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Rewiring Eating Disorder Recovery: Neuroethical Implications of tDCS in ED Treatment

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The term “fatal illness” can immediately strike fear. When we hear it, a few diseases often come to mind– cancer, heart disease, stroke, Alzheimer’s, depression, and more. However, we often overlook an illness that can devastate both the mind and body in a myriad of ways: eating disorders.

Eating disorders (ED) are psychiatric conditions that are associated with disturbances in eating behaviors as well as thoughts and emotions related to eating (K. Wu *et al.* [1]). Yielding the second highest mortality rate of any psychiatric illness, EDs harbor the potential to uproot individuals’ lives and detrimentally impact global society (J. Arcelus, A. J. Mitchell, J. Wales, and S. Nielsen [2]). Every 52 minutes, one person dies as a direct consequence to one ([3]), resulting in the annual loss of over 3.3 million healthy life years worldwide (D. Van Hoeken and H. W. Hoek [4]).

The symptoms of EDs vary depending on the condition, but this paper specifically focuses on anorexia nervosa (AN), bulimia nervosa (BN), and binge-eating disorder (BED). As a life-threatening illness, AN is characterized by an abnormally low body weight and intense fear of weight gain, resulting in the compulsive need to exercise and reduce food intake ([5]). BN differs from AN in that it includes episodes of binge eating (consuming a large amount of food in a short period of time), followed by purging, which may include vomiting, overexercising, or using laxatives ([5]). BED, on the other hand, involves binging without purging, which often results in individuals experiencing feelings of guilt, disgust, and shame after consuming large amounts of food ([5]). Despite their differences, all three EDs are serious health conditions that disrupt an individual’s relationship with food.

Unfortunately, the standard treatment for these disorders is far from ideal. Individuals suffering from them may undergo psychotherapy, take medications –often in the form of antidepressants and antipsychotics– and participate in nutritional counseling. In severe cases, particularly for AN patients with critically low BMI, hospitalization may be required ([6]). As of now, psychotherapies have significant limitations and often produce mixed results, with cognitive behavioral therapy sometimes yielding high dropout rates, inconsistent efficacy, and limited long-term success (H. Russell *et al.* [7]). Similarly, medications do not cure ED, as the majority of patients often experience minimal symptom improvement and adverse side effects with the existing options (D. L. Reas and C. M. Grilo [8]). Hence, due to its current inability to effectively reach and address the widespread population, ED treatment remains in its infancy. However, we are now on the precipice of a technological revolution, and within it may lie the key to revolutionizing ED treatment for the better: neuromodulation.

Neuromodulation refers to the technology that can alter neural signaling in the body. By sending electrical pulses to stimulate certain nerves, neuromodulatory devices can

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profoundly influence the brain's activity, harboring the potential to save lives. Although this technology is primarily utilized to address conditions unrelated to mental health disorders, such as chronic neuropathic pain (K. Yu, X. Niu, and B. He [9]), researchers are currently testing its scope by exploring its application to EDs. With the goal of improving BMI and patients' mental health, neuromodulatory techniques serve as a promising alternative to the limitations of existing treatments (K. Wu *et al.* [1]).

There are numerous forms of neuromodulation– some invasive and others non-invasive. Deep brain stimulation (DBS) and vagus nerve stimulation (VNS) are invasive neuromodulatory techniques that require the insertion of a device into the body to provide mild electrical impulses. They are adjustable and reversible, allowing for flexibility in treatment and greater patient autonomy (Cleveland Clinic, 2022). Although these procedures exhibit potential in treating ED, both require a surgical procedure, which exposes individuals to a variety of medical risks and complications. In the case of DBS, these risks include internal bleeding, infection, stroke, and a coma, coupled with troubling side effects, such as issues with balancing, double vision, seizures, and depression (Cleveland Clinic, 2022). VNS can also yield risks and serious side effects, including difficulty swallowing, vocal paralysis, throat pain, shortness of breath, and sleep apnea ([10]).

On the other hand, with non-invasive neuromodulation, we can bypass these complications. Transcranial direct current stimulation (tDCS) is a modern method that can be applied by trained personnel– it acts to modulate the rate of naturally occurring neuronal firing within the stimulated tissue. In tDCS, a weak electrical current is delivered through two scalp electrodes –an anodal electrode, which increases the membrane potential, and a cathodal electrode, which decreases it– via a portable battery-powered stimulator (G. J. Elder and J.-P. Taylor [11]). With low purchase costs, mild adverse effects, and great therapeutic potential, this technology offers a promising answer for ED patients (S. Baumann *et al.* [12]). Unlike transcranial magnetic stimulation (TMS), tDCS is easier to administer, making it a viable option for widespread use.

However, before we consider the implementation of tDCS as a therapeutic tool for ED treatment, we must first evaluate its ethical implications. Given its low cost, portability, ability to target specific brain areas, potential unknown effects on the developing brain, and long-lasting impact, tDCS raises special ethical concerns. With the bioethical principles of autonomy, non-maleficence, beneficence, and justice in mind, how can we effectively implement this technology to treat ED? After all, how much autonomy do ED patients truly have in their decision-making? What are the general ethical considerations of neurotechnological treatment on mental health conditions? This paper seeks to explore the ethical controversies that can arise from tDCS, including its potential risks and implications for treatment. By considering possible misuse, safety concerns, and cognitive vulnerability, the ethical implications of applying tDCS in these specific circumstances can be thoroughly evaluated – offering a potential solution to this raging mental health crisis.

