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Editorial Open Access

# Transcranial Direct Current Stimulation for Neurodegenerative Disorders

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## Editorial

Transcranial direct current stimulation (tDCS) is a technique developed more than fifty years ago [1]. tDCS acts modulating the excitability of a targeted brain area by altering neuronal membrane potentials, consequently modifying the brain circuitries related to the targeted areas [2,3]. tDCS has been recently considered as a potential non-invasive tool for neuromodulation due to its ability to promote cortical changes, reflecting on changes in motor and cognitive functions [3-7].

tDCS works applying a small electrical current across a particular region of the brain. This is usually done non-invasively via two small electrodes placed on the scalp [1,3,5-7]. tDCS could be used to treat patients who had suffered some type of neurodegeneration, such as Alzheimer's or Parkinson's disease [8]. Thus, tDCS has gained public attention due its reported capability to improve motor and cognitive abilities for these patients [9].

In line with this, research has shown evidence that stimulating specific regions associated with certain mental functions or mechanisms can deliver a temporary improvement in using those functions [7]. The main reason for the use of this promising technique in improving human cognitive and motor performance is its ability to foster lasting effects [3]. This is due to neuroplasticity, the ability that human brain has to adapt itself by demands of any nature imposed upon him, and the use of tDCS with duration and sufficient magnitude of current can cause lasting changes in the brain [9].

Currently, few studies have been conducted on tDCS for PD and AD. For instance, Fregni et al. [10] analyzed the effects of a single session of tDCS applied to the left dorsolateral prefrontal cortex (DLPFC) and primary motor cortex (M1) in PD patients who did not take medication. The study showed that the anodal tDCS applied to M1 resulted in a significant improvement of motor functions in PD as evidenced by the simple reaction time and motor scores of the Unified Parkinson's Disease Rating Scale (UPDRS) compared with the sham-tDCS. These effects were specific for the polarity of tDCS, while the site of stimulation, such as cathodal stimulation in M1 and anodal stimulation in DLPFC induced small effects, which were not significantly different from placebo stimulation. Moreover, the effects of tDCS were associated with an effect dependent on the motor polarity corticospinal excitability in PD patients: while anodal stimulation resulted in a strong increase in the corticospinal excitability, cathodal stimulation decreased slightly. In another study, Boggio et al. [11] assessed the working memory in patients with PD. The results showed a significant improvement in working memory in accordance with the accuracy observed in task execution after application of anodal tDCS to the left DLPFC at 2 mA. The other stimulation conditions: sham-tDCS, anodal tDCS applied to the left DLPFC with 1 mA or anodal tDCS applied to the M1 with 1 mA did not result in a significant change in the task performance. These results suggest not only a specific site for tDCS application, but also the specificity of the applied current dose, i.e., 1 mA vs 2 mA. More recently, Doruk et al. [12] examined the immediate and long-term effects of 10 consecutive sessions of tDCS applied to the right DLPFC, left DLPFC or sham on cognitive functions, depressive symptoms and motor functions from 18 PD patients. The findings revealed that anodal-tDCS of both left and right DLPFC resulted in prolonged improvements in executive function, compared to sham-tDCS at the 1-month follow-up.

The experiment of Ferrucci et al. [13] examined to whether anodal tDCS applied to the temporoparietal cortex (TPC) could improve recognition memory in 10 patients with mild AD. Anodal-, cathodal- and sham-tDCS were applied to TPC bilaterally into 3 different sessions using as protocol 15 min at 1.5 mA, with at least 1 week among each application. Anodal-tDCS significantly enhanced recognition memory, while the cathodal-tDCS significantly decreased the accuracy of word recognition task. In an elegant study, Boggio et al. [14] investigated the effects of the anodal-tDCS applied to both left temporal cortex (TC) and DLPFC or sham-tDCS for 30 min at 2 mA on the recognition memory, working memory and selective attention in patients with mild to severe AD. The sessions complied with 48 hours interval among them, and the patients were assessed at each session starting 10 min after onset of stimulation and extending to the end of it. The anodal-tDCS applied to the TC and DLPFC resulted in significant improvement in visual recognition memory, however, no effect was observed in the working memory.

Despite the positive findings, these studies have some limitations. The first limitation, the question whether the effects were longstanding were not measured, and furthermore, any behavioral assessment was not carried out to verify whether the observed effects are clinically relevant. Another point to consider is the fact that working memory was measured by a digit task more suited to assess attention than memory. More specifically in AD, characterized by decreased synaptic plasticity, which eventually leads to failure in certain plasticity mechanisms [15] and an abnormal hypoplasticity state [16], the tDCS becomes particularly relevant and intriguing, since it can allow facilitation of neuronal plasticity by induction of long-term effects.

tDCS seems to be a potential noninvasive brain stimulation technique to treat patients with AD and PD. Few studies were conducted but showed positive effects and provided initial evidence about the effects of tDCS for improvement of certain cognitive function and the delay in disease progression. However, some variables and certain parameters should be taken into account, such as current intensity (mA), duration of session, electrode size ($cm^2$), current

density (mA/cm$^2$) and total load (intensity/electrode size) and to assess effects under different contexts, for example, period ON or OFF medication. Therefore, further studies should be conducted.

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