Transcranial electrical stimulation mitigates motion adaption in V1, MT, and MST neurons of awake, behaving macaques

Kohitij Kar, Jacob Duijnhouwer, and Bart Krekelberg.

Transcranial electrical stimulation (tES) is used in the clinic to treat depression, expedite recovery from stroke, and has been used to augment human cognition. Moreover, it is finding increasing use in behavioral neuroscience as a tool to modulate brain activity noninvasively. Its widespread use notwithstanding, the mechanisms by which the externally applied electric fields modulate brain and behavior are still poorly understood. Previously we have reported that tES (10 Hz, 0.5 mA) over hMT+ reduces adaptation in human subjects. This led us to hypothesize that subthreshold rhythmic membrane voltage modulations produced by tES reduce adaptation in motion selective neurons. Here we test this hypothesis with single unit recordings in V1, MT, and MST of the macaque monkey.

We recorded from adapted and unadapted cells with and without tES. The tES electrodes were placed extra-cranially on either side of the recording chamber (over area MT). In the adaptation condition, we presented the adapter stimulus (dots moving coherently in the cell's preferred direction) for 3 s. This was followed by a 300 ms blank period and a 300 ms test phase during which we presented a random dot stimulus moving coherently in one of eight directions. In the stimulation condition the visual adapter stimulus was accompanied by tES (10 Hz, 1.0 mA). In unadapted control trials, the adapter stimulus was replaced by a noise stimulus consisting of dots moving in random directions.

We measured changes in tuning amplitude and tuning width of the cells and the evoked LFP responses. tES diminished the effects of adaptation on motion selective cells. Notably, whenever adaptation decreased (or increased) tuning amplitude of a neuron, the concurrent application of tES with adaptation reduced this suppression (or facilitation). Similarly when adaptation sharpened (or broadened) the tuning width of a cell, application of tES during adaptation reduced this sharpening (or broadening). Similar mitigation of adaptation was found in the evoked LFP. These results provide novel insight into how tES interacts with neural activity and establishes the awake, behaving macaque as a model to study the mechanisms of tES in-vivo.