occur, the metacognitive monitoring process will detect them, and a control process will be activated to deal with the problem.

Metacognition consists of three components: monitoring, control (or regulation), and metacognitive knowledge and experience (Beran, 2012; Nelson, 1996). First, metacognitive monitoring refers to the evaluation of an individual’s cognitive functioning, including the level of confidence and accuracy of judgments, knowledge, and performance (Koriat, 2006; Nelson & Narens, 1990). It comes in various forms. For example, a tip-of-the-tongue phenomenon involves a metacognitive judgment about the possession of a piece of information even though the information is not immediately accessible (e.g., “I know that I know this, but I can’t recall it at this moment”). Other forms of monitoring include retrospective monitoring, which evaluates the adequacy of a response, and prospective monitoring, which judges a person’s ability to carry out a cognitive task.

The assessment of cognitive performance (including decision-making) is crucial for the guidance of behavior and further decision-making, especially when external feedback is unavailable or only sporadic. However, metacognitive monitoring sometimes fails and is not always reliable (for example, when an individual exhibits overconfidence that he or she will remember more information on a future test than he or she actually does). Furthermore, metacognitive abilities vary across individuals (Fleming, Weil, Nagy, Dolan, & Rees, 2010; Kelemen, Frost, & Weaver, 2000) and can be sensitive to physiological and environmental factors (Nelson et al., 1990; Slife & Weaver, 1992). Neuroimaging studies and evidence from neurological disorders suggest that prospective judgments are supported by medial prefrontal cortex (PFC) function, whereas retrospective judgments depend on lateral PFC (Fleming & Dolan, 2012). Metacognitive monitoring is useful for the subject as it can be used by metacognitive control to facilitate cognitive performance.
Metacognitive control refers to the ability to adjust the cognitive process (Dunlosky & Metcalfe, 2008; Nelson et al., 1990). It appears in several forms, depending on the task and the resources available to the subject. For example, an individual can avoid answering questions or provide more general answers to questions that he or she is likely to get wrong. When engaging in tasks, an individual can strategically manipulate his or her attention to improve overall performance; whereas while learning, cognitive control allows the individual to select more effective learning strategies, such as deciding to continue or stop the current practice.

To achieve a cognitive goal, metacognitive monitoring and control work closely together. Metacognitive monitoring enables an assessment of the effort required for tasks before actually performing them and leads to the strategic manipulation of cognitive resources. That is, the evaluation of current cognitive activity through metacognitive monitoring indicates if the current object-level operation is sufficient for achieving a subject’s goals or whether an adjustment is required. For instance, given limited time, an evaluation of the difficulty of tasks can inform cognitive control about time allocation so as to maximize performance. In addition, metacognitive control is guided by the monitoring operation, which informs an individual if the top-down regulation is effective and, if not, how to readjust. For example, monitoring a person’s competency to accomplish a task and the improvement of his or her ability in a learning process allows for an assessment of the current learning strategy.

In addition to metacognitive monitoring and control, metacognitive knowledge and experience constitute an individual’s descriptive knowledge and experience about the interplay between the characteristics of his or her cognitive ability, the task at hand, and strategies adopted or available (Dunlosky & Metcalfe, 2008; Flavell, 1979). For instance, metacognitive knowledge may be the judgment of the individual’s competency at a given task (e.g., memorizing people’s names) and available strategy to cope with this task (e.g., adopting mnemonic techniques or practicing repeatedly). In comparison, a feeling of knowing—the experience of being able to retrieve a specific piece of information—is an example of a metacognitive feeling. Other examples of metacognitive knowledge and experience include confidence judgments (judging confidence in a response), ease of learning judgments (perception of the difficulty of items in advance of learning), and knowing judgments (reducing uncertainty about belief accuracy). Metacognitive knowledge and experience allow a subject to reflect and report on the cognitive process.
As discussed earlier, monitoring may fail to correctly assess a person’s own cognitive functioning. As such, metacognitive knowledge and experience may be incorrect, since an individual may over- or underestimate his or her ability and the difficulty of the task. Furthermore, recent studies have identified dissociations between cognitive performance and metacognitive judgment (Schwartz & Díaz, 2014; Schwartz & Metcalfe, 1992), and such findings support the view that metacognitive judgment results from heuristic cues instead of direct access to the content of cognitive activities (Koriat, 2000). For example, a tip-of-the-tongue phenomenon is an example of a feeling of knowing without a corresponding retrieval of contents.