1. The Potential of tDCS for Treating ED

First, research suggests that tDCS can benefit AN patients by alleviating ED symptoms. Given that AN patients exhibit brain abnormalities, particularly in areas such as the dorsolateral prefrontal cortex (DLPFC), modulating these regions could help reduce ED symptoms (Z. Rząd, J. Rog, N. Kajka, P. Szewczyk, P. Krukow, and H. Karakuła-Juchnowicz [13]). Patients with AN also exhibit increased activity in the brain's right frontal hemisphere, indicating the potential need for excitatory tDCS to stimulate the left hemisphere and restore hemispheric balance (Z. Rząd, J. Rog, N. Kajka, P. Szewczyk, P. Krukow, and H. Karakuła-Juchnowicz [13]). Interestingly, three smaller open-label studies

evaluating the efficacy of left DLPFC anodal stimulation in AN have reported improvements in patients' BMI, eating patterns, and emotional well being (E. M. Khedr, N. A. Elfetoh, A. M. Ali, and M. Noamany [14]; F. Costanzo *et al.* [15]; R. Strumila *et al.* [16]). Although these studies differed in methodology, they all noted minimal adverse effects associated with tDCS treatment.

Similarly, BN patients are also characterized by changes in their DLPFC, a brain region involved in reward processing and self-regulatory control, which raises the need for neuromodulation (J. McClelland, N. Bozhilova, I. Campbell, and U. Schmidt [17]). In a double-blind randomized trial, thirty-nine participants received three sessions of targeted tDCS using different methods (M. Kekic *et al.* [18]). One approach, with the anode placed on the right and the cathode placed on the left, improved mood and reduced cognitive symptoms associated with ED (M. Kekic *et al.* [18]). This method assisted with suppressing the urge to binge-eat and increasing self-regulatory behavior, thus demonstrating the potential of tDCS in treating BN patients.

Patients with BED also experience abnormalities with self-regulatory processes. Hence, one experimental trial investigated the efficacy of at-home self-administered tDCS for this condition, recruiting 82 participants who were overweight and met the criteria for BED diagnosis ([19]). After undergoing tDCS treatment with attention bias modification training (ABMT), BED patients experienced significant weight loss, changes in eating behavior, and improvements in mood ([19]).

2. The Ethical Concerns Underlying tDCS

Despite the promising nature of tDCS, it holds certain drawbacks. Currently, tDCS remains unregulated by the U.S Food and Drug Administration (FDA) for over-the-counter and clinical use. Hence, as information regarding this technology has grown in accessibility over the years, users are increasingly utilizing it to conduct self-experimentation. They have formed an online tDCS community, "DIY-tDCS," which focuses on creating a self-stimulating mental health treatment by manufacturing a device based on basic tools and electronic parts (A. Wexler [20]). This, in turn, enables ED patients to avoid physicians in seeking treatment and thus circumvent the traditional process of informed consent. Since tDCS presents itself as a lightweight, low-risk, and inexpensive alternative, it holds a higher chance of being misused, such as for enhancement application, recreational using, and using without supervision (G. Tortella [21]). This misuse could worsen the challenges of managing ED since patients might prioritize self-directed, unsupervised interventions over evidence-based professional care.

Additionally, while tDCS may present minimal and benign side effects –mainly appearing as problems with the skin– in the short term, its long-term side effects remain unknown (H. Matsumoto and Y. Ugawa [22]). No studies of note have evaluated the long-term consequences of tDCS on ED patients, which raises the need for further evaluation to confirm its safety.

Anatomical differences may reduce the effectiveness of tDCS in treating ED patients compared to healthy individuals. After all, people with ED are characterized by altered cortical folding and lower levels of fat– factors that change the transfer of energy to the brain's surface (K. C. Widdows and N. J. Davis [23]). Thus, the efficacy of brain stimulation is dependent on the individual's nutritional state, which proves particularly significant when applying this technology to ED patients. If tDCS use is also extended to minors, it is also crucial to consider that, depending on the size of the head, a specific dose of stimulation will have a larger effect on the brain of a child or younger person compared to the brain of an adult (K. C. Widdows and N. J. Davis [23]). This calls for individualized

tDCS treatments to ensure maximal beneficence. Since studies have yet to evaluate all the ways in which nuances of an individual's brain morphology can impact the effect of neuromodulation, additional research in this field is needed.

Using neuromodulation for treating psychological disorders such as ED also begs the question of whether the treated patients' cognitive capacities are compromised. The technology tDCS grants individuals significant autonomy, which raises concerns regarding its use and consent to use by ED patients. Individuals with long-term ED often face significant neuropsychological impairments (A. Grau, E. Magallón-Neri, G. Faus, and G. Feixas [24]). These impairments, compounded by the cognitive effects of nutritional deficiencies, may impact their ability to make well-informed decisions about treatment and its potential risks (N. Scarmeas, C. A. Anastasiou, and M. Yannakoulia [25]).

