NEUROPHYSIOLOGY

Possible treatment to rehabilitate the brain from addiction

A new study shows that a rehabilitating mechanism known as transcranial magnetic stimulation can be used as a treatment for substance use disorders.

Kawther Elolaimi

In a paper recently published in *Frontiers*, Corinna Bolloni et al., investigate transcranial magnetic stimulation (TMS) mechanisms and usage as a potential treatment for addiction.[1] TMS has been used to improve symptoms of depression and is a noninvasive procedure that uses repetitive magnetic fields to stimulate nerve cells in the brain.[2] This method has been proven to be innovative, safe and cost effective, however the mechanism and effectiveness for addiction treatment remain a mystery which we hope this study will uncover.[1,3] This study indicates that TMS can be used as a promising treatment for addiction and hopefully can change the rewiring of the brain to avoid substance usage as shown in the figure below.[1] They discovered that post treatment, drug intake had been reduced in comparison to pre-treatment. Their evidence claims that TMS can indeed produce adaptations to specific brain areas changing the pathway and firing patterns of cells resulting is substantial physical behavioral changes as well as reduced intake.[1,3] This implies that this treatment can alter the wiring of the brains of those who are addicts to potentially prevent them from continuing their addiction.

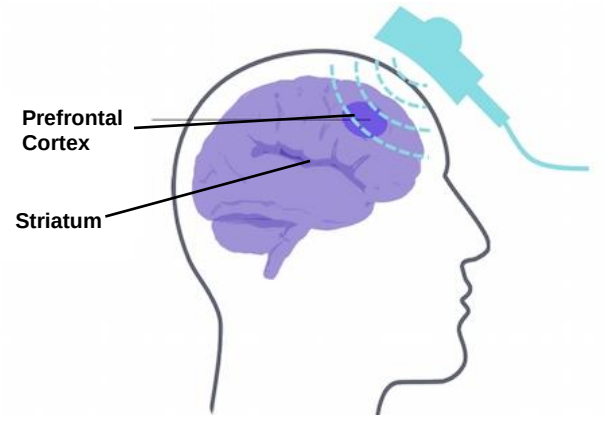
Substance use disorders (SUDs) represent a major public health concern worldwide and are a leading cause of disease and mortality.[1,3,4] The addiction becomes compulsive and difficult to control despite harmful consequences.[3,4] There are about 27.7 million users in the western world alone allowing researchers to gain a general consensus on drug addiction and identifying therapeutic options which they consider to be limited.[1,3,7] Circuits in the brain involved in reward seeking behavior as well as fear processing adapt as a result of chronic use and abuse of drugs as mentioned in the figure below.[3,5] The pathway of these circuits has become a primary focus of researchers who aim to develop treatment methods to disrupt these cycles. When you constantly keep using something or repeating a certain action, you come prone to it, therefore changing the cycle starting with the brain may alter that behavior or habit allowing you to change or quit it. However, it is unclear exactly which pathways and processes in the brain are associated with the development and progression of addictive disorders.[5,6,7] In the USA alone, the cost to illicit drugs exceeds 700 billion dollars a year.[6,7] Currently, TMS has been widely studied to be used as a potential treatment to disrupt cycles in the brain to alter behavior. TMS contain magnetic fields which are generated with a coil placed over the scalp and transmit electrical currents to the brain as demonstrated in the figure below.[1,2,3] As mentioned, it is a noninvasive and painless procedure with repetitive stimulation that allows for long-term changes in the brain which facilitate or impede specific behaviors depending on the area of the brain that gets stimulated.[1,2,3]

This study was conducted on ten addicts with an average age of 35 years who on average have been dependent on cocaine for 13 years and consumed an average of 0.5 to 20ng/mg (7.75 ng/mg) of cocaine, cannabis, and/ or opioids. A *hair test* was used to measure the amount of drug

intake since it provides long-term information about drug consumption with higher sensitivity and specificity in comparison to urine analysis. The subjects were administered with 12 repetitive TMS sessions 3 times a week for 4 weeks with the intensity of the stimulation set at the lowest intensity required to provoke a neuronal response. During the TMS sessions, the prefrontal cortex was targeted and stimulated bilaterally. Drug intake was dependent of hair analysis at baseline, which was assessed before treatment, after 1 month, after 3 months, and after 6 months for a total of three treatment sessions at the end of each indicated month.

