

TDCS: The Intriguing, Uncertain Future of Direct-to-Consumer Brain Stimulation Treatments

Abstract

Within the past decade, direct-to-consumer neurotechnologies have garnered significant attention from researchers and consumers alike. One such technology is transcranial direct current stimulation (tDCS), a non-invasive procedure in which weak electrical currents are fired through the cortex, resulting in changes in neuronal activity attributed to cognitive benefits. Private companies are manufacturing and promoting tDCS devices to consumers as a novel, convenient way to boost cognition- or even alleviate symptoms of neurological disorders. A movement consisting of thousands of “do it yourself” users is active across social media platforms and websites. These users are sharing insights as to how tDCS has impacted them, and helping others navigate the process of this unique technology. However, as tDCS lacks government backing, most users are acting without the recommendation of a neurologist or physician, posing legal and liability concerns. This paper will examine the cultural context of tDCS usage, applications of tDCS, its growing at-home users, and the implications for the future of tDCS and direct-to-consumer neurotechnology.

The Emergence of tDCS as a Novel Brain Stimulation Treatment

There is a steadily-growing online community for a treatment that modulates brain activity. This treatment is unique in its commerciality- it is small, relatively cheap compared to the alternatives, and can be purchased and delivered for at-home, self-administered use. It is an entirely direct-to-consumer treatment, with no involvement needed from a physician, hospital, or healthcare institution.

The treatment, transcranial direct current stimulation (tDCS), is a neuromodulator that passes a weak current (about 1-2mA) through the wearer’s cortex using at least two electrodes that are attached to the head [1]. The currents modulate neuronal activity, resulting in perceived cognitive benefits. Despite the electrodes being placed over specific areas, research has shown tDCS produces a widespread modulation of neural networks across the brain [2]. Compared to other brain stimulation treatments, tDCS has undeniable appeal. Users aren’t placed under anesthesia while a

strong current induces a bodily seizure, like with electroconvulsive therapy. Additionally, tDCS is non-invasive compared to deep brain stimulation, which requires brain surgery to attach the electrodes directly to the brain [3][4]. These alternative procedures are physically and financially taxing, but they have something tDCS does not, despite years of research and testing: FDA approval. The world is shifting into the era of hypercommercialism, in which social media outlets are used to advertise easily accessible and usable products. Many private companies are manufacturing and selling tDCS devices under the premise that they can alleviate symptoms of neurological disorders and improve cognition. The question therein lies as to how policymakers should respond.

Effects of tDCS on the Brain

Researchers report improvement in patients' symptoms of multiple neurological disorders after undergoing tDCS [5]. Particularly, researchers have investigated the safety and efficiency of tDCS for the treatment of depressive disorders, which many of its fellow brain stimulation treatments have obtained FDA approval for. Patients diagnosed with major depressive disorder, unipolar depression, and bipolar depression responded positively to actual tDCS treatment compared to sham tDCS, with the difference in dropout rates and adverse effect rates not statistically significant between the two groups [6][7]. In addition to treating neurological disorders, tDCS also improves cognitive functions such as long-term and working memory, verb learning, and motion perception in healthy brains [8][9][10]. However, in subjects with neurological disorders (depression, schizophrenia, etc.), tDCS treatment improved working memory while other cognitive functions such as executive functioning, verbal fluency, and processing speed were unaffected [11]. This implies the effects of tDCS may be applicable to some cognitive functions but not others, casting some uncertainty over whether it is appropriate to market it as an all-around "brain booster". Additionally, it is important to note that the FDA does not approve treatment devices that are marketed for solely improving cognitive function, despite users already utilizing tDCS for that very purpose [12].

