Conference: Neuroscience 2015

Transcranial alternating current stimulation strengthens learning of color-orientation associations.

Yinghua Liu[1,2], Kohitij Kar[1,2], Bart Krekelberg[1]

[1]Center for Molecular and Behavioral Neuroscience, Rutgers, The State University of New Jersey, Newark, NJ

[2]Behavioral and Neural Sciences Graduate Program, Rutgers, The State University of New Jersey, Newark, NJ

Transcranial current stimulation (tCS) has been found to improve cognitive function in various domains (e.g. memory, language, vision, cognitive aging, etc.). Despite its growing use, the underlying neural mechanism remain unclear. To investigate how tCS influences learning, we examined the effects of transcranial alternating current stimulation (tACS) on the McCollough Effect (ME). In contrast to many visual aftereffects that typically extinguish within a few seconds, the ME is an orientation-contingent color aftereffect that can persist for days. This long time scale as well as the orientation contingency of the ME indicate that the acquisition of the ME can serve as a low level model of a learning process that associates orientation and color in the visual pathway. Moreover, there is strong evidence to suggest that the ME originates in primary visual cortex (V1). These properties make the ME a suitable phenomenon to study the neural basis of tACS' influence on learning.

We induced the ME in participants with two alternating sets of gratings paired with two complementary colors (vertical-red and horizontal-green, alternated every 1 s for 4 s: induction stimuli). After induction, a test pattern (300 ms) of neutral white gratings was perceived to be tinted with colors complementary to the original pairing (i.e., vertical-green and horizontal-red). We quantified this ME by adjusting the colors of the test patterns to null participants' perceived ME. This procedure was repeated to build up the strength of the ME. In the tACS condition, electrical stimulation (0.5 mA, 50 Hz) was applied with one electrode over area V1 (Oz) and one on the vertex (Cz). Stimulation was only applied during the presentation of the induction stimuli.

In the absence of tACS, the build-up of the ME typically saturated within a few minutes. In the presence of tACS, however, no such saturation was observed. As a consequence, the ME was significantly larger in the tACS compared to the no-tACS condition. In other words, tACS strengthened the learning of color-orientation association that is necessary for perceiving the ME. Based on our previous work (Kar and Krekelberg, J. Neurosci. 34.21 (2014): 7334-7340), we speculate that tACS attenuated the adaptation of early visual neurons sensitive to orientation or color. This reduced adaption would result in stronger input to neural populations that detect the conjunction of orientation and color, and this could enhance the learning of the orientation-color association. These results lay the groundwork for future experiments that will test this hypothesis using behavioral experiments and electrophysiological recordings in macaque V1.