Throughout the course of the six months, the researchers observed decreased drug consumption from the onset to the end of treatment which was six months later. After the first treatment, they immediately started to notice decreased consumption of drug intake from the participants. They used 10 Hz stimulation which was the minimal amount of stimulation required to enhance neuronal responses which activated 1000 pulses. The duration of each treatment session lasted about 10 minutes. The frequency activated a response and significantly reduced the amount of drug consumption in all participants in the 6-month period, however, a greater frequency may prevent drug consumption entirely in a shorter amount of time.

The results of this study supported the claim made from previous studies claiming that TMS can be used as a potential treatment to cure drug addiction. However, additional research is highly encouraged to further understand the correlation between frequency stimulation and drug consumption in hopes to alter the wiring of the brain and break the addiction. Additionally, though not mentioned in detail earlier, some studies have only used unilateral (asymmetric) stimulation in one specific site in the brain while this study conducted bilateral stimulation. They thought this would decrease drug consumption at a faster rate since addiction affects the whole brain and not just one area. They believe that it would be more of a suitable method for clinical studies aimed at reducing drug intake. Though additional studies are needed, the results in this study seem promising and supportive of the treatment option of using TMS to treat addiction. As of now though, exercise contains many health benefits and is also being considered as a treatment option for drug addiction.[9] In addition, scientists are also developing new pharmaceutical treatments for drug addiction.[12]



This figure shows transcranial magnetic stimulation at the prefrontal cortex. This mechanism aims to disrupt the cycle of addiction and prevent substance use disorders. Addiction affects many brain areas cycling throughout the prefrontal cortex which anticipates the reward, the striatum and surrounding brain structures during intoxication, and finally the amygdala when negative affects occur such as withdrawal.

REFERENCES

1. Bolloni, et al. “Bilateral Transcranial Magnetic Stimulation of the Prefrontal Cortex Reduces Cocaine Intake: A Pilot Study.” *Frontiers*, Frontiers, 19 July 2016, www.frontiersin.org/articles/10.3389/fpsyt.2016.00133/full.
2. “Transcranial Magnetic Stimulation.” *Mayo Clinic*, Mayo Foundation for Medical Education and Research, 27 Nov. 2018, www.mayoclinic.org/tests-procedures/transcranial-magnetic-stimulation/about/pac-20384625.
3. Diana, Marco, et al. “Rehabilitating the Addicted Brain with Transcranial Magnetic Stimulation.” *Nature News*, Nature Publishing Group, 29 Sept. 2017, www.nature.com/articles/nrn.2017.113.

4. Substance Use Disorder: MedlinePlus Medical Encyclopedia." *MedlinePlus*, U.S. National Library of Medicine, medlineplus.gov/ency/article/001522.htm.
5. "Biological Evidence for Paradoxical Improvement of Psychiatric Disorder Symptoms by Addictive Drugs." *Trends in Pharmacological Sciences*, Elsevier Current Trends, 4 Apr. 2017, www.sciencedirect.com/science/article/pii/S0165614717300627.
6. Herman, Melissa A, and Marisa Roberto. "The Addicted Brain: Understanding the Neurophysiological Mechanisms of Addictive Disorders." *Frontiers in Integrative Neuroscience*, Frontiers Media S.A., 19 Mar. 2015, www.ncbi.nlm.nih.gov/pmc/articles/PMC4365688/.
7. "Neurobiologic Advances from the Brain Disease Model of Addiction | NEJM." *New England Journal of Medicine*, www.nejm.org/doi/full/10.1056/nejmra1511480.
8. Dunlop, Katharine, et al. "Noninvasive Brain Stimulation Treatments for Addiction and Major Depression." *Annals of the New York Academy of Sciences*, John Wiley and Sons Inc., Apr. 2017, www.ncbi.nlm.nih.gov/pmc/articles/PMC5434820/.
9. "Exercise as a Novel Treatment for Drug Addiction: A Neurobiological and Stage-Dependent Hypothesis." *Neuroscience & Biobehavioral Reviews*, Pergamon, 24 June 2013, www.sciencedirect.com/science/article/pii/S0149763413001668.
10. Volkow, Nora, and Ting-Kai Li. "The Neuroscience of Addiction." *Nature News*, Nature Publishing Group, www.nature.com/articles/nn1105-1429.
11. "Drug Abuse as a Problem of Impaired Control: Current Approaches and Findings." *SAGE Journals*, journals.sagepub.com/doi/abs/10.1177/1534582303257007.
12. "The Addicted Brain." *Cambridge Neuroscience*, www.neuroscience.cam.ac.uk/research/cameos/AddictedBrain.php.