Neural consequences of transcranial direct current stimulation in the primary visual cortex of awake, behaving macaques

Kohitij Kar, and Bart Krekelberg

Transcranial direct current stimulation (tDCS) has been used successfully as a noninvasive neuromodulation tool to affect behavior in both the clinic and in the cognitive neurosciences. The most commonly accepted neuromodulatory effect of tDCS is a subthreshold membrane polarization. Even though some studies support the view that anodal tDCS increases cortical excitability while cathodal tDCS decreases it, reports in the literature are contradictory.. To shed light on the neural consequences of tDCS, we investigated the tDCS-induced changes in neural activity in the macaque primary visual cortex.

We recorded neural activity from area V1, with chronically implanted floating microelectrode arrays before and after applying tDCS. During each experimental session, we first mapped visual responses and orientation, spatial frequency, and contrast tuning using full field grating stimuli . Second, we applied tDCS for 20 minutes; either cathodal (-1 mA), anodal (+1 mA), or sham (0 mA). One (active) tDCS electrode was placed on the occipital pole of the monkey while the other (reference) was placed near the vertex. Third, we mapped the visual responses and tuning properties again, using the same stimuli. . We compared the multiunit activity (MUA) before and after stimulation.

We found that 20 minutes of anodal stimulation significantly increased the multi-unit activity across multiple electrodes. This supports the view that anodal tDCS increases excitability. We did not find any specific contrast or spatial frequency dependence of this anodal tDCS-induced enhancement. Sham or cathodal tDCS did not have any consistent effect on the MUA. To our knowledge, this is the first study demonstrating the efficacy of tDCS to induce electrophysiological changes in the non-human primate. Given the significant structural and functional similarities between the macaque and human brain, and our ability to measure both behavioral and neural consequences of transcranial stimulation, this animal model has the potential to provide unique insight into the neural mechanisms underlying tDCS and its (clinical) use in humans.