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NEUROMODULATION USING CROSS-FREQUENCY COUPLING TACS: PRELIMINARY DATA

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Abstract

Non-invasive brain stimulation (NIBS) techniques are widely used in both clinical and experimental settings because they can modulate and provide information about ongoing cortical activity. It is well known that our brain works in networks and that frequency changes probably sustain communication among different cortical areas. In particular, the cross-frequency coupling (CFC) phenomenon is thought to mediate large-scale integration and communication by synchronizing the discharge frequencies of other neuronal populations in time.

Based on the CFC hypothesis, this study aimed to interfere with the spontaneous cortical activity of primary motor cortices (M1) using an innovative transcranial alternating current stimulation (tACS) protocol. Seven healthy subjects underwent two experimental sessions in which we applied either 20 minutes of theta-gamma tACS (θ-γ tACS) or 20 minutes of sham tACS (s-tACS).

To assess the aftereffects induced with this protocol, we used transcranial magnetic stimulation (TMS) over left M1 to evaluate cortical changes in different intracortical circuits before and after the intervention. In particular, we tested motor evoked potentials (MEP), Short Intracortical Facilitation (SICF), and Short Intracortical Inhibition-Intracortical Facilitation (SICI-ICF) before and after the stimulation. We expected there to be a shift in the balance between inhibitory and excitatory activity only following the θ-γ tACS stimulation. The main result of the study is that θ-γ tACS exerted an effect on SICI, leading to a lower inhibition after the stimulation ($p < 0.05$), whereas no changes were found in the MEP and ICF following stimulation ($p > 0.05$). Importantly we found no statistically significant differences in any of the neurophysiological measures (i.e. MEP, SICF, SICI-ICF) following the sham condition.

These preliminary data suggest that combining different frequencies for tACS interventions may effectively induce changes in cortical activity. Understanding the neural underpinnings of such neuromodulation may shed light on the future therapeutic application in clinical settings.

Research Category and Technology and Methods

Basic Research: 8. Transcranial Alternating Current Stimulation (tACS)

Keywords: tACS, TMS, cross-frequency , neurophysiology

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RTMS OF THE SMA: A SYSTEMATIC REVIEW OF CLINICAL AND FUNDAMENTAL APPROACHES

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Abstract

The supplementary motor area (SMA) is a multifunctional brain region divided into two subregions: the pre-SMA and SMA-proper. Non-invasive brain stimulation was applied to both regions and reported to be successful in treating various neurological and psychiatric conditions. Here we systematically review studies involving repetitive transcranial magnetic stimulation (rTMS) applied over the SMA-proper/pre-SMA in healthy and clinical populations to leverage information about the future outlook of these regions neuromodulation.

We included all original studies in English from the PubMed, Cochrane, and Scopus databases (PROSPERO ID - CRD42020141289). All studies were divided into two subgroups: (1) only healthy volunteers, (2) including patients. The following data were extracted from each study: sample characteristics, function investigated, rTMS parameters, the way of TMS coil targeting, and the primary outcome.

The final review sample consisted of 129 studies; a similar amount of studies was performed in healthy (68 studies) and clinical (61 studies) populations. There were substantially more articles dedicated to SMA-proper, compared to pre-SMA stimulation, both in the healthy (44 vs 19) and clinical subgroup (53 vs 12). In the healthy subgroup, SMA-proper target was used primarily to modulate the motor function (65%), 25% of articles were dedicated to cognitive processes, 10% of articles reported only neurophysiological output such as functional connectivity. Interestingly, pre-SMA stimulation in healthy population was mostly done to modulate motor function (79%). At the same time, in the clinical population, SMA-proper target was primarily used for motor function modulation in neurological populations, in particular Parkinson's disease (>40%), while pre-SMA target was used predominantly in the psychiatric population of obsessive-compulsive disorder.

Our review supports some preliminary conclusions about SMA-proper/pre-SMA as a highly promising target for NIBS in a wide range of neuropsychiatric conditions. However, more research, including EF modeling is needed to define interhemispheric and SMA/pre-SMA functional differences.

Research Category and Technology and Methods

Basic Research: 10. Transcranial Magnetic Stimulation (TMS)

Keywords: SMA, pre-SMA, rTMS, non-invasive brain stimulation

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EXPLORING SENSE OF AGENCY WITH NONINVASIVE BRAIN STIMULATION: AN RTMS/EEG STUDY

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Abstract

Sense of agency (SoA) is the feeling that one's action is the cause of an external sensory event. Previous neurostimulation and neuroimaging studies suggest that the inferior parietal lobe (IPL) acts as a key structure in comparing action representations with action outcomes. Particularly the right IPL has been identified as an area responsible for a sense of agency. In the present study, we explored the effect of rTMS neurostimulation on the sense of agency. Participants (n=16) completed four visits in which they received a TMS protocol followed by a simple sensorimotor SoA task in which they controlled the movement of a cursor on a screen. They were asked to indicate whenever they experienced the movement as being externally perturbed.

Our goal is to evaluate whether the tendency to over-attribute own actions to others is linked to inhibitory or rather excitatory stimulation of right IPL and to explore how are these changes reflected in resting state EEG. To this end, the effect of the inhibitory 1 Hz protocol and excitatory 10 Hz and 20 Hz protocols applied over the right IPL is compared with the placebo (sham).