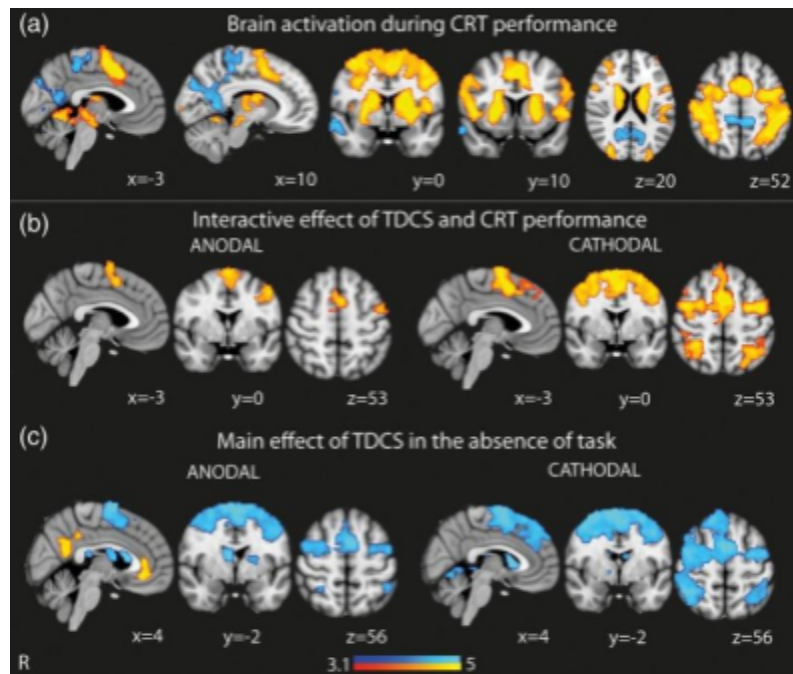


Figure 1. Subject's brain activity with anodal (excitatory) and cathodal (inhibitory) tDCS during a choice reaction task vs. rest [2]

Emerging DIY TDCS Treatment: The Age of "Neurohacks" and Consumer Convenience

TDCS is one piece of the newly-emerging age of “neurohacking”, named after the “life-hacking” revolution characterized by novel, creative tips that make life easier [13]. Neurohacking addresses the neurological aspect of that, characterizing the brain as a medium that can be enhanced, whether through dietary supplements, drugs, or brain stimulation treatments like tDCS. There are thousands of tDCS users sharing their experiences and even tutorials on how to self-administer the treatment across social platforms and websites [12]. It could be argued that tDCS resembles other neuromodulators that are commonplace in society, such as caffeine or alcohol. The question is, are DIY tDCS users looking too far ahead into the future, or is it policymakers that should begin to address it as they acknowledge the newfound place of direct-to-consumer neurotechnologies within neurolaw? Most users on the tDCS subreddit agree it would be beneficial to have guidelines concerning tDCS usage from government agencies or experts, including neurologists [12].

TDCS vs. TMS

TDCS has a sister treatment, TMS (transcranial magnetic stimulation), which is also non-invasive and involves passing a weak current through the cortex in order to modulate neuronal activity. In many ways, tDCS and TMS are two sides of the same coin- except TMS has been FDA-approved for the treatment of depression since 2008 [14]. However, those diagnosed with depression cannot immediately begin TMS treatment at their local hospital or clinic. To qualify for insurance coverage of TMS, a patient not only must be diagnosed with major depressive disorder by a physician but must have also undergone at least one treatment (such as SSRIs or SNRIs) without satisfactory results. According to Dr. Linda Carpenter, a psychiatrist at Butler Hospital, that description fits a third of all people diagnosed with depression. Furthermore, the roughly 20 million people that have already undergone TMS treatments had to meet these conditions before doing so [14]. The implications of this are significant, as millions had to meet government-established requirements to undergo TMS that those who use tDCS are bypassing, simply because there is limited government policy addressing it.

Implications

Direct-to-consumer neurotechnologies such as tDCS are more affordable and convenient alternatives to hospital treatment options. Conversely, they have potential legal, ethical, and social ramifications. A consumer faced with the choice between an easy, DIY treatment that can be ordered on eBay or Amazon for around 100 dollars or an invasive treatment costing thousands of dollars with severe potential side effects will most likely be inclined to make the more cost-effective, convenient choice- even if that option does not have any government backing or fails to properly target their symptoms. There is also the issue of patient injury, which sparks another debate around liability. The issues surrounding socioeconomic context, health policy, consumer discretion, and physician recommendation is unique to tDCS, and ever-relevant as the world shifts into a direct-to-consumer age of neurotechnology.

