

Title: Neurocognitive effects of transcranial direct current stimulation (tDCS) in healthy younger adults

Author: Daria Kukuła

Doctoral dissertation prepared under the supervision of Dr. Monika Wiłkość-Dębczyńska, professor of the university and Dr. Anna Rasmus

**Purpose of the study with scientific justification:** The study conducted addressed the neurocognitive effects of transcranial direct current stimulation (tDCS) in healthy subjects during early adulthood. The purpose of the study was to investigate the effects of transcranial direct current stimulation on executive function processes in healthy adults and to examine differences between active and placebo stimulation. The use of direct current stimulation in healthy individuals is primarily aimed at evaluating the effectiveness of this method and gaining a better understanding of its mechanism of action. Such interactions contribute to optimizing mental performance, which in turn may be helpful in meeting the demands placed on individuals in early adulthood. Such interactions can also be protective and contribute to building cognitive reserve. In addition, understanding the effects of stimulation on specific domains of executive function in healthy individuals may provide a basis for using it as a treatment for cognitive disorders.

**Method:** The study was based on tDCS stimulation (active vs. placebo) as the independent variable and executive function processes, consisting of working memory, arousal process, inhibition and action control as dependent variables. Sociodemographic variables such as gender and age were also controlled.

The study included 90 subjects in early adulthood, who were divided into three equal groups: experimental, active control and passive control. The mean age in the experimental group was  $M=27.33$  ( $SD=4.28$ ), in the active control group  $M=28.03$  ( $SD=3.85$ ) and in the passive control group  $M=27.93$  ( $SD=3.96$ ). There were 15 women and 15 men in each group. The study examined the effects of tDCS stimulation on working memory, arousal, inhibition and action control processes, and whether the stimulation had different effects depending on the subjects' gender. The area stimulated was the dorsolateral prefrontal cortex (DLPFC), which is associated with working memory processes. Subjects in the experimental group participated in 10 sessions of tDCS stimulation, during the traction of which a current of 2 mA was applied for 30 minutes, with a rise and fall period of 20 seconds each. The mounting of the electrodes was as follows: anode: F3, cathode: Fp2. Circular sponge electrodes with an area of  $25\text{cm}^2$  were used. The

active control group also participated in 10 meetings, during which the procedure was identical to that of the experimental group. The only difference was that the subjects received an increasing current during the first 20 seconds, after which the stimulator turned off. This was done to create conditions in the placebo group that were as close to active stimulation as possible, so that the participants would not be able to recognize which group they were in. Each subject underwent two assessments of cognitive functioning: before participating in the stimulation cycle and after completing it, with the second measurement taking place 1-3 days after the cycle ended.

**Results:** The analyses showed that tDCS stimulation improved working memory, expressed in: the number of correct repetitions of digits directly, the percentage of correct movements in BCST, and the ratio of movements made to the minimum number of movements in TOL; the process of arousal, expressed in: the number of correct responses in the GNG task and the CTT-2 execution time; the process of inhibition, expressed in: the number of incorrect responses in the GNG task; the action control process expressed in: the percentage of conceptual level responses, the percentage of perseverative and non-perseverative errors in the BCST, the difference of movements made with the least number of movements and the total execution time of the TOL task. In addition, the baseline level of executive functioning is related to the magnitude of improvement: the lower the pre-test score, the greater the improvement in subjects after tDCS stimulation. No relationship was confirmed between the magnitude of improvement in working memory and the magnitude of improvement in other components of executive function. There was also no relationship between gender and the effect obtained after tDCS stimulation.

**Conclusions:** The results indicate that the tDCS stimulation method is effective in improving executive functions, which include working memory, arousal, inhibition and action control processes in healthy individuals in early adulthood. Gender did not differentiate the subjects in terms of the effectiveness of tDCS stimulation.

### **Keywords**

transcranial direct current stimulation (tDCS); executive functions; early adulthood.