How is metacognition relevant in DIYers’ practice of stimulating their own brains? The next section discusses the roles that metacognition might play in DIY brain stimulation.

### 3.2 The role of metacognition in DIY brain stimulation

DIYers’ use of tDCS relies on the users’ self-regulation of the brain stimulation, and thus metacognitive monitoring and control are heavily involved. The heavy involvement of metacognitive abilities distinguishes the use of brain stimulation in a home setting from that in a professional setting. In the latter, the application of brain stimulation does not necessarily depend on the subject’s monitoring, and therefore, compared with DIY brain stimulation, there is less control or less sense of control over the stimulation.

Metacognitive monitoring in DIY tDCS requires users to observe their cognitive activities and performance in cognitive tasks, and such observation provides guidance for the practice. As reviewed in Section 2.2, when stimulating their brains for cognitive enhancement, DIYers rely on their own subjective judgments or their performance on cognitive tasks to determine the effects and effectiveness of the practice (Jwa, 2015; Wexler, 2016, 2018). Some DIYers share information on Reddit about how they observe and record their cognitive activities, performance, strategies, and thoughts. For example, a user wrote a software program to record the application and perceived effect; while another one combined electroencephalography (EEG) to record brain activation. Such observations and judgments demand that an individual monitors his or her cognitive activities, capacities, and

---

b [https://www.reddit.com/r/tDCS/comments/bc0jbc/i_made_some_code_to_keep_a_record_of_using_tdes/](https://www.reddit.com/r/tDCS/comments/bc0jbc/i_made_some_code_to_keep_a_record_of_using_tdes/).

c [https://www.reddit.com/r/tDCS/comments/2f6y5k/recorded_the_effects_of_that_tdes_device_with_a/](https://www.reddit.com/r/tDCS/comments/2f6y5k/recorded_the_effects_of_that_tdes_device_with_a/).
changes, as well as metacognitive knowledge and experience about his or her cognitive condition. Individuals may infer improvement in the cognitive capacities from their metacognitive knowledge and experience concerning the difficulty of tasks, their confidence in their performance outcome, or their ability to perform a cognitive task. For instance, a tDCS DIYer may use a working memory task, an n-back task,\(^d\) to track his or her performance and the effect of using brain stimulation on working memory. In addition to objectively recorded performance scores, judgments about the ease of the task and confidence in their performance may also contribute to individuals’ perceived improvement.

With respect to metacognitive control, using brain stimulation provides users with an additional way to manage their cognitive state or ability. Metacognitive control allows individuals to modify their cognitive processing, guided by metacognitive monitoring. For instance, DIYers explore not only how to stimulate their brains to maximize the effect, but also which strategy works better for a particular cognitive task (e.g., maintaining a pattern, or rehearsing or not rehearsing for n-back tasks to track working memory enhancement).\(^e\) They evaluate their strategy and performance, which may lead them to decide to adopt the same strategy, modify it, or switch to a new one.

Furthermore, manipulating a person’s cognitive functioning or psychological state through tDCS is comparable to metacognitive control. Similar to the typical metacognitive control, the way in which users adjust their stimulation can be guided by the monitoring process. When an adjustment is made, cognitive functioning and performance are monitored in order to evaluate the adjustment. Using brain stimulation devices to intervene in a person’s brain and manipulate cognitive functions can be regarded as an alternative, indirect way to control cognitive processing.