References

- [1] Chase, Henry W. et al. (27/08/2019). Transcranial Direct Current Stimulation: a Roadmap for Research, from Mechanism of Action to Clinical Implementation. *Molecular Psychiatry*. <https://doi.org/10.1038/s41380-019-0499-9>. Retrieved: 02/07/2023.
- [2] Li, Lucia M. et al. (15/02/2019). Brain State and Polarity Dependent Modulation of Brain Networks by Transcranial Direct Current Stimulation. *Human Brain Mapping*. <https://doi.org/10.1002/hbm.24420>. Retrieved: 05/07/2023.
- [3] Coleman, Deandra. (2023). Brain Stimulation Services. Johns Hopkins Medicine. https://www.hopkinsmedicine.org/psychiatry/specialty_areas/brain_stimulation/services.html. Retrieved: 02/07/2023.
- [4] Mayo Clinic Staff. (03/09/2021). Deep Brain Stimulation. Mayo Clinic. <https://www.mayoclinic.org/tests-procedures/deep-brain-stimulation/about/pac-20384562>. Retrieved: 02/07/2023.
- [5] Shmerling, Robert H. (10/03/2023). Transcranial Direct Current Stimulation Claims, Safety, and Overview. Center for Health and the Global Environment. <https://chgeharvard.org/transcranial-direct-current-stimulation-claims-safety-and-overview/>. Retrieved: 05/07/2023.
- [6] Moffa, Adriano H. et al. (15/10/2017). Safety and Acceptability of Transcranial Direct Current Stimulation for the Acute Treatment of Major Depressive Episodes: Analysis of Individual Patient Data. *Journal of Affective Disorders*. <https://doi.org/10.1016/j.jad.2017.06.021>. Retrieved: 04/07/2023.
- [7] Mutz, Julian et al. (12/05/2018). Efficacy and Acceptability of Non-Invasive Brain Stimulation for the Treatment of Adult Unipolar and Bipolar Depression: A Systematic Review and Meta-Analysis of Randomized Sham-Controlled Trials. *Neuroscience and Biobehavioral Reviews*. <https://doi.org/10.1016/j.neubiorev.2018.05.015>. Retrieved: 04/07/2023.
- [8] Lovelace, Berkeley Jr. (22/08/2022). Braincap Appears to Boost Memory for At Least 1 Month, Early Research Finds. *NBC Health News*. <https://www.nbcnews.com/health/health-news/brain-zapping-cap-appears-boost-memory-least-1-month-early-research-fi-rcna43949>. Retrieved: 08/07/2023.
- [9] Fiori, Valentina et al. (01/11/2018). Transcranial Direct Current Stimulation (tDCS) Facilitates Verb Learning By Altering Effective Connectivity in the Healthy Brain. *NeuroImage*. <https://doi.org/10.1016/j.neuroimage.2018.07.040>. Retrieved: 07/07/2023.
- [10] Battaglini, Luca et al. (28/04/2017). Anodal and Cathodal Electrical Stimulation Over V5 Improves Motion Perception By Signal Enhancement and Noise Reduction. *Brain Stimulation*. <https://doi.org/10.1016/j.brs.2017.04.128>. Retrieved: 07/07/2023.
- [11] Begemann, Marieke J. et al. (19/10/2020). Efficacy of Non-Invasive Brain Stimulation on Cognitive Functioning in Brain Disorders: A Meta-Analysis. *Psychological Medicine*. <https://doi.org/10.1017/S0033291720003670>. Retrieved: 10/07/2023.
- [12] Jwa, Anita. (02/07/2015). Early Adopters of the Magical Thinking Cap: A Study on Do-It-Yourself (DIY) Transcranial Direct Current Stimulation (tDCS) User Community. *Journal of Law and the Biosciences*. <https://doi.org/10.1093/jlb/lsv017>. Retrieved: 11/07/2023.
- [13] Wexler, Anna. (10/05/2017). The Social Context of “Do-It-Yourself” Brain Stimulation: Neurohackers, Biohackers, and Lifehackers. *Frontiers in Human Neuroscience*. <https://doi.org/10.3389/fnhum.2017.00224>. Retrieved: 11/07/2023.
- [14] Esposito, Lisa. (07/02/2022). What is TMS Treatment for Depression?. *US News*. <https://health.usnews.com/conditions/articles/tms-therapy>. Retrieved: 03/07/2023.