This, in turn, raises the question of whether tDCS should be incorporated into ED treatment models. Due to the debilitating condition that ED patients are in, causing them to resist treatment, they often face coercion (J. A. Matusek and M. O. Wright [26]). Should coercion, in this case, be preserved? Would patients genuinely be consenting to tDCS administered by a physician, or would their agreement be influenced by the fear of facing involuntary commitment if they refused? Or, should tDCS be presented as a do-it-yourself (DIY) option to help avoid coercive treatment altogether? If the latter option is chosen, individuals with ED who are in denial about their condition and fearful of weight gain may be more likely to refuse treatment– potentially exacerbating their illness. Although the principle of autonomy involves respecting autonomous decisions despite believing in the wrongness of another's choice, it is also crucial to consider that autonomous decisions rely upon one's ability to use rational deliberation and whether or not one is competent enough to make a particular choice (J. A. Matusek and M. O. Wright [26]). Granting ED patients greater autonomy, in this case, may harm their health in the long term.

The question of distributive justice serves as another key concern surrounding the implementation of tDCS (O. M. Lapenta, C. A. Valasek, A. R. Brunoni, and P. S. Boggio [27]). Considering that individuals may continue to lack the financial means to provide themselves with tDCS treatment, they may face an unfair advantage. The aim of ED treatment is to be accessible and treat as many affected individuals as possible in an efficient manner, which may not be achieved on a global, national, or even regional basis with current healthcare inequities. In the case that tDCS may be utilized for purposes outside of mental health disorder treatment (e.g cognitive enhancement), the issue of justice becomes significantly more pressing, raising the question of how innovative technology could widen the gap between people of differing socioeconomic status (O. M. Lapenta, C. A. Valasek, A. R. Brunoni, and P. S. Boggio [27]).

3. Weighing The Benefits and Ethical Challenges

Despite the promising potential that tDCS holds for ED treatment, it holds significant ethical drawbacks. In the case of autonomy, tDCS is unique in that it offers users the opportunity to exercise their autonomy, which differs from most standard ED treatment plans. Unlike specialized treatment facilities or cognitive behavioral therapy, this neuro technology enables users to control the administration of their treatment. This can enable patients to feel empowered in their recovery and take ownership of their progress. However, greater autonomy can also prevent recovery, in some cases– considering that ED patients experience compromised cognitive capacity and are therefore more inclined to make choices that harm their well-being. They would be more likely to engage in maladaptive behaviors in their treatment.

While the misuse of tDCS (e.g incorrect placement of electrodes or excessive intensity) can put the individual at risk for skin problems, it has not inflicted severe harm to subjects. This technology thus far has exhibited non-maleficence, meaning it avoids causing harm to patients, as evidenced by the mild side effects thus far. However, its long term effects remain unknown.

Regarding beneficence, which refers to the efficacy of treatment, tDCS has shown promising preliminary results, signifying that it holds the potential to reduce ED symptoms. Its ability to stimulate certain regions of the brain enables it to promote self-regulation, improve mood, and reduce disordered eating behaviors. As a result, its application can address the gaps of other, less effective treatments.

Lastly, it remains crucial to promote widespread accessibility to affordable mental health care and emerging therapeutic technologies, which can help bridge the gap in treatment equity and ultimately uplift underserved populations. A lack of access to mental health treatment violates the ethical principle of justice. Thus, policymakers, healthcare providers, and researchers must collaborate to utilize tDCS in a manner that upholds ethical standards but also empowers marginalized communities.

4. Moving Toward Ethical Integration

Ultimately, tDCS presents concerns surrounding autonomy, treatment efficacy, safety, and health equity. These concerns emphasize the need for a thoughtful approach to integrate tDCS into clinical practice. By implementing comprehensive healthcare policies, many of these issues can be effectively addressed, thus paving the way for ethical and more equitable applications of this technology.

Presenting a new ethical-decision making model serves as the first step. This involves transparently explaining the rationale behind the client's treatment recommendation and actively inviting the client and other key stakeholders to participate in this decision process (J. A. Matusek and M. O. Wright [26]). To resolve conflicting viewpoints found in working with clients with severe ED, an interactive, process-oriented model is needed. Such a model is also crucial to ensure that innovative treatments such as tDCS are being implemented responsibly.

In addition to this model, tDCS should be incorporated into a comprehensive care plan that includes psychotherapy, nutritional counseling, and medical monitoring to maximize its benefits. This way, patients can be granted some autonomy while also being able to engage in a well-rounded and supported treatment approach.

Access to tDCS can be increased through the implementation of funding to subsidize tDCS treatments for low-income patients. For insurance coverage purposes, tDCS should be recognized as a reimbursable treatment option for eating disorders. The use of telehealth can also expand access by offering remote consultations and monitoring, particularly for patients in underserved areas.

Therefore, the administration of tDCS provides a promising method for ED treatment–one that is accessible, effective, and empowering for the patient and mental health society.

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