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Секція IV.
ОСНОВИ ВЗАЄМОДІЇ ПСИХОЛОГА, УЧИТЕЛЯ І БАТЬКІВ В УМОВАХ ОСВІТНЬОГО ПРОЦЕСУ

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THE EFFECTS OF PREFRONTAL CORTEX TRANSCRANIAL DIRECT CURRENT STIMULATION (TDCS) ON FOOD CRAVING IN ADULTS - RESEARCH REVIEW

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1. Introduction

According to the latest study released by the Lancet, more than 1 billion people in the world are living with obesity. Moreover, obesity among adults has more than doubled since 1990, and has quadrupled among children and adolescents (Phelps et al., 2024). Food craving plays an important role in etiology of obesity and overweight. Craving, has been defined as „an irresistible urge to consume" and has been associated with both overeating and substance abuse (Wang et al., 2004). The results of recent neuropsychological studies have been shown that the dorsolateral prefrontal cortex (DLPFC) is related to balanced appetite regulation. The DLPFC is a functional structure of the human brain that is responsible for the executive functions such as decision-making, cognitive flexibility, and inhibition (Mostafavi et al., 2018). What is more, hypoactivation of DLPFC has been associated with less ability for eating control. In this case, results of studies using non-invasive brain stimulation technique called transcranial direct current stimulation (tDCS), has been indicated to reduce food craving. TDCS is a neuromodulation technique with potential to treat eating disorders and obesity by increasing DLPFC activity. This form of stimulation involves the application of a weak electrical current, typically up to 2 milliampere (mA), to a specific region of the brain via two electrodes that are placed over the scalp (Nitsche & Paulus, 2000).The present research examine the latest studies results on the effects of prefrontal cortex transcranial direct current stimulation on food craving in adults.

2. Food craving and its association with functioning of dorsolateral prefrontal cortex (DLPFC)

The dorsolateral prefrontal cortex (DLPFC), is a functional structure of the human brain located in the frontal lobe. It's associated with several cognitive functions, including working memory, executive functioning, inhibition of impulses and decision-making. Overall, the DLPFC plays a critical role in higher-order cognitive functions and is essential for adaptive behavior and goal-directed actions. It is also shown that that the dorsolateral prefrontal cortex is related to balanced appetite

regulation (Mostafavi et al., 2018). What is more, researches have also indicated that hypoactivation of the DLPFC is associated with a reduced ability to control eating, particularly in obese individuals. This suggests a potential link between the DLPFC and the regulation of food craving and eating behavior. The DLPFC is part of the brain's reward system, which is involved in the recognition and control of food intake. When the DLPFC is not functioning optimally, it may lead to an imbalance in the reward system, resulting in increased food cravings and overeating. Indeed, dysregulation of the DLPFC has been linked with greater impulsive behaviors, often leading to overconsumption (Gluck et al., 2017). It prompts the right brain hypothesis of obesity, which suggest that a decrease in the right dorsolateral PFC (DLPFC) activities may lead to obesogenic behaviors through poor appetite control (Tabasi et al., 2024). Simultaneously, it postulates that enhancing the activity of the right dorsolateral prefrontal cortex (DLPFC) may strengthen inhibitory control, a core component governing executive self-regulatory processes and goal-oriented eating behavior, thus suppressing the reward-related activity in the reward–cognition neural circuits that drive food craving and overeating (Ljubisavljevic et al., 2016). Neuroimaging research showed that various frontal brain regions besides the DLPFC are linked to general cognitive control, including the anterior cingulate cortex, the ventrolateral prefrontal cortex, the orbitofronal cortex, the medial PFC and the inferior frontal gyrus (IFG). For example, neuroimaging evidence displays that DLPFC activity and functional coupling to the ventromedial PFC promote healthy food choices and successful dietary self-control (Ester & Kullmann, 2021).

More recently, Iranian researchers have been investigating the role of omega-3 fatty acids in the DLPFC. The recent study published in the Iran Journal of Psychiatry in 2024, investigates the combined effects of Transcranial Direct Current Stimulation (tDCS) and omega-3 supplementation on food craving, executive functions, weight, and depressive symptoms in women with depression and overweight. The most important and main hypothesis of this research was based on the fact that the mechanism of effect of omega-3 on the symptoms of depression as well as obesity is formed through its accumulation in the DLPFC, especially in women (Tabasi et al., 2024). The study found that the combination of tDCS and omega-3 showed a significant positive effect on weight change and a trend towards improving executive functions and reducing food cravings in women with depression and overweight. This indicates that the interaction between omega-3 and tDCS may have a beneficial impact on the DLPFC, which could be a potential mechanism for the observed improvements in weight and related cognitive and behavioral outcomes.

Collectively, the findings imply that the DLPFC and its connections to other frontal regions play a crucial role in effective dietary self-control, highlighting this frontal network as a key focus for obesity treatment. However, the current literature does not definitively indicate whether the right or left DLPFC has a greater impact on dysregulated eating behavior, with evidence existing for both sides.

