INCM Assignment 3

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Paper Name: The Roles Potassium Currents Play in Regulating the Electrical Activity of Ventral Cochlear Nucleus Neurons.

Concise understanding of the paper:

We understand the existing work done in this field and come to the conclusion that The many discrepancies between the previous models and the new experimental data suggests that there is a need to examine the roles K^+ currents play in regulating the electrical activity of VCN neurons. More than anything in order to code it out, it became important to understand the VCN Somatic model, its biology and all the currents that describe it. After that, it became easy to code out the model and generate results.

VCN Somatic Model

$$C_m \frac{dV}{dt} = I_A + I_{LT} + I_{HT} + I_{Na} + I_h + I_{lk} + I_E - I_{ext}$$

VCN Model in paper (first-order differential equation): Single electrical compartment with membrane capacitance C_m connected in parallel with:

1. Fast-inactivating A-type K^+ current (I_A). A-type currents are: voltage-gated, calcium-independent potassium currents that undergo rapid activation and inactivaton.

    1. Normally, currents are divided into 2: Slow delayed rectifier currents and rapid A type currents. HH-model first used the term delayed rectifier to describe voltag dependent K^+ currents.

    2. A-type currents are voltage-gated, Ca^{2^+} -independent K^+ currents that are distinguished from typical delayed rectifier currents by rapid rates of inactivation. Kinetically, A-type currents bear closer resemblance to voltage-gated Na+ currents than to delayed rectifier K^+ currents.

2. Fast-activating slow-inactivating low-threshold K^+ current (I_{LT}).

3. High threshold K^+ current (I_{HT}).

4. Fast inactivating TTX-sensitive Na^+ current.
5. Hyperpolarization activated cation current I_h
6. Leakage current I_{lk}
7. Excitatory synaptic current I_E
8. External electrode current source.

$C_m = 12pF$ which was average value computed from population of VCN cells.

Model Parameter Inclusion Exclusion

Using other models and notebooks for coding reference, we can understand that accomodating for all parameters is difficult, instead we try to model and compare few parameters only to understand how the major variables impact the entire current-clamp responses.

We use the following parameters mentioned below for our analysis and comparison:

```
# Maximal conductances of different cell types in nS
maximal_conductances = dict(
type1c=(1000, 150, 0, 0, 0.5, 0, 2),
type1t=(1000, 80, 0, 65, 0.5, 0, 2),
type12=(1000, 150, 20, 0, 2, 0, 2),
type21=(1000, 150, 35, 0, 3.5, 0, 2),
type2=(1000, 150, 200, 0, 20, 0, 2),
)
gnabar, gkhtbar, gkltbar, gkabar, ghbar, gbarno, gl = [x * nS for x in
maximal_conductances[neuron_type]]
```

The equations for modelling are given very clearly in the last few pages of the paper. All that needed to be done was type it out in `Brian2` format and run it in a Google Colab notebook.
