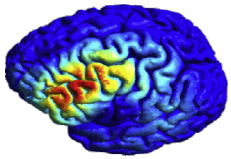
Investigating tACS-induced neural entrainment in a computational model of morphologically realistic neurons



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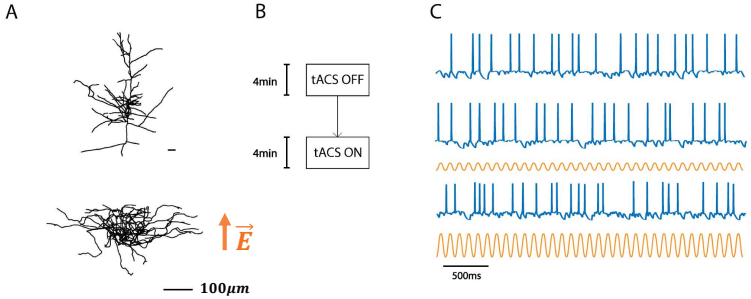
Introduction

Transcranial alternating current stimulation (tACS) is a non-invasive neuromodulation method which directly interacts with brain oscillatory activity. One of its proposed mechanisms is to induce neural entrainment: a synchronization between the neural population activity and the stimulation oscillation. tACS holds promise as a new treatment for brain disorders characterized by pathological brain oscillations. Neural responses to oscillating electric fields depend on the intrinsic properties of cells and need to be carefully characterized.

Methods



*(A) Morphologies of different types of neurons (B) tACS stimulation protocol (C) **Top**. Baseline neural activity. **Middle**. Weak electric field strength (0.5 mV/mm). **Bottom**. Strong electric field strength (1 mV/mm)*

Morphologically realistic models of neocortical neurons are stimulated by a 10Hz tACS with realistic amplitudes.

For each electric field strengths and each neuron morphology, the neural activity is characterized by computing the phase-locking value (PLV) and the polarization length.

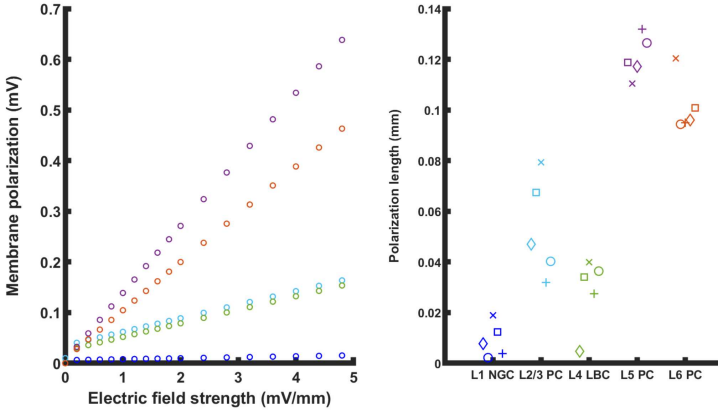
$$PLV = \left| \frac{\sum_{n=1}^{N} e^{i\theta(t,n)}}{N} \right|$$

N is the number of trials

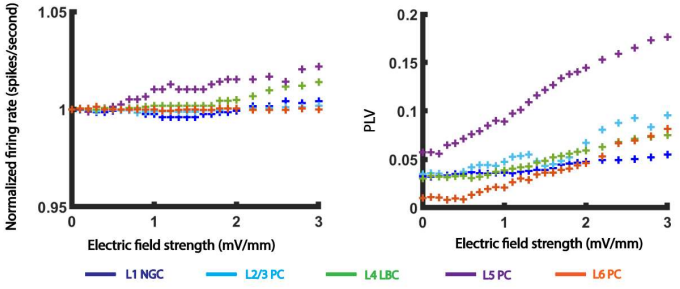
$\theta(t,n)$ is the difference between the instantaneous phase of the two signals at time t and trial n

Results

For subthreshold activity, both types of neurons polarize linearly with the electric field strengths however excitatory neurons have a higher polarization length.



For both neuron types, phase-locking increases with electric field amplitude, but the firing rate does not (less than 4% increase).



Conclusion

Our results show the effects of oscillating electric fields on single neurons and can help distinguish which neurons are responsive to tACS. These results are in line with animal experimental studies. Further steps will include modelling tACS effects on neuronal populations.

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