Effects of Transcutaneous Alternating Current Stimulation in Posterior Parietal Cortex

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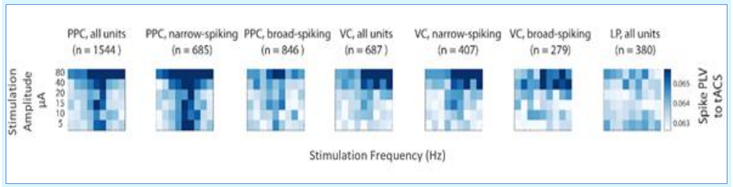
Abstract

Transcranial alternating current stimulation (tACS) is a method of delivering weak electrical currents to the brain to synchronize neural networks. Prior studies have shown that tACS has entrained neurons in the posterior parietal cortex (PPC) in an Arnold Tongue pattern, specifically narrow-spiking neurons. This experiment tests the hypothesis that peripheral stimulation will not entrain neurons in the PPC. Alternating current stimulation was delivered peripherally to ferrets through the back, and was delivered in a range of frequencies around the individual alpha frequency for each ferret. In vivo recording of electrophysiological data through the PPC showed that peripheral stimulation did not entrain narrow-spiking or broad-spiking neurons in the PPC and that no Arnold tongue pattern was revealed in the brain.

Introduction

Transcranial alternating current stimulation (tACS) is a type of electrical stimulation where a sinusoidal current waveform is delivered to the brain to create synchronized networks among different neurons (Negahbani et al., 2019). Synchronization occurs through phase-locking, where phases (different points in time on the wave) of the oscillation in the brain align with the phases of the periodic stimulation that is being given (Fröhlich, 2015b). For neurological disorders where cortical oscillations are not functioning properly, tACS can potentially act as a treatment and help regulate cognition (Fröhlich, 2015a).

To see if neuron entrainment (i.e. synchronization) has occurred, we look for an Arnold tongue pattern in the brain. This pattern is in a triangle shape, and shows the range of frequencies at which the neurons become entrained (Fröhlich, 2015a; Fröhlich, 2015b). Here are prior results:



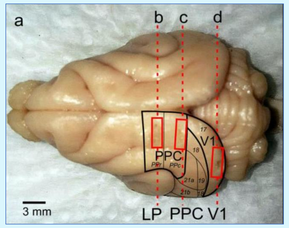
Transcranial alternating current stimulation engages cortical alpha oscillations in single neuron level (Huang, Stitt, et al., 2021, in press)

Hypothesis

The hypothesis for this control experiment is that delivering alpha frequencies to the ferret through an area of the body besides the scalp (in this case, the animal's back) will not result in an Arnold tongue pattern in the PPC.

Methods

Surgery: There is an electrode implanted in the PPC, LP and V1 areas (even though the main focus for this experiment is PPC) that will record electrophysiological data, a head post that will hold the ferret's head in place during recording, and an optrode implant for later experiments after the control ones are done.



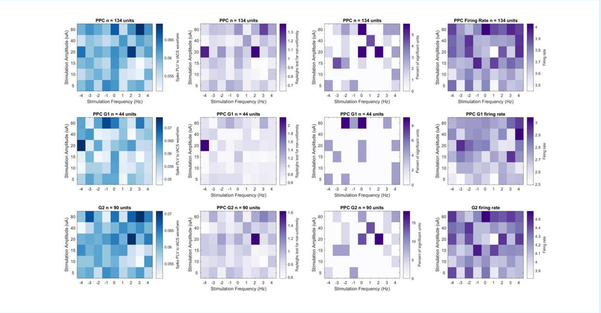
(Huang, Stitt, et al., 2021, in press)

Setup: The ferrets are placed in the body fixation tube and a head clamp goes over the head post that was implanted on the skull during surgery. After the clamp is screwed in place, a head stage is placed into the PPC electrode connector. This will record electrophysiology data from the PPC. Then two carbon rubber electrodes are placed on the ferret's back, which has been shaved, about two inches apart. This is will deliver the electrical current stimulation.

Resting Pupil Recording: Before tACS recording can start, resting sessions are done to get the animal's endogenous alpha frequency. Every animal has their own peak endogenous alpha frequency, and stimulation will be given around this frequency in order to optimally target this oscillation.

tACS Recording: A range of frequencies ± 4 Hz around each animal's individual endogenous alpha frequency along with other amplitudes is delivered to the animal during different repetitions of electrical current stimulation. This allows us to see if alpha stimulation closer to the animal's endogenous frequency entrains neurons better. Recording lasts for one and a half hours with fifty four repetitions of stimulation. Each stimulation lasts for 90 seconds and is followed by 10 seconds of an interstimulus interval with no stimulation.

Results



Peripheral Stimulation Using Alternating Currents Does Not Entrain Alpha Oscillations in the PPC (Huang, Stitt, et al., 2021, in press)

Discussion

The hypothesis for this experiment was that stimulation of peripheral nerves with an alternating current would not result in entrainment of alpha oscillations in the brain, and the data produced supports this hypothesis. Knowing that the entrainment of neurons in the PPC does not come from other sensory input will allow researchers to rule out the indirect stimulation of the PPC as a confounding variable during actual tACS procedures, although this experiment will need to be replicated to ensure that this really is the case.

References

Fröhlich, F. (2015a). Experiments and models of cortical oscillations as a target for noninvasive brain stimulation. Progress in Brain Research Computational Neurostimulation, 222, 41-73. doi:10.1016/bs.pbr.2015.07.025

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