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To cite this version:

HAL Id: hal-01402515
https://inria.hal.science/hal-01402515
Submitted on 24 Nov 2016

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Firing patterns in model networks of hippocampal persistent firing neurons
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Motivation
- Persistent firing has long been thought to be the neural mechanism underlying short-term memory encoding and storage [1]
- We analyse the dynamics of networks of persistent firing hippocampal neurons
- We hypothesise that these circuits could contribute to the emergence of theta oscillations in the hippocampus

Neuron Model
- Neuron Model [4]:
  \[
  C_m \frac{dV_m}{dt} = -I_{ leak} - I_{ h} - I_{ m} - I_{ M} - I_{ CA} - I_{ CAN} + I_{ stim} 
  \]
- Hodgkin-Huxley and M Currents:
  \[I_{ leak} = f(V_m) \quad I_{ h} = f(V_m) \quad I_{ CA} = f(V_m) \quad I_{ M} = f(V_m)\]
- Excitatory Postsynaptic Current:
  \[I_{ CAN} = -g_C (V_m - E_C) \]

Calcium Dynamics
- The Calcium Dynamics:
  \[
  \frac{d[Ca^{2+}]}{dt} = \frac{\gamma(I_{Ca})}{\tau_{Ca}} - \frac{[Ca^{2+}]}{\tau_{Ca}} \quad I_{Ca} = \frac{\gamma(I_{Ca})}{\tau_{Ca}} 
  \]
- The CAN Current:
  \[I_{CAN} = f(V_m, m) \quad \frac{dm}{dt} = \alpha_m (1 - m) - \beta_m m \quad \alpha_m = \sigma [(Ca^{2+})^n] \quad \beta_m = \beta_{CAN} T \]

Fitting Model to In-Vitro Data

Results – Network Firing Regimes

Results – CAN-Mediated Theta Oscillations

The interaction between CAN-mediated persistent firing and synaptic activity allow for the emergence of self-sustained synchronous theta oscillations in the CAN pyramidal network.

Conclusion
- Networks of CAN-equipped neurons display a rich array of firing regimes
- Self-sustained theta oscillations emerge from the interaction between CAN-mediated persistent firing and synaptic activity.

References