However, given that metacognitive monitoring can be inaccurate, the perceived improvement that results from, or is influenced by, metacognitive knowledge or experience may be misleading. Therefore, the role of metacognition can be an unreliable indicator of a person’s cognitive performance. The incorrect judgments of an individual’s cognitive functioning and abilities may create illusory perceived effects or prevent the user from being aware of the effects, either of which can undermine the use of brain stimulation.

---

\(^d\) The n-back task is widely used to assess working memory. Participants are instructed to monitor a series of stimuli and to respond when a stimulus is the same as one previously presented in the trials.

\(^e\) https://www.reddit.com/r/tDCS/comments/3vew3o/touching_5_on_dual_nback/.
In addition to the role of metacognition in managing the cognitive operation in using brain stimulation to enhance cognitive functions, theoretically speaking, metacognition itself can potentially be a target of enhancement. Even though metacognition has not yet been a target of intervention for the tDCS user community, it can potentially be a more effective way to enhance a person’s cognitive performance. By enhancing their metacognitive abilities, users could improve their learning abilities, and this could indirectly be considered a kind of cognitive enhancement.

To date, only a few studies have investigated the effects on metacognitive abilities caused by using tDCS. For instance, Chua and Ahmed (2016) found that stimulating dorsolateral prefrontal cortex (DLPFC) led to improved memory monitoring accuracy; that is, the subjects’ feeling-of-knowing judgments became better predictors of memory performance. However, it is crucial to note that such an effect may vary with the cognitive bases of the judgments (e.g., familiarity with the stimulus) (Gaynor & Chua, 2019). Since there is no sufficient evidence to indicate the effects of tDCS on metacognitive ability—let alone the effects on learning—metacognitive enhancement remains only a distant possibility.

4. The problem of measuring effectiveness in DIY brain stimulation and metacognition

For DIYers who stimulate their brains outside of professional settings with the purpose of enhancing cognitive performance, one of the most important concerns is to know the effect of this practice. However, there are many difficulties in evaluating the effectiveness of this kind of practice. This section lays out these challenges. First, while scientific studies have found tDCS to have positive effects on cognitive functions, its effectiveness has yet to be established. Methodological reasons include the small sample size, short-term trials, and the variety of measures used in the studies (Farah, 2015).

Second, even if a method of stimulating the brain is reported to be effective, it is far from guaranteed to produce the same effect in every individual. Complications increase as the applications are used by individual DIYers at home with the expectation of producing effects similar to those reported in the scientific literature. One of the reasons for this is that no standard protocol is available, and some DIYers who consult the protocols in scientific studies alter them (e.g., by changing current density, total charge, stimulation duration, electrode location) as they experiment on themselves.
Furthermore, individual differences in biological and psychological traits may affect the results, since the specific electrode placement affects brain regions in different ways (Utz, Dimova, Oppenländer, & Kerkhoff, 2010). The effectiveness of brain stimulation relies on finding the correct stimulation site, and functional magnetic resonance imaging (fMRI) is often employed to identify locations in the most effective studies on the enhancement benefits of tDCS (Dresler et al., 2013). However, fMRI is unlikely to be incorporated into home-based tDCS. As such, it remains a challenge to ensure the correct stimulation location. The difference in handedness is another example. While most of the subjects in previous studies have been right-handed, left-handed DIYers, due to the lateralized brain function, may encounter moderately different effects compared to right-handed individuals (Schade, Moliadze, Paulus, & Antal, 2012). Considering such differences, some left-handed DIYers modified their protocols (e.g., flipping the montages) in the hope of accounting for the lateralization (Fitz & Reiner, 2014). Other factors—such as an individual’s familiarity and prior experience with DIY tDCS, expectations of the effect, and subjective assessment—are all likely to influence the effects on an individual.

