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A computational model of Suprachiasmatic Nucleus (SCN) for circadian rhythm modulation based on ion channel conductance and calcium dynamics

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The suprachiasmatic nucleus (SCN), the master biological clock of circadian rhythms, has been highly interested for biological rhythms in animals. Physiological and molecular biological studies [1-3] and computational modeling approach [4] have investigated channels contributing to circadian rhythms of spike firing frequency. The aim of this study was to investigate possible contribution of each channel to circadian rhythms using Hodgkin-Huxley-type model containing BK channel, potassium channel, sodium channel, and calcium concentration oscillation. We found that the change in channel conductance modulated firing rates from high regular firing to low irregular firing with high sensitivity of the channel. In agreement with experimental data, the persistent sodium currents also highly contributed to modulation in spike firing frequency. The leak potassium currents and fast delayed rectifier currents exhibited to restrict the circadian firing range and regulation of interspike intervals. Most interestingly, the sinusoidal shape of the diurnal change in the channel conductance reproduced the change in diurnal firing rates. The calcium concentration oscillation and BK channel activity were examined to determine the synchronized circadian

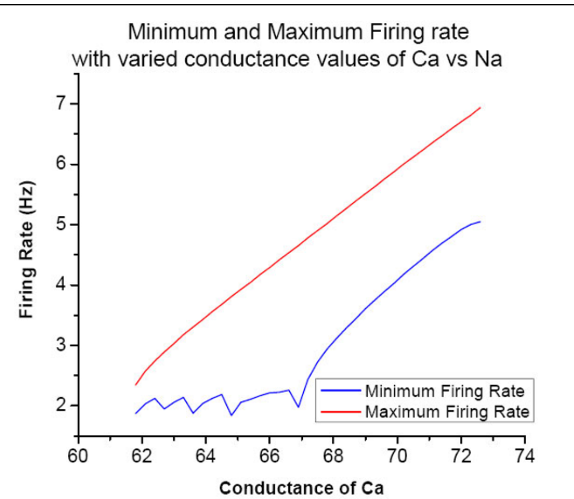

Figure 1 Minimum & Maximum firing rates with varied conductance values of calcium and sodium channels.

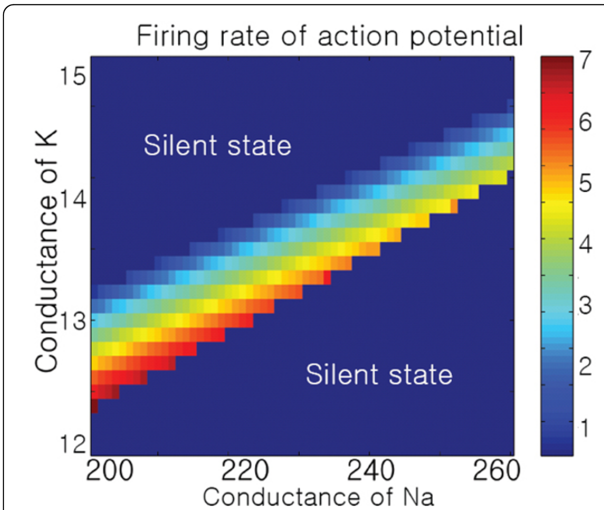

Figure 2 Firing rate distributions with change in sodium and potassium channel conductances.

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oscillation and phase shifting of firing rate in the neural network models structured by graph theory. We suggest that the model may be a guidance of channel properties in experimental conditions and be helpful to explain the circadian behaviors of SCN neurons.

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