Increased default mode network activity after high-frequency DLPFC rTMS

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Introduction. Transcranial magnetic stimulation (TMS) is a non-invasive technique that uses short magnetic pulses over the scalp to induce electrical currents in the superficial neurocortex. While TMS was initially designed to introduce a transit neuronal effect, the repetitive application of TMS (rTMS) has been shown to have long-lasting effects, which provokes its application for treating various neuro-psychiatrical or neuro-psychological disorders. In contrast to the increasing popularity of TMS, the mechanism of TMS affecting brain function is still elusive. The purpose of this study was to assess rTMS effects on resting state brain activity in normal healthy adult brain. The rTMS target area was the dorsolateral prefrontal cortex (DLPFC), which is a key element of many high-order brain functions, including inhibition control, attention, working memory, decision making, etc.

Methods: Resting state fMRI (rsfMRI, TR/TE=2s/30ms) were acquired from 40 healthy young adults (mean age: 22.73±2.84, 17 males) twice before and after receiving 20-Hz rTMS or SHAM stimulation (n=20 for each group). TMS was applied to the left dorsolateral prefrontal cortex (DLPFC). The order of applying or not applying rTMS (or SHAM) was counterbalanced and the second time of experiment was conducted two days later. rTMS stimuli contained 20 pulses per second (20 Hz) for 2.5 sec, with an inter-train interval of 28 sec. The pulse magnitude was adjusted to be 90% of the resting motor threshold. rsfMRI data were processed using SPM with standard routines recommended in the literature. Resting state brain activity was assessed by the fractional amplitude of low-frequency fluctuations (fALFF) and the posterior cingulate cortex (PCC)-seeded functional connectivity (FC) analysis. DLFPC was also used as a seed to assess the potential rTMS-induced changes to its FC to the rest of the brain.

Results: As compared to SHAM, rTMS significantly increased fALFF in anterior cingulate cortex (ACC) and PCC-FC in the default mode network (DMN) including prefrontal cortex, hippocampus, temporal cortex, and parietal cortex. Using the suprathreshold fALFF ACC cluster as the seed revealed similar FC increase patterns. rTMS didn’t show alterations to FC to DLPFC.

Conclusions: Our data suggest that rTMS can affect remote brain regions not necessarily through direct connections but through an inter-connected network. rTMS on DLPFC provides an effective way to modulate resting brain activity in DMN, suggesting using it as an alternative to overt functional task, which can be used in a widespread of brain training or functional modulatory treatment.