3. Use of transcranial direct current stimulation (tDCS) on food craving in adults

Transcranial Direct Current Stimulation (tDCS) is a neurostimulation therapy that applies a low-intensity current to the scalp, targeting areas like the DLPFC. tDCS

is not considered invasive and has shown potential in treating neurological conditions. This form of stimulation involves the application of a weak electrical current, typically up to 2 milliampere (mA), to a specific region of the brain via two electrodes that are placed over the scalp (Nitsche & Paulus, 2000). This therapeutic NIBS (non-invasive brain stimulation) technique has been applied in several researches to modulate neural activity of the DLPFC for control of eating and appetite. Stimulation of the DLPFC by tDCS has been suggested to decrease hedonic appetite and food craving, leading to reduced food consumption by weakening the reward response. The majority of tDCS research investigating its impact on food cravings has focused on stimulating the right DLPFC. This choice is rooted in its association with inhibitory control and reward-based learning. Some trials aimed to enhance self-control by stimulating the left DLPFC or targeting both sites by using anodal stimulation at the right and left DLPFC, respectively (Ester & Kullmann, 2021).

The idea of the potential modulation of DLPFC activity for the management of craving for food emerged from studies demonstrating that non-invasive stimulation of DLPFC, using techniques such as repetitive transcranial magnetic stimulation (rTMS) and transcranial direct current stimulation (tDCS), can effectively alter other forms of craving such as smoking, alcoholism, cocaine addiction, and eating disorders (Ljubisavljevic et al., 2016). One of the first brain imaging studies of food cravings was published in 2004 by Pelchat and colleagues. Using fMRI, Pelchat et al. (2004) found that food cravings activate the same areas that are normally associated with drug cravings (Goldman et al., 2011). What is more, even though the theory that foods can trigger an addictive process remains controversial, neurobiological evidence shows similar neural pathways between food craving and drug craving (Ester & Kullmann, 2021).

Additionally, tDCS has been found to improve self-reported ability to resist food in adults with frequent food cravings. These findings suggest that the DLPFC is a key area in the brain's regulatory mechanisms for food craving, and that stimulating this area with tDCS can influence these mechanisms to help manage food cravings and potentially aid in weight management. The first study that explored the effects of tDCS on food craving showed that a single session of anodal (excitatory) tDCS of the right DLPFC induced a significant decrease in craving for viewed food. Other studies that used the same anode right/cathode left DLPFC stimulation showed that single session of tDCS may temporarily increase the ability to resist food, reduce caloric intake, and decrease craving for sweet but not savory foods .

There are many studies that have focused on measuring state food craving, when identifying the effects of tDCS on hedonic appetite. The first study to identify the impact of tDCS on hedonic appetite compared anodal stimulation to the left and right DLPFC in 21 healthy-weight individuals with frequent food cravings, defined as experiencing 3 or more strong urges to consume high-calorie foods per day (Fregni et al., 2008). When applying 2 mA stimulation for 20 min, a significant reduction in food craving was observed following tDCS over the right DLPFC, but not when applied to the left hemisphere (Beaumont et al., 2021b).

In recent years, there has been a rapid increase in the number of studies utilizing tDCS to influence eating behavior. Nevertheless, the efficacy of tDCS remains uncertain due to conflicting study outcomes, with individual variances emerging as a crucial determinant in the effectiveness of non-invasive brain stimulation techniques. There are also other factors that impact the effectiveness of stimulation and determine results. Ray et al. (2019) reported sex-effects (reduction in food was only observed in women with low attentional impulsivity). Additional research has also revealed gender-specific effects of tDCS on various cognitive functions. For example, one study found that men experience improvements in verbal working memory with tDCS stimulation of the left DLPFC, while women benefit from stimulation of the right DLPFC (Meiron & Lavidor, 2013). The recent analysis concluded that neither the stimulation site (anodal left or right DLPFC) nor the current intensity (1 or 2 mA) has a significant effect on tDCS outcomes (Chen et al., 2020). However, the duration of stimulation proved to be a significant factor, indicating that a longer total stimulation time correlated with a more pronounced reduction in craving.

4. Conclusions

All in all, there is a great deal of potential for tDCS as a non-invasive technique for the modulation of food cravings in adults. Studies investigating the impact of tDCS on food craving have primarily focused on stimulating the dorsolateral prefrontal cortex (DLPFC), particularly the right hemisphere, although it's important to note that this isn't a universal rule, as some studies have targeted the left hemisphere or other brain regions. Research findings also suggest that tDCS holds promise in reducing food cravings, with longer stimulation durations correlating with more significant reductions in craving intensity. However, the effectiveness of tDCS may vary depending on individual factors such as gender, highlighting the need for personalized treatment approaches.

Overall, while the research on tDCS and food craving is still evolving, it offers a promising avenue for intervention in addressing unhealthy eating behaviors. Understanding how tDCS affects food craving is crucial in addressing issues related to overeating, obesity, and related health concerns. Further studies are needed to refine stimulation protocols, explore individual differences in treatment response, and elucidate the long-term effects of tDCS on food craving and eating habits in adults.

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LINKS BETWEEN ADOLESCENTS' MENTAL HEALTH, FEELINGS OF SAFETY AT SCHOOL AND AGGRESSIVE BEHAVIOR

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In times of major global challanges, such as pandemics and ongoing war in Ukraine and other countries, adolescents face major mental health challenges. It has been estimated that 1 in 7 adolescents in the world is affected by a mental health disorder. According to the Official Statistics Portal, in 2022 there were 5343 adolescents in Lithuania with a mental and behavioural disorder. Given the relevance of mental health difficulties, this study aims to investigate how adolescents' mental health difficulties (anxiety, stress and depression) and perceived safety of the environment are related to adolescents' aggressive behaviours. Thus, the study aimed to determine whether the intensity of aggressive behaviour can be related to the characteristics of the immediate environment of the growing person and the mental health difficulties experienced.