Third, while there is no guarantee of the reported effects of tDCS on every individual, measuring the effects of the application on an individual subject is challenging. The effects can be subtle and take time to appear. The experimental setting cannot be replicated at home to examine the effects since it requires an appropriate number of subjects. Even if one tries to mimic the setting in a scientific study and compare the effects against the reported performance of the control group, the lack of long-term study will prevent one from being able to examine the effects of the application on oneself over a relatively longer period of time. Some tDCS DIYers pursuing cognitive enhancement track their performance in cognitive tasks in the hope of measuring potential effects. However, the observed improvement in performance does not necessarily result from the brain stimulation: it can also be due to a placebo effect or the repetitive practice of cognitive tasks. Furthermore, it is unclear whether the act of self-administering tDCS facilitates the placebo effect. If it does so, this leads to more variables in comparing an individual home-based tDCS user and controls in scientific studies. It would be difficult to differentiate these on an individual level.

---

f [https://www.reddit.com/r/tDCS/comments/5fd6w3/left_handed_tdcers_may_want_to_flip_the_montage/](https://www.reddit.com/r/tDCS/comments/5fd6w3/left_handed_tdcers_may_want_to_flip_the_montage/).

g What is more, a placebo response may be fortified by tDCS (Schambra, Bikson, Wager, DosSantos, & DaSilva, 2014).
Fourth, as reviewed in Section 2.2, DIYers rely on their subjective judgments of the effects of brain stimulation to determine effectiveness. However, as highlighted earlier, our metacognition may not always be reliable. The self-evaluation of performance or effects may be inaccurate due to individual and environmental factors. Furthermore, even if an individual can accurately judge his or her cognitive progress, determining the causes of such progress is a challenge, as the effects of placebo, cognitive training, and bias still cannot be easily excluded. In conclusion, the adoption of subjective judgments and the lack of effective alternative methods make it impossible to determine whether the application of brain stimulation provides the particular effects that an individual is after.

5. The ethical dimension

The uncertainty of the effectiveness of DIY brain stimulation raises some ethical concerns. In this section, I will consider three issues: truthfulness, authenticity, and the conception of enhancement. This section illustrates the relevance of these issues to the difficulty of measuring the effects and examines what these considerations entail. I suggest that the ethical implications do not simply pertain to the permissibility or regulation of DIY practice, but rather concern something much subtler: DIY users’ knowledge of the practice of using neurotechnology, their expectations, their awareness of the potential ineffectiveness, and general scientific literacy.

To illustrate the ethical issues involved in DIY brain stimulation, I introduce four hypothetical tDCS home users: The first is a DIY practitioner (user A), who believes that brain stimulation with tDCS will improve her particular cognitive ability and self-administers brain stimulation at home in pursuit of modifying her cognition through the application. To assess the effects, the user utilizes cognitive tasks to track the effects of the brain stimulation. When an improvement in her performance is observed, it is directly attributed to the use of tDCS without being aware of, or consciously considering, other possibilities. Similarly, the second practitioner (user B), who, with a similar belief and goal, is also using tDCS to improve her cognitive function and is tracking her progress, is, in her case, aware of the complexity of measuring the effects of the brain stimulation. This user, unlike user A, is aware of the possibility that her perceived improvement may not be the result of the application. The third user (user C) is similar to users A and B, except insofar as her goal is to improve her particular cognitive ability through the process of applying the tDCS to herself, which
includes the brain stimulation, the act of self-administration, and Accompanying activities such as the cognitive tasks—rather than through the brain stimulation alone. This person may or may not understand the problem of measuring the effects of brain stimulation. Finally, the last user (user D) identifies herself as a member of the citizen science movement, or as someone whose intention is to experiment with brain stimulation and acquire the power to change her physiological and psychological states. She uses tDCS at home and also tracks her own performance in cognitive tasks. In the following sections, these cases will be used to examine the issues of truthfulness, authenticity, and the conception of enhancement in the rest of this section. It is noted that the fictitious cases are different from non-fictitious ones (Hildt, 2014), and these cases are simplified for the convenience of the analysis and discussion. A real-life tDCS DIYer is likely to be a combination of these hypothetical users (or of other kinds of user not mentioned here), or they might alternate between these characterizations.

