Title: *Transcranial Electrical Stimulation (tES) in children with dyslexia and dyscalculia*

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Abstract

Transcranial electrical stimulation (tES), such as transcranial direct current stimulation (tDCS) and transcranial random noise stimulation (tRNS), encompasses a range of painless and affordable tools used to directly and non-invasively manipulate brain activity and, in turn, to modulate the related cognitive processes or behaviours.

In children and adolescents with dyslexia, Costanzo et al. (2016a) first documented text reading changes after one session of left anodal/right cathodal tDCS set at 1mA for 20min over parieto-temporal regions compared to sham tDCS and the reverse polarity montage. This effective tDCS setup was applied for 18 sessions while participants underwent a reading training. Findings showed that the active tDCS group improved low-frequency and non-word reading efficiency immediately after, at medium- (1 month later) and long-term (6 month later) compared to sham tDCS (Costanzo et al., 2016b; 2019). In addition, it was demonstrated that even only 5 sessions of stand-alone tDCS over parieto-occipital regions set at 1mA for 20min improved non-word reading speed immediately after, 1 week and 1 month later the end of the treatment (Lazzaro et al., 2021a; Battisti et al., in press). Interestingly, adolescents with severe word reading fluency problems and a higher cognitive level would be the population most likely to benefit from tDCS treatment combined with reading training (Lazzaro et al., 2021b). Further, reading changes would appear to be mediated or, at least in part, explained by changes in motion perception and visuospatial attentional skills (Lazzaro et al., 2021c).

Whereas, the application of tES in numerical cognition is still in its emergent phase. In a recent systematic review emerged the effectiveness of tES in improving both number (80%) and arithmetic (76%) processing in healthy adults (Lazzaro et al., 2022). In particular, tRNS demonstrated more consistent enhancements compared to tDCS. For this reason, Lazzaro et al. (in submission) applied tRNS set at 0.75 mA for 20 min over dorsolateral prefrontal cortex (Frontal Group) or posterior parietal cortex (Parietal Group) for 10 days concurrently with cognitive training in 24 youths with dyscalculia. Results showed that the Parietal Group improved in mathematical abilities at 1 week later the end of the treatment compared to Frontal Group, but not to Sham Group. No significant differences emerged between Frontal and Sham Groups. Although preliminary, current results offer insights of combining tRNS and cognitive training for selectively improving numerical cognition of youths with dyscalculia by targeting parietal brain regions.

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