Basic Models in Computational Neuroscience

Te Shi[1]

[1] Institute of Artificial Intelligence, Hefei Comprehensive National Science Center, No.5089 West Wangjiang Road Hefei, Anhui, China;

Electrophysiology involves the measurement of electrical activity in biological tissues, particularly in neurons. Through techniques such as patch-clamp recording and extracellular recording, researchers can investigate various aspects of neuronal function, including action potentials, synaptic transmission, and ion channel dynamics (Fig.1).

In computational neuroscience, models are indispensable for simulating and understanding neural behavior. The integrate-and-fire model represents one of the simplest yet powerful models, describing neuron firing based on membrane potential dynamics. The Hodgkin-Huxley model, on the other hand, offers a more detailed representation by incorporating ion channel kinetics, allowing for a nuanced exploration of action potential generation. Additionally, excitatory and inhibitory neurons play crucial roles in neural processing. Excitatory neurons promote neural activity, while inhibitory neurons counterbalance this activity by suppressing it. Understanding the interplay between excitatory and inhibitory neurons is essential for deciphering complex neural circuits.

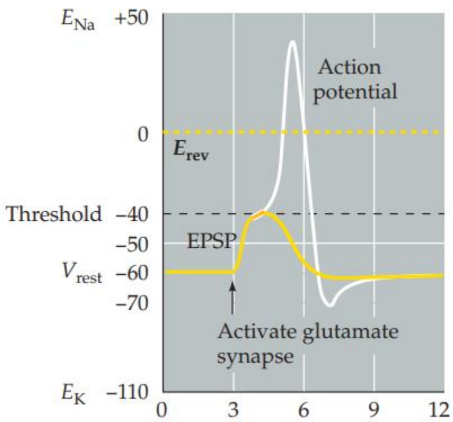


Figure 1. Reversal potentials and threshold potentials determine postsynaptic excitation and inhibition[1].

Neuron group models extend beyond single neurons to capture interactions within neural networks. These models describe the dynamics of populations of neurons, offering insights into phenomena such as synchronization, oscillations, and information processing in the brain. Complex neural functions rely on the intricate interactions among a large number of neurons, underscoring the significance of neuron group models in elucidating the underlying mechanisms of brain function.

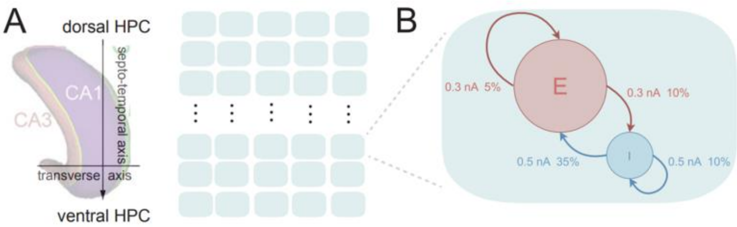


Figure 2. Computational models for hippocampal traveling waves[2].

In neuron group models, first-order differential equations are used to describe the activity of neuron populations. Different types of neuron populations, such as excitatory or inhibitory neurons, correspond to different activation coefficients. Interactions between neuron populations or their self-signaling lead to behaviors such as competition and oscillation. We will see how researchers use neuron group models to explain decision-making, memory, and navigation.

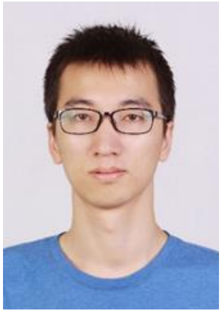
Keywords: The integrate-and-fire model, Hodgkin-Huxley model; neuro group models;

REFERENCES

[1] Purves, D., et al. (2018) Neuroscience. 6th Edition, Sinauer Associates, New York.

[2] Wu, Y., & Chen, Z. S. (2023). Computational models for state-dependent traveling waves in hippocampal formation. bioRxiv: the preprint server for biology, 2023.05.19.541436.

BIOGRAPHY



Te Shi has completed his PhD from Physics Department, University of Science and Technology of China, China in 2023 and performed postdoctoral studies in Neuroscience. He is now interested in Micro-Connectomics based on Volume Electron Microscopy (VEM).