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Exploring the potential impact of very low intensity TMS on resting state neurophysiological activity: A TMS-EEG entrainment study in humans

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Abstract

Rodent studies have shown that low intensity TMS (LI-TMS) induces cortical electric fields (~0.1 V/m) that modulate neuron excitability and promote circuit repair. However, to modulate brain excitability or entrain oscillations in humans, TMS is conventionally delivered at much higher field densities (~65-95 V/m). Here we designed an experiment to determine the ability of LI-TMS at field densities similar to those used in prior rodent studies to modulate oscillatory activity at rest in humans. We first generated biophysical human head models of current distribution emulating low intensity cortical currents used in rodents. On such basis, we determined the output intensity required to induce LI-TMS in modeled human heads/brains, using commercially available TMS devices (Magstim SuperRapid2 a 70 mm butterfly-coil). Finally, a cohort healthy human participants (n=6) underwent a neuro-navigated TMS session with under scalp EEG and EMG monitoring. We assessed the effects of short 4-pulse bursts of either rhythmic (20Hz), arrhythmic, or sham stimulation delivered to the left primary motor cortex M1 at low (LI-TMS) compared to a conventional (HI-TMS, 60% MSO) intensity. EEG data were pre-processed and differences in power and local and interregional synchrony measures elicited at both intensities were estimated and compared across conditions. In parallel, each participant's E-field MRI based biophysical models at a macro- (brain volume) and micro-scale (isolated neocortical neurons) levels were generated. Our scalp EEG preliminary analyses together with evidence from neuron models support the ability of LI-TMS to modulate human brain membrane potentials and elicit frequency-specific oscillatory activity, facilitating spontaneous firing, probably through calcium-dependent cascades. The results are relevant since evidence on LI-TMS modulatory and entrainment effects and their mechanism of action will allow a more efficient use of this approach and drive the development of portable multifocal neuromodulation devices able to manipulate cerebral network synchrony.

Research Category and Technology and Methods

Translational Research: 10. Transcranial Magnetic Stimulation (TMS)

Keywords

transcranial magnetic stimulation, oscillatory entrainment, spontaneous activity, casual neuromodulation