5.1 Truthfulness

It is crucial that DIYers are fully informed before and while using brain stimulation devices on themselves, i.e., they must have a full understanding of how to use the device as well as the potential effects and risks associated with its use. There are two ways in which the issue of truthfulness is of concern in this matter: the first relates to users being informed honestly by the manufacturers of brain stimulation devices for non-medical purposes; the second relates to users being self-aware about and honest with themselves with regard to results.

The concern of users being treated truthfully and honestly is pertinent to users who purchase their devices from manufacturers. In such cases, manufacturers bear the responsibility of providing detailed characteristics of the products and they ought to be cautious of the information provided to market the products since this is one of the main sources of information for users who have purchased their devices (Wexler, 2018). Attributing any effects of brain stimulation to the product without sufficient evidence or failing to warn of side effects will mislead consumers and cultivate false expectations. Evidence-based guidelines will help prevent users from perceiving illusory effects. In addition to manufacturers, the information provided by other parties, such as the media, other users in the DIY brain stimulation community, and professionals in medicine, science, or ethics—even though it can provide information from multiple perspectives and
therefore promote truthfulness—can also potentially undermine truthfulness (Dubljević, Saigle, & Racine, 2014). Aside from positive effects and potentially adverse effects, DIYers should also be informed of the potential ineffectiveness of using the device and the difficulties of measuring the effects on themselves to grant users reasonable expectations. However, it is unclear who should bear this responsibility.

The other worry of diminishing truthfulness relates to individuals deceiving themselves or failing to keep themselves well-informed about the effects and effectiveness of brain stimulation. Here, self-deception is regarded as “information-processing biases that give priority to welcome over unwelcome information” (von Hippel & Trivers, 2011:2). What motivates an individual to continue self-administering brain stimulation may be the perceived effects, curiosity, or patience in waiting for the effects to kick in. However, as we have seen in Section 4, the manifold difficulties of measuring the effectiveness of tDCS on an individual DIYer in a home-based setting suggest that an individual rarely has an accurate picture of the effects of brain stimulation. Even when he or she perceives an improvement in cognitive capacity, it may be the result of other factors, rather than the use of brain stimulation. The worry of undermining truthfulness depends on whether the user is able to fully grasp, and make an honest assessment of his or her own condition, including all the possibilities and options available to them. A full awareness of the potential ineffectiveness of brain stimulation entails a user conceiving of all the potential causes of an improvement in cognitive functioning (if there is perceived improvement), and not just attributing improvement to brain stimulation. This can be clearly illustrated by comparing users A and B, introduced earlier. User A is concerning, as she is either ignorant of the complications and simply attributes any perceived effect to brain stimulation, or she comprehends all the possibilities but chooses to ignore them and thus deceives herself into firmly believing in the effectiveness of the practice. In comparison, the effects and the effectiveness of brain stimulation may be equally uncertain for user B. However, she is informed, and open to herself about all the potential underlying causes of improvement, and is truthful as to what can be happening.

Let us now compare users A and B with user C. Their differences lie in the subtle difference in their goals: the former expects to improve her cognitive ability directly by brain stimulation, whereas the latter expects to do so through the whole process of stimulating her own brain, which includes the act of self-administration. For user C, it does not matter whether the perceived improvement results from the brain stimulation, the repetitive
practice of cognitive tasks, the placebo effect, or other causes, for it is not relevant to her motive. Therefore, it is not crucial for user C to be aware of the complexity of measuring the effects and effectiveness of brain stimulation.

