Modulation of the Visual Cortex by Non Invasive Brain Stimulation

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Introduction

Here we focus on the investigation of the primary visual cortex (V1) by using Transcranial Magnetic Stimulation (TMS) and Transcranial Direct Current Stimulation (tDCS) aiming to develop a useful neuromodulatory protocol to disentangle the actual controversies of the current literature and to explore potential effects of the manipulation of the visual cortex for future clinical application.

Visual Awareness

- *"Attention does not determine whether stimuli reach a conscious state but determines whether a (conscious) report about stimuli is possible"* (Lamme, 2003, p.13)
- Actual evidence suggest that the conditions necessary and sufficient for awareness involve the activation , of a distributed representation of the visual scene, on V1 and ventral visual areas and also activity of frontal and parietal areas, but don't fall on single brain area (Rees, 2007)
- Neural activation in specific brain areas is not enough to raise awareness, horizontal and feedback connections, sources of recurrent processing, are necessary to have awareness (Lamme, 2000).

Non Invasive Brain Stimulation (NIBS)

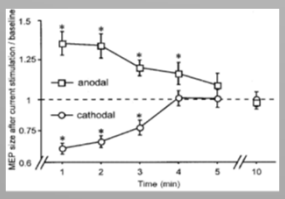
- Allow transitory modulation of neural activity through different kinds of stimulations, what has as consequence facilitatory or inhibitory behavioural effects (Miniussi, Harris & Ruzzoli, 2013)
- NIBS techniques can be used for clinical and research purposes: perform diagnostics, neurophysiological interventions, focal neuropharmacology, and to study cognitive processes by identifying brain regions involved and how these regions are involved.
- Cortical plasticity: reversibly interaction with normal learning and behaviour, consequence of induction of lasting changes in cortical excitability.

Transcranial Magnetic Stimulation (TMS)

- Neuromodulation and neuroexcitation delivered by a pulse (strong and transient magnetic field) that induce a transitory electric current in the targeted cortical area. This elicit a fast and over the threshold depolarization of the cell membranes.

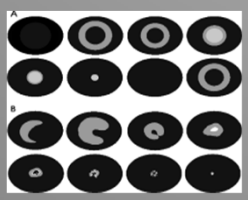
Transcranial Direct Current Stimulation (tDCS)

- Neuromodulatory technique based on constant low-level electric currents (0.5-2.0 mA).
- Different polarities modulate cortical excitability changing the resting voltage of the neural membrane.
- AeCi effect: anodal-excitation (depolarization) and cathodal-inhibition (hyperpolarization)



(Nitsche & Paulus, 2000)

Modulation of Visual Awareness by NIBS



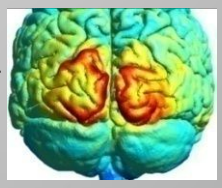
(Nicholson, 2002)

- VA is a broad concept including subjective visual experiences. Awareness of visual stimuli from internally generated and external inputs.
- Phosphenes: brief artificial flash-like visual percepts, that last only for few milliseconds (TMS induced).
- Phosphene threshold (PT): index of visual cortical excitability; minimum intensity needed to induce phosphene perception.

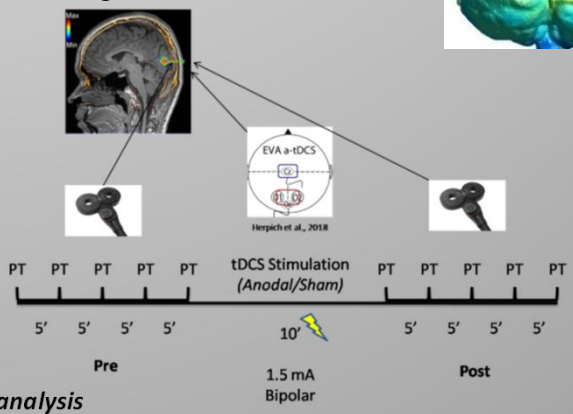
Research proposal

Methods

- This experiment is designed after earlier studies testing the AeCi effect on visual cortex. Some are confirmatory studies for the effects of this dichotomy model on visual cortex (Antal, Nitsche & Paulus, 2006; Sczesny-Kaiser et al., 2016) but others failed to find these neuromodulatory effects on visual cortex excitability (Brückner & Kammer, 2016¸ Antal, Nitsche & Paulus, 2001).
- **Participants**: Etimate N=21 healthy volunteers (50% male) with no history of mental pathologies or migraine and with MR scan. Tested 7 participants (5 females), with an average age of 23.7 (Range: 20-29).
- **TMS**: delivered on the center of primary visual cortex (V1), the calcarine cortex, through a MagPro X100 (MagVenture) stimulator with MCF-B65 induction focal coil (75-mm wing radius) which is used to produce biphasic TMS pulses.
- **MR Scans**: for a correct localization by a neuronavigation TMS system (Localite TMS Navigator, Localite GmbH) in an MRI-guided stimulation design.
- **tDCS**: anodal (a-tDCS) and sham stimulation. Delivered by a battery-driven current stimulator (BrainSTIM, EMS Medical, Italy) through surface saline-soaked sponge electrodes (size, 5x7 cm). Anodal electrode located over Oz and cathodal on Fpz.
- **PT estimation** by staircase method while the participants attend a fixation cross on a white screen.



Experimental Design

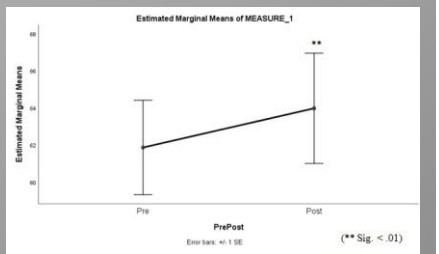


Data analysis

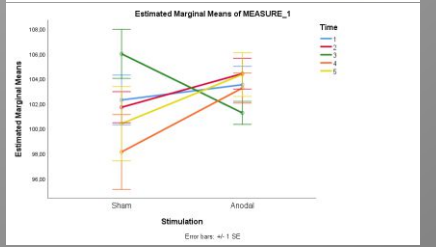
- 2 Way ANOVAs (one for a-tDCS and one for Sham conditions): Conditions (Pre, Post) x Time (4 levels)
- 2 Way ANOVA: Stimulation (A,S) x Time (4 levels)

Current Results

- Two-way repeated measures ANOVA on anodal condition: only significant main effect on the preliminar analysis of the factor Pre-Post ($F(1,6) = 16.661$, $p = .006$, $\eta_p^2 = .922$) [*Inhibitory Effect*]



- Interaction Time*Stimulation for normalized measures: differences between sham and anodal conditions relatively close to being significant for time 2 (p=.158), time 3 (p=.106), and time 4 (p=.124) [*Time Decay*]



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