Abstract View

DEPLETION OF EXTRACELLULAR CALCIUM IN THE CEREBELLAR GLOMERULUS.

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In the cerebellar glomerulus, a mossy fiber (MF) axon terminal is wrapped by 30-50 granule cell (GC) dendrites, and is enclosed by a glial sheath. We explored the hypothesis that the concentration of extracellular calcium ([Ca++]o) in the glomerulus can change as a function of the amount of GC activity. If this occurs, it suggests a novel learning rule for weight changes at the MF-GC synapses, one in which mutual information between the input and output layers is maximized. To explore whether [Ca++]o would change based on GC activity, we have performed simulations with MCell, a Monte Carlo simulator of molecular biophysics. A model glomerulus was constructed from tessellated surfaces. The space between these membranes contained diffusing Ca++ ions. The membranes were populated with Ca++ channels whose parameters were varied in simulations within biologically reasonable ranges. Our simulations quantify the rate at which Ca++ is depleted in the glomerulus as a function of the firing rate of the GCs and MFs. Given a constant firing rate of both the MF and GCs, [Ca++]o levels reach new steady state with a time constatnt of ~100-150 ms. MF activity contributes to the rate at which [Ca++]o levels reach the new steady state, but not to the average level of [Ca++]o at steady state. Thus, the level of Ca++ at steady state is primarily a function of the GC activity. The simulations also show that the magnitude and duration of [Ca++]o depletion is highly sensitive to the completeness of ensheathment by the glial cell. In order to measure the extent of ensheathment, we have begun electron microscopic studies of the glial sheath. In summary, our simulations explore the range in which [Ca++]o levels in the glomerulus will reflect a sum of post-synaptic activity; in this range, novel learning rules based on information-theoretic principles can be realized.

Citation:
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