5.2 Authenticity and autonomy

Another key issue is authenticity, which is one of the central topics of dispute in the cognitive enhancement debate. There are two major conceptions of authenticity: authenticity as self-discovery, and authenticity as self-creation (Bolt, 2007). This section focuses on the latter conception for two reasons. First, understanding authenticity as self-discovery presumes some kind of essential nature or defining characteristics as the self to which an individual ought to be true (Elliott, 1998). However, this static nature or related characteristics are unclear. Second, ethicists endorsing the former tend to argue against individuals using neurotechnologies to modify their cognition. The central concerns for them are the permissibility of using technology to modify a person’s cognitive functioning and whether the technology can indeed modify cognitive functioning (e.g., Erler, 2011), instead of the difficulty of measuring the effectiveness of neurotechnologies on an individual DIYer, which is not an issue of direct relevance to their concern of changing the essential nature or defining characteristics of oneself.

How is the concept of authenticity understood in terms of self-creation? According to DeGrazia, “any self-creation project that is autonomous and honest is ipso facto authentic” (DeGrazia, 2005:112); that is, authenticity consists of three key elements: self-creation, autonomy, and honesty. Self-creation refers to “the conscious, deliberate shaping of one’s own personality, character, other significant traits [...] or life direction” (DeGrazia, 2005:89–90). Using brain stimulation devices to intervene in the brain in order to manipulate a person’s cognitive processing is regarded as a project of self-creation.

This concept of authenticity is intertwined with the concept of autonomy; indeed, they are sometimes defined interchangeably. Take Christman’s (2018) generic definition as an example: “to be autonomous is to be one’s own person, to be directed by considerations, desires, conditions, and characteristics that are not simply imposed externally upon one, but are part of what can somehow be considered one’s authentic self.” Autonomy, in addition, requires the subject to prefer the actions he or she performs, the
preference to be identified by the subject, and the identification to be care-
fully reflected on to exclude any influences that might lead to alienation.
Therefore, according to DeGrazia (2005), projects of self-creation should
involve setting goals and plans about the kind of person an individual iden-
tifies as and the way in which one wishes to lead his or her life, as well as
taking actions and making decisions to realize plans and achieve goals in
a truthful manner. Accordingly, the issues of authenticity and autonomy,
beyond the consideration of truthfulness, concern not only whether the sub-
ject is in possession of full knowledge about his or her own possible condi-
tions and options (which is addressed in the issue of truthfulness), but also the
actions one chooses to perform given the set goal and knowledge of it.

With respect to DIY brain stimulation, the issue of authenticity prompts
DIYers to reflect on their self-creation—brain stimulation—plan, including
the goals, actions, outcome, and how these are related to one another. It
requires the individual to contemplate his or her reasons for using brain stim-
ulation (e.g., to improve cognitive abilities, to experiment with tDCS), as
well as to have an understanding of what actions could help to achieve their
goals and what the potential outcomes are. This includes understanding the
difficulties of measuring the effectiveness of the intervention and consider-
ing other possible causes of the effects. Examining the cases of the four users
helps to illustrate how the issue is considered. Awareness of the possibility
that the brain stimulation is not effective is important for users A and B,
as the effectiveness of the intervention is crucial in determining whether
the given action (i.e., stimulating the brain in such a way) will help achieve
their goals. Suppose user A’s self-administration is not effective or less effec-
tive than she believes it to be. Before she realizes the issue, she is deceived or
self-deceived in the pursuit of her cognitive enhancement goal and fails to
reflect on her goals and actions. On the other hand, consider user C; her goal
of using tDCS is to improve her cognitive ability in the process of stimulat-
ing her own brain—a different kind of goal from that of users A and B.
Whether user C is aware of the potential causes of effects does not influence
the user with respect to the issue of authenticity as the effectiveness of the
brain stimulation alone is not as crucial for her to achieve her goal.

