ABSTRACT

Electric stimulation, such as tDCS and DBS, is used widely in clinical and academic settings in the treatment of neurological diseases and disorders. However, little is known about the mechanisms that underlie electrical stimulation on a cellular level. Our research utilizing the Aplysia californica buccal ganglia neurons built upon previous findings concerning the presence of neuronal activity states, but demonstrate that these states play a role in the cell’s responsiveness to electrical stimulation. It was demonstrated that fast-firing neurons are more resistant to inhibitory stimulation as compared to slow-firing neurons. NEURON computational modeling revealed differences in ion channel dynamics that may underlie the differences in stimulation responsiveness that are associated with neuronal states. Our findings call upon further investigation into neuronal state-dependent stimulation as clinical application of electrical stimulation progresses.

METHODS

- Aplysia californica and buccal neurons
- Intracellular recording
- Electric stimulation with extracellular electrode
- High-frequency stimulation protocol (i.e., used in tDCS)
- Cathodic stimulation protocol (i.e., used in DBS)
- Computer simulation with multi-compartment NEURON model

RESULTS

1. Neuron characterization via morphological & electrophysiological profiles
   A. Neuron depolarization
   B. Neuron hyperpolarization

2. State-dependent neural inhibition with cathodic inhibition (i.e., tDCS)
   A.
   B.

3. State-dependent neural inhibition with high-frequency stimulation (i.e., DBS)
   A.
   B.

REFERENCES


CONCLUSION AND DISCUSSION

1. Neural inhibition by electric stimulation depends on the activation state of the neuron. It is more difficult to inhibit neurons with high activity.
2. Ion channel dynamics that sustain the action potentials are easier to be manipulated by the electric stimulation in the low active neurons than in the high active neurons.
3. Clinic implications: direct continuous monitoring of neural activity (EEG or fMRI) is essential for optimal stimulation outcomes.