Transcranial alternating current stimulation affects human BOLD responses during motion adaptation

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Introduction

Transcranial alternating current stimulation (tACS) is a promising tool for clinical applications and basic neuroscience research. Understanding tACS-induced physiological changes is crucial for its

development as a successful neuromodulatory tool. We have previously shown that tACS (10Hz) applied over the parietal cortex reduces motion aftereffect and improves motion discriminability in human subjects [1]. In the current study we investigate the potential neural correlates of these tACS-induced changes in the human motion area (hMT+).

Methods

Ten subjects participated in the experiments (5 female). fMRI images were acquired using a 3T MRI scanner (Tim Trio, Siemens); tACS was applied inside the scanner (for review of technique, see [2]). Each session started with a structural scan followed by four functional scans (TR=2s; voxel size=3x3x3mm^3). tACS was delivered (max. intensity = 0.5 mA, 10 Hz) through a STG4002 stimulus generator (Multi Channel Systems). The stimulating electrodes were prepared with conductive gel (Signa) applied onto conductive rubber electrodes (surface area = 45.6 cm^2). One electrode was placed over left hMT+, the other on the vertex.

We used the visual motion adaptation paradigm from Huk et al. [3] to quantify motion adaptation in the BOLD signal. Subjects fixated a dot at the center of the screen while we presented two moving gratings on either side of the dot. In each session both gratings initially moved inward for 30s (l*ong adapter*). Subsequent trials were classified into two conditions. During *opposite direction trials* a top-up adapter (both gratings moving inwards for 4s) was followed by a test stimulus moving outward for 0.5 s. During *adapted direction trials* the adapter was followed by a test stimulus moving inward for 0.5 s. The sequence of trials (i.e., after the initial 30 s *long adaptation)* alternated between three opposite direction trials and three adapted direction trials. tACS was applied whenever the adapter stimulus was on the screen (i.e. during the induction of adaptation).

We analyzed the fMRI data with BrainVoyager and MATLAB. We defined area hMT+ by a sphere (15 mm radius) around the Talairach coordinates (40,-60, 0) for the right hemisphere and (-40,-60, 0) for the left hemisphere.

Results

We quantified adaptation as the difference in BOLD response in area hMT+ between the *opposite direction trials* and the *adapted direction trials*. When no tACS was applied, the average BOLD responses to *opposite direction* trials were significantly larger than *adapted direction trials* for both hemispheres. We refer to this as BOLD adaptation. This corroborates the results of Huk et al. [3] and shows that these voxels showed direction selective (BOLD) adaptation.

The application of tACS during adaptation induced statistically significant changes in BOLD adaptation at hMT+ of the left (tACS applied) compared to the right hemisphere. These effects, however, were quite heterogeneous across subjects, with tACS increasing adaptation in some subjects while decreasing adaptation in others. We also estimated the correlation (functional connectivity) between the stimulated and non-stimulated hMT+ regions and found that it was

significantly reduced ($p<0.05$; Wilcoxon signed rank test) during the *adapted direction trials* compared to the *opposite direction trials*.

Conclusions

These results support our hypothesis that tACS interacts with the neural mechanisms of motion adaptation even though the results are more complex than a simple reduction in (BOLD) adaptation. This complexity may be a consequence of subject- or even voxel-specific differences in the level of adaptation (a factor that played an important role in behavioral measures of tACS-induced modulation of adaptation [1]).

References

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