On the other hand, DIYers using brain stimulations to intervene in
their brain activities can potentially foster authenticity. Consider user D,
if the core value for her to use home-based neurotechnologies is to own
and use the tool of manipulating her own cognitive functioning (Wexler,
2017). For this kind of user, the act of using brain stimulation is aligned with
the goal which involves whom the users identify themselves to be.
Furthermore, to manage a person’s own cognitive functioning using metacognitive monitoring and self-administration of brain stimulation—in addition to metacognitive control—allows users to manifest their mental agency in a new way; that is, the access to brain stimulation devices expands user D’s potential to govern her own psychological states and cognitive abilities. However, in user D’s case, being aware of the potential ineffectiveness is crucial for her, as failing to do so can result in an illusory sense of agency, of being in control, and therefore risks undermining authenticity.

In summary, it depends not only on how informed the DIY practitioners are—whether they are aware of the potential ineffectiveness—but also on what goals they have set for using their brain stimulation devices. In fact, there is a way of understanding the concept of enhancement which allows the act of using brain stimulation to be considered as enhancement in and of itself, despite its potential ineffectiveness.

5.3 The concept of enhancement

It would be a mistake to conclude from the previous discussion that using tDCS to improve cognitive abilities is not an attainable goal for DIYers using brain stimulation. It merely requires users to be aware of the possibilities concerning their conditions, including potential ineffectiveness and other causes for improvements in cognitive ability. In this sense, tDCS can be used for cognitive enhancement. However, there are other interesting ways of regarding DIY brain stimulation as enhancement. This section briefly reviews the conceptual issue of enhancement and discusses the different perspectives prompted by the conceptual issue.

The concept of cognitive enhancement has received a diverse range of treatments (Parens, 2005; Savulescu, Sandberg, & Kahane, 2011). On the one hand, it can be seen as any intervention that improves a particular cognitive function beyond what is necessary for good health (Parens, 1998). This has been the most common notion used in scientific literature on enhancement studies which focus on a single cognitive function and involve healthy subjects, an intervention, and a particular way of measuring performance and improvement. On the other hand, we can adopt a much broader conception of enhancement, such as any interventions that manipulate a person’s psychological state or capacity based on the self-interests of the individual. Savulescu et al. (2011) welfarist definition shares the same spirit: “[a]ny change in the biology or psychology of a person which increases the chances of leading a good life in the relevant set of circumstances” (Savulescu et al., 2011:7).
The first concept is about the condition of a particular cognitive ability, whereas the second concept concerns the overall state of the subject. A major difference between these two conceptions is the way to determine whether the subject is better off after the intervention. For the former, it is determined locally: it is based on the change of a single cognitive ability (e.g., working memory), perhaps through a single type or limited types of assessment method (e.g., n-back task). In contrast, with respect to the second conception, determining whether an intervention is considered as an enhancement requires a more holistic assessment. The interests of the individual are taken into account, and therefore the improvement of a single cognitive ability may not necessarily imply enhancement. Cases in which the improvement of one cognitive faculty may lead to the cost of another (Iuculano & Cohen Kadosh, 2013) are regarded as cognitive enhancement in the first sense, but not necessarily in the second.

The difficulty of measuring the effectiveness of brain stimulation is of concern if cognitive enhancement is understood in the first sense. Whether there exists any effect and whether this effect is a result of the stimulation determines whether this is an instance of cognitive enhancement. However, if endorsing the second conception of cognitive enhancement, this is determined by the subject’s self-interests. If a user, like users A and B, demands improvement effects from the application of tDCS, then the difficulty of measuring the effectiveness matters. However, for some users, like user C, it does not matter if the perceived improvement results from the stimulation or placebo, as long as there is an improvement in cognitive performance accompanying the process of DIY brain stimulation.

