Transcranial alternating current stimulation

Transcranial alternating current stimulation (tACS) is a non-invasive brain stimulation technique that allows interaction with endogenous cortical oscillatory rhythms by means of external sinusoidal potentials.

Comparing both fMRI WM tasks, Transcranial direct current stimulation tDCS seem to exert its neural effects through a reduction in neural activity after stimulation, whilst tACS increases neural activity during stimulation, occurring in both modulations mainly within DMN areas.

Computational modeling and human studies suggest that transcranial alternating current stimulation (tACS) modulates alpha oscillations by entrainment. Yet, a direct examination of how tACS interacts with neuronal spiking activity that gives rise to the alpha oscillation in the thalamocortical system has been lacking. Here, we demonstrate how tACS entrains endogenous alpha oscillations in head-fixed awake ferrets. We first show that endogenous alpha oscillations in the posterior parietal cortex drive the primary visual cortex and the higher-order visual thalamus. Spike-field coherence is largest for the alpha frequency band, and presumed fast-spiking inhibitory interneurons exhibit strongest coupling to this oscillation. We then apply alpha-tACS that results in a field strength comparable to what is commonly used in humans (<0.5 mV/mm). Both in these ferret experiments and in a computational model of the thalamo-cortical system, tACS entrains alpha oscillations by following the theoretically predicted Arnold tongue. Intriguingly, the fast-spiking inhibitory interneurons exhibit a stronger entrainment response to tACS in both the ferret experiments and the computational model, likely due to their stronger endogenous coupling to the alpha oscillation. This findings demonstrate the in vivo mechanism of action for the modulation of the alpha oscillation by tACS [1].

Nineteen patients with diffuse, blunt, non-severe TBI (mean age 32.7 ± 11.4 years; 4 women and 15 men; Glasgow Coma Scale before transcranial alternating current stimulation (tACS) 14.1 ± 0.5) were treated by 10 Hz in-phase tACS applied for 30 minutes to the left and right lateral prefrontal cortex at 21 days after TBI. Regional cerebral oxygen saturation (SctO2) in the frontal lobes was measured simultaneously by the cerebral oximeter. Significance was preset to $P < 0.05$. The SctO2 values before tACS were not different between hemispheres ~65%. After 15 minutes of tACS, a significant ($p < 0.05$) decrease in regional SctO2 was observed with the minimum at the eighth minute of 53.4 ± 3.2% and 53.4 ± 3.2% in the left and right hemispheres, respectively. At the end of the stimulation (30 minutes), the hemispheric differences in cerebral oxygen saturation became statistically insignificant again ($p > 0.05$). Therefore, tACS causes a significant decrease in SctO2, probably, due to neuronal activation. This data indicate that tACS may need to be supplemented with oxygen therapy. Further research is required [2].

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Huang WA, Stitt IM, Negahbani E, Passey DJ, Ahn S, Davey M, Dannhauer M, Doan TT, Hoover AC,

Peterchev AV, Radtke-Schuller S, Fröhlich F. Transcranial alternating current stimulation entrains alpha oscillations by preferential phase synchronization of fast-spiking cortical neurons to stimulation waveform. Nat Commun. 2021 May 25;12(1):3151. doi: 10.1038/s41467-021-23021-2. PMID: 34035240.

2)

Trofimov AO, Kopylov AA, Martynov DS, Zorkova AV, Trofimova K, Cheremuhin PN, Bragin DE. The Changes in Brain Oxygenation During Transcranial Alternating Current Stimulation as Consequences of Traumatic Brain Injury: A Near-Infrared Spectroscopy Study. Adv Exp Med Biol. 2021;1269:235-239. doi: 10.1007/978-3-030-48238-1_37. PMID: 33966223.