Repeated Anodal tDCS Coupled with Cognitive Training for Patients with Severe Traumatic Brain Injury
A Pilot RCT

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1 OBJECTIVES

Cognitive rehabilitation becomes a practice standard in treatment of memory and attention impairments which are typically the main targets of cognitive training after severe traumatic brain injury (TBI) (Cicerone et al., 2011). However, functional gains from this form of therapy are still limited and patients usually require long-lasting, and costly rehabilitation.

Non-invasive neuromodulatory techniques, aimed to boost neuroplastic changes in the brain, are expected to enhance the effects of behavioural interventions. One of these techniques - transcranial direct current stimulation (tDCS) delivers a low electric current that modulates the resting potential of neurons that underlie the stimulation site. Anodal tDCS (A-tDCS) which increases cortical excitability has been shown to improve cognitive performance both in healthy individuals (Chi et al., 2010) and patients with brain damage (Jo et al., 2009). However, efficacy of this method in alleviating cognitive impairments post TBI has not been tested to date.

In this pilot, randomized controlled trial (RCT) we aimed to determine whether cumulative A-tDCS of the left dorso-lateral prefrontal cortex (DLPFC) could enhance rehabilitation of memory and attention in patients with severe TBI. The target area of stimulation was chosen based on recent data that demonstrated DLPFC involvement during attention and memory task performance (Blumenfeld et al, 2011).

2 METHODS

Twenty three adult patients (17 men and 6 women; mean age: 28.7±8) with severe TBI (4-92 months prior to enrollment) and subsequent cognitive deficits participated in the study. They were randomly allocated to two groups. The experimental group (N=12) received 15 (5 times/week for 3 weeks) 10-min. A-tDCS (anode over left DLPFC; cathode above the contralateral supraorbital area; stimulation parameters: 1 mA, current density= 0,028mA/cm2) sessions followed by 60-min. cognitive training. The control group (N=11) received the same amount of cognitive rehabilitation, but the A-tDCS was applied only during the first 30 sec. (sham condition).

3 OUTCOME MEASURES

The effects of A-tDCS were measured using a battery of tests of memory, and attention, assessed both in visual and auditory modality. The battery included tests from Cambridge Neuropsychological Test Automated Battery (CANTAB, Cambridge Cognition, Cambridge, United Kingdom) (Pattern Recognition Memory, Spatial Span, Rapid Visual Processing), Rey's Auditory Verbal Learning Test, and Paced Auditory Serial Addition Test. European Brain Injury Questionnaire (EBIQ) was used to assess subjective impact of cognitive and emotional problems on daily functioning.

Participants were tested twice before the start of the rehabilitation programme (to control for spontaneous recovery), immediately after its completion, and four months post rehabilitation treatment completion.

4 RESULTS

Most patients tolerated the stimulation well. Some participants experienced tingling sensations, itching, drowsiness, headache, stinging, dizziness, and one had a panic attack.

The effects of spontaneous recovery, and the effects of the applied therapy on short-term efficacy, and long-term efficacy were assessed with a mixed model ANOVA, with *time of assessment* as a within-

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group factor and *intervention* as a between-groups factor. Effect sizes were determined with Cohen's d (the mean change score divided by the pooled standard deviation).

The results of pretreatment comparison suggested relatively stable cognitive functions in both groups during the first (pretreatment) phase of the experiment. The two groups exhibited similar effect sizes.

Post-treatment comparisons generally revealed improved cognitive performance and higher effect sizes in both groups. In six outcome measures, the tDCS group performed better than the sham group. Importantly however, none of the differences between groups were statistically significant.

At the 4-month follow-up, both groups showed improved performance in most tests (compared to pre-treatment), as indicated by the increases in effect sizes. The tDCS group achieved higher effect sizes than the sham group in five outcome measures. However, the differences between the groups were not sufficiently marked to reach the significance level.

5 DISCUSSION

In this study, we hypothesized that consecutive A-tDCSs would facilitate adaptive changes in neural networks that were involved in attention control and memory track formation. We assumed that these changes would strengthen the effects of the cognitive training.

Our results did not provide sufficiently strong evidence to support the use of repeated A-tDCS over the left DLPFC for neuromodulation supplementary to cognitive rehabilitation of individuals recovering from severe TBI. However, since the tDCS-treated group exhibited overall larger effects sizes, some positive response to stimulation may be possible. It is likely that longer and/or more intense stimulation as well as better control of EEG activity (Ulam et al., 2014) will result in more beneficial effects in future studies.

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