There can be other senses in which a subject is enhanced by the act of self-administering brain stimulation if the focus is on the subject as a whole rather than a particular cognitive function, and the self-interests of the subject are taken into account. First, the mere act of using a brain stimulation device as a potential tool to manipulate a person’s cognition can be regarded as a kind of enhancement if the interest of the subject (like user D) is to gain control over a person’s own psychology. Using neurotechnologies to manipulate his or her cognitive processing and abilities provides a sense of control or agency. Such manipulation can be regarded as an unorthodox example of cognitive enhancement if endorsing the second conception, as long as taking control of one’s psychological states and cognitive abilities is

https://www.reddit.com/r/tDCS/comments/5x0y6c/experience_with_tdcs_for_enhanced_learning/.
considered a part of leading a good life. Second, as discussed in Section 3.2, manipulating one’s cognitive functioning or psychological states through brain stimulation is comparable to metacognitive control. Using brain stimulation devices to intervene in a person’s own brain and manipulate cognitive functions can be regarded as an alternative, indirect way to control cognitive processing. A DIYer’s gaining access to a DIY brain stimulation device and putting it on themselves enhances their ability to control their own cognitive functioning and accordingly this can be seen as a kind of metacognitive enhancement.

5.4 Practical implications for stakeholders

Examining the problem of measuring the effectiveness of brain stimulation in relation to the normative issues of truthfulness and authenticity and the conceptual issue of cognitive enhancement provides some practical implications for stakeholders. However, such implications are not as straightforward as to simply question the permissibility of DIY brain stimulation or how it should be regulated. Rather, the situation is more nuanced. As I have detailed above, the difficulties of measuring the effects and effectiveness of using brain stimulation are manifold, and deciphering the causes of any perceived improvement is challenging. Whether the potential ineffectiveness compromises the values of truthfulness and authenticity depends on whether the user is aware of the complicated underlying causes, how the user sets his or her goals, and what kind of person the user wants to be. The uncertainty of the effectiveness of brain stimulation on an individual does not amount to supporting or opposing the permissibility of using brain stimulation devices, and considerations about regulation are not sufficient to address these worries. Instead, education is equally—if not more—important (De Ridder, Vanneste, & Focquaert, 2014). The key is to equip the DIYers with relevant background knowledge and neuroscientific literacy to determine their relationship to the neurotechnology, including their goal in using it, how the practice is undertaken, and their expected outcomes. In addition, it is crucial to have responsible and truthful communication about the intervention’s effects and the uncertainties between DIYers and other parties—such as the device manufacturers, media, other users in the DIY brain stimulation community, and professionals in medicine, science, or ethics. Thus, a platform is required where these various parties can come together to interact and communicate with one another.
I agree with Wexler (2017) in that the use of brain stimulation in a home setting should be considered within the context of citizen science or the neurohacking movement. Since the main purpose of using tDCS for enhancement may not solely be to improve a person’s own cognitive functioning (Wexler, 2018), I suggest that individuals’ access to brain intervention can be regarded as an improvement in the control of their own cognitive functioning. This can be regarded as a kind of enhancement, in the senses discussed above. In addition, for DIYers who want to gain control of their psychological states and functioning, brain stimulation technology has the potential to foster authenticity.

6. Conclusion

This chapter focused on the illusory effects that users of brain stimulation may experience and considered the potential concerns arising from these effects. A significant number of DIYers rely on their subjective judgments to determine the effects of the stimulation. However, deciphering the causes of these effects is challenging, since they can result not only from the stimulation but also from placebo effects, the repetitive practice of cognitive tasks, sample bias, and other causes. I highlighted the role of metacognition as it is crucial for brain stimulation DIYers in two ways. First, cognitive monitoring contributes to users’ perceived effects and subjective judgment of the effectiveness of the stimulation. Considering the individual differences in metacognitive monitoring and its sensitivity to environmental factors helps us to understand the complexity of evaluating effectiveness. Second, DIYers monitoring their cognitive activities and controlling them through the use of brain stimulation can be seen as gaining mental agency. The access to this new way of managing a person’s own cognitive functioning can potentially promote authenticity and be considered an enhancement for individuals who seek to have control over their mental states.

Acknowledgment

I am grateful to Elisabeth Hildt, Imre Bard, and Judy Illes for their helpful comments on earlier versions of this paper.

References


