Interictal Spike Depolarization in the Neocortex: Relationship to Action Potential Inactivation
Lauren Lossner, Biomedical Engineering
Mentor: Dr. Bradley Greger, Associate Professor
School of Biological and Health Systems Engineering

Background
- **Epilepsy:** Neurological condition that affects the nervous system; usually diagnosed after at least two seizures of unknown medical condition
- **Kandel and Spencer:** 1960 publication
  - Classification of spontaneous firing patterns; IIS depolarization occurs and triggers AP firing
- **Hodgkin-Huxley Model**
  - AP inactivation; depolarizations trigger an inward current carried by Na⁺ ions followed by an outward current carried by K⁺ ions

Research Objective
**Objective:** H-H model utilized to predict pathophysiology of AP inactivation and how it was affected by IIS depolarization

Methods

**In Silico:**
- Hodgkin-Huxley Model
- Gaussian function: model of interictal spikes
- White noise

**Ex Vivo:**
- Small block of brain tissue removed and placed into oxygenated slicing solution
- 4/9 neurons analyzed
- Intercital spikes do not occur in excised tissue with normal artificial cerebrospinal fluid

Data and Findings

**HODGKIN-HUXLEY MODEL**

![H-H model showing APs affected by range of depolarization values.](image)

**INTRACELLULAR DATA**

![APs affected by IIS depolarization.](image)

Conclusions
- AP waveforms displayed increased duration and decreased amplitude during depolarization, consistent with the definition of inactivated action potentials.
- Comparison: As the simulated IIS amplitude increased, AP firing became inactivated
- Hodgkin-Huxley Model was in good agreement in predicting the effect of IIS depolarization on AP inactivation as seen in the intracellular recordings!

Future Work and Implications
- **Synapses strengthen through plasticity**
- **Interictal spikes cause bursts of action potentials**
- **Interictal spikes contribute to epileptogenesis**

- IIS propagation during seizures and the effect of AP firing correlate with synapse strength if cells fire at the same time
- Could provide clinical use for epilepsy treatment

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