

POSTER PRESENTATION

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Optimization of the squid giant axon leak conductance for repetitive firing

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From Nineteenth Annual Computational Neuroscience Meeting: CNS*2010
San Antonio, TX, USA. 24-30 July 2010

Recent work [1] indicates that the leak conductance (G_L) in the squid giant axon is optimal for the action potential firing frequency. Assuming a chloride leak current, the measured G_L of approximately 0.3 mS/cm^2 is very close to the theoretical optimal value that minimizes the absolute refractory period, or equivalently, that maximizes the highest frequency at which action potentials can be generated. These results were obtained by simulating brief, sharp current injections at one end of a Hodgkin-Huxley axon model, consistent with the standard experimental technique for measuring refractory periods. However, it is known [2] that constant current inputs to one end of a spatially axon can also evoke repetitive firing over a relatively narrow range of input strength. We have therefore investigated the optimality of G_L for constant input currents (I_{DC}). We find that the repetitive firing frequency is indeed maximized near biological values of G_L for lower values of I_{DC} (Figure 1). However, at higher values of I_{DC} , the frequency-optimal G_L goes to 0, and the firing frequency itself is even higher. Thus, solely from the point of view of maximizing repetitive firing frequency under constant current input, the combination of a high input current strength and little to no leak conductance would seem best. However, when one takes temperature into account, it suggests why evolution has not chosen this strategy. The ocean temperatures which a cold-blooded squid encounters can vary by as much as 10 degrees Celsius over a few months [3]. The repetitive firing of the axon therefore must be able to function over such a range. As shown in Figure 2, the range of G_L - I_{DC} parameter space over which repetitive firing can occur shrinks dramatically with increasing temperature. Since the value of G_L is presumably unchangeable, the configuration which

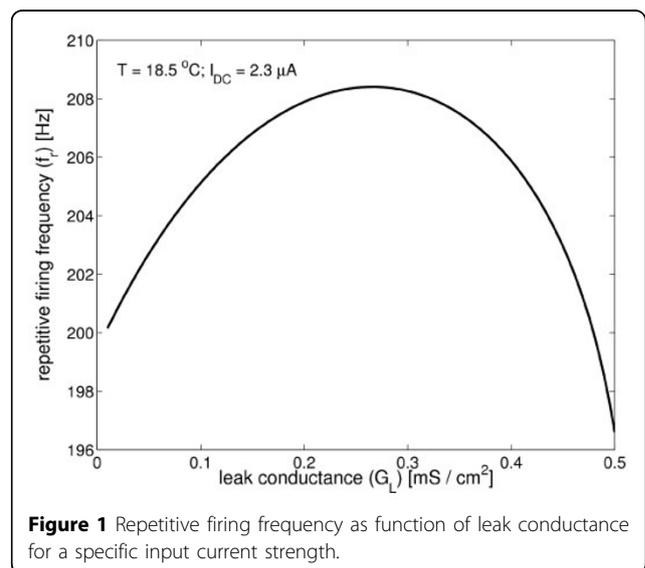


Figure 1 Repetitive firing frequency as function of leak conductance for a specific input current strength.

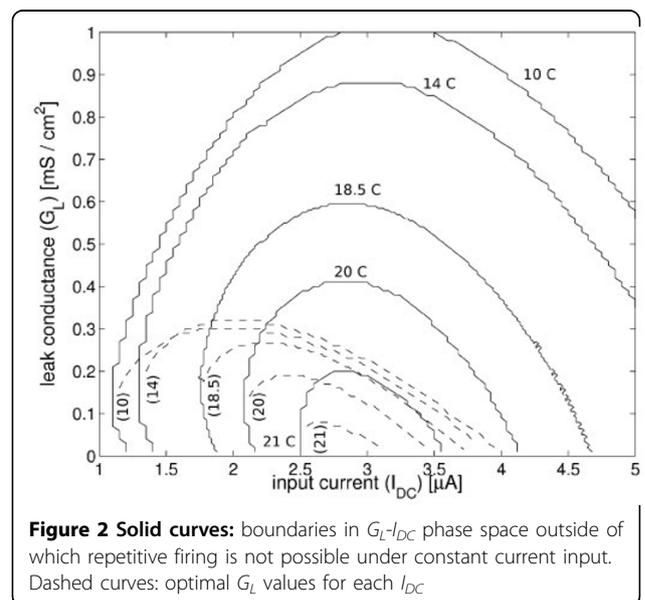


Figure 2 Solid curves: boundaries in G_L - I_{DC} phase space outside of which repetitive firing is not possible under constant current input. Dashed curves: optimal G_L values for each I_{DC}

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best preserves the ability of the axon to repetitively fire over the largest range of temperature favors G_L values near the biological value.

Published: 20 July 2010

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doi:10.1186/1471-2202-11-S1-P138

Cite this article as: Crotty: Optimization of the squid giant axon leak conductance for repetitive firing. *BMC Neuroscience* 2010 **11**(Suppl 1):P138.

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