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Letter to the Editor

tDCS reactivation of dormant adaptation circuits

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1. Introduction

Prism Adaptation (PA) is a behavioral training in which individuals adapt to a shift of the visual field during a pointing task (Redding, Rossetti, & Wallace, 2005). When prisms are worn subjects show a deviation in the direction of the prism shift (terminal error) that is progressively corrected through active exposure (adaptation) and that leads to a transient deviation in the opposite side once glasses are removed (after-effect). This technique has been used for neurological rehabilitation purposes such as for spatial neglect, which is a peculiar neuropsychological syndrome following right hemisphere stroke, characterized by a deficit to pay attention and act toward the controlesional hemifield (Bisiach, 1999). Recent studies reported a significant improvement of neglect symptoms after one session of rightward PA (Rossetti et al., 1998) and long lasting amelioration following a training that involves several sessions (Jacquin-Courtois et al., 2013). Although an increasing literature supports efficacy of PA, some patients seem to not benefit from it (Jacquin-Courtois et al., 2013) and the need to improve this rehabilitation tool arises.

Among the newest techniques in neuropsychological rehabilitation, transcranial Direct Current Stimulation (tDCS), a non-invasive and painless brain stimulation method, has also been used to treat spatial neglect, but only preliminary findings are available that need to be transposed into clinically-relevant effects (see Jacquin-Courtois, 2015 for a review).

These methods are increasingly applied to healthy subjects, alone (Michel et al., 2003 for PA and Sparing et al., 2009 for tDCS) or in combination (O'Shea et al., 2013; Panico, Sagliano, Grossi, & Trojano, 2016), in order to understand their physiology and limitations. In this respect, tDCS over the primary motor cortex (M1) can improve motor learning (Reis & Fritsch, 2011), boost the retention of a newly acquired visuo-

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motor transformation (Galea, Vazquez, Pasricha, de Xivry, & Celnik, 2011), and combined with PA consolidates after-effects over several days (O'Shea et al., 2013).

One clinically relevant perspective would be to maintain brain activity generated in adaptation circuits without having to perform the behavioral task. Here we used neuromodulation to try and reactivate the adaptive mechanisms of PA and we tested whether delayed stimulation alone would be able to reactivate the prisms' after-effect and affect its retention.

2. Materials and method

Twenty healthy subjects randomly divided in two groups (Re-Activate Group, 10 participants; Control Group, 10 participants) were tested. On Day1 and Day2 pre-test and post-test were used to measure after-effects of an intervention. On Day1 the intervention consisted in tDCS during PA. On Day2 participant received tDCS alone (no PA) to ascertain the possibility to reactivate the prism after-effect using neuromodulation (real tDCS in the Re-Activate Group and sham tDCS in the Control Group). To further assess the potential long lasting nature of the reactivated after-effect, a follow-up test was carried out after 24 h (Day3; see Fig. 1A).

PA was performed with glasses shifting the visual field by 10° rightward. Both groups of participants executed 200 rapid pointing movements with the right index toward two visual targets located to the left or to the right of body axis (see Rode et al., 2015).

A 1.0 mA tDCS was delivered by a constant current stimulator (Neuroconn GmH) using two surface saline-soaked sponge electrodes (area = 35 cm^2). In line with the above mentioned studies on motor learning improvement and retention, we decided to place the anodal electrode over the left M1, 5 cm ventro-lateral to the vertex, and the cathodal electrode on the right orbitofrontal region (Nitsche et al., 2003). Sham stimulation was performed in the same way as active stimulation but the stimulator turned off after 30 sec.

Prisms after-effect was evaluated by means of open-loop pointing (OLP) to a visual target with no hand sight (Rode et al., 2015). Twenty OLP movements were performed before (Pre) and after (Post) the PA-tDCS session on Day1 and before and after tDCS alone on Day2. The difference between the mean deviation in the OLP movements in Day1Pre-Day1Post

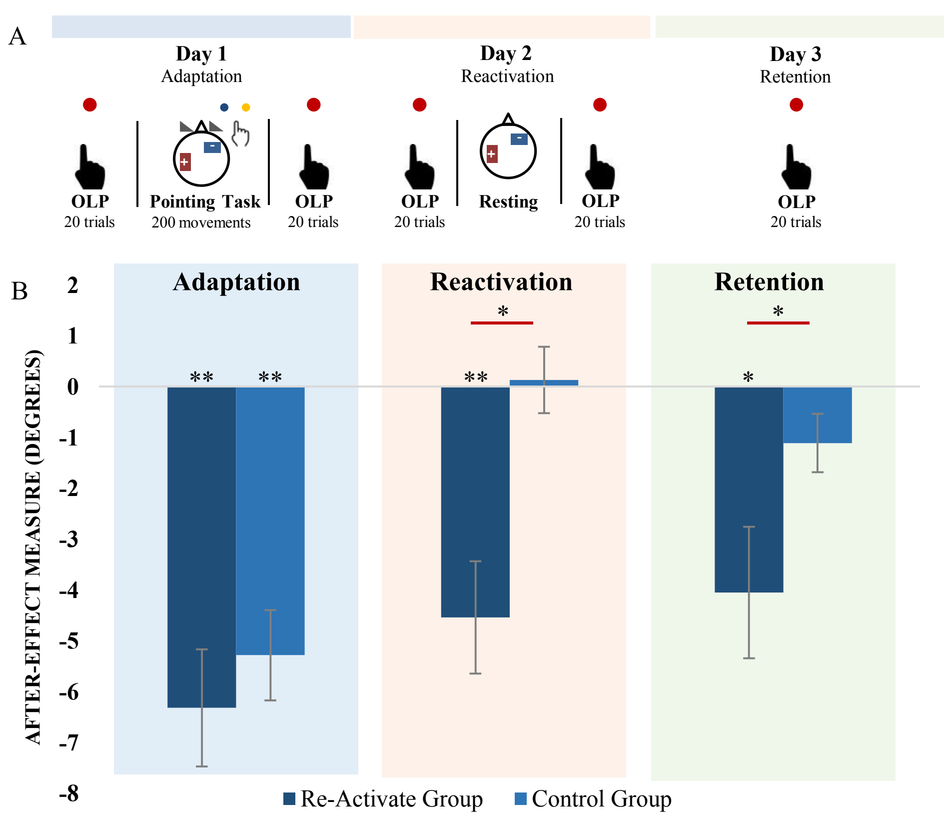

Fig. 1 — A) Experimental design. On Day1, participants performed a pointing task wearing prism glasses during real stimulation. Before and after the stimulation they performed open loop pointing (OLP) to assess adaptation. On Day2, participants received only real (Re-Activate Group) or sham stimulation (Control Group). Before and after the stimulation both groups performed an OLP to assess the reactivation of the after-effect. On Day 3, participants performed only the OLP in order to assess retention. The black hand indicates that participant could see neither their hand nor the outcome of their movement during the OLP, while the white hand indicates that they could see both the terminal part and the outcome of the pointing movement during prism exposure. B) After-effect measures in the Re-Activate Group and Control Group on Day1 (which assessed adaptation), Day2 (which assessed the reactivation of after-effect) and Day3 (assessing retention). The red bars report the results from ANOVAs; ** different from 0 at $p < .01$; *different from 0 at $p < .05$.