Self-sustained activity in a random network

Aishwarya Unnikrishnan, Nebojsa Gasparovic, Pascal Hecker, Sze Ying

Integrate-and-fire (IF) neurons

- Networks show asynchronous irregular (AI) activity states
  - In cerebral cortex of awake animals
- Conductance based model: adaptive exponential integrate-and-fire model

$$C_m \frac{dV}{dt} = -g_L (V - E_L) + g_L \Delta \exp\left[(V - V_T)/\Delta\right] - w/S$$

$$\frac{dw}{dt} = \frac{1}{\tau_w} [a (V - E_L) - w]$$

Parameters

- Cm: membrane capacitance
- gL: leak conductance
- EL: resting potential (-60mV)
- Delta: steepness of the exponential approach to threshold VT
- S: membrane area
- w: adaptation variable
  - tau_w: Time constant (600ms)
- a: Adaptation dynamics parameter (uS)
- b: w is incremented by b (nA) at each spike = strength of adaptation

Integrate-and-fire (IF) neurons

$$C_m \frac{dV_i}{dt} = -g_L (V_i - E_L) + g_L \Delta_i \exp\left[(V - V_{Ti}) / \Delta_i) - w_i / S - \sum_j g_{ji} \left(V_i - E_j\right)\right.$$

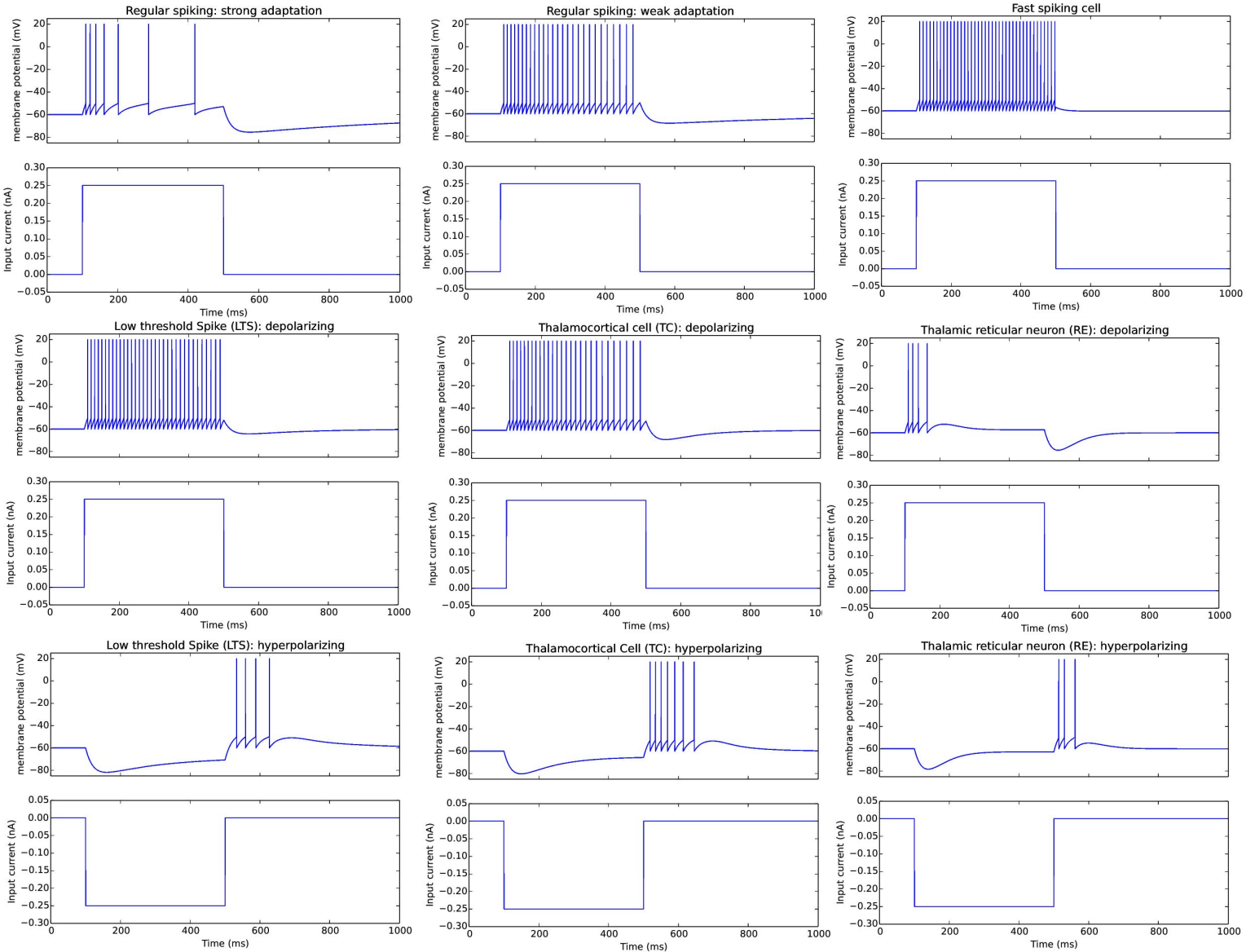
$$\frac{dw_i}{dt} = \frac{1}{\tau_{w_i}} \left[a_i \left(V_i - E_L\right) - w_i\right]$$

Network model
Parameters

- gij: conductance of synapse from neuron j to i
- Ej reversal potential of synapse (0 mV for excitatory, -80mV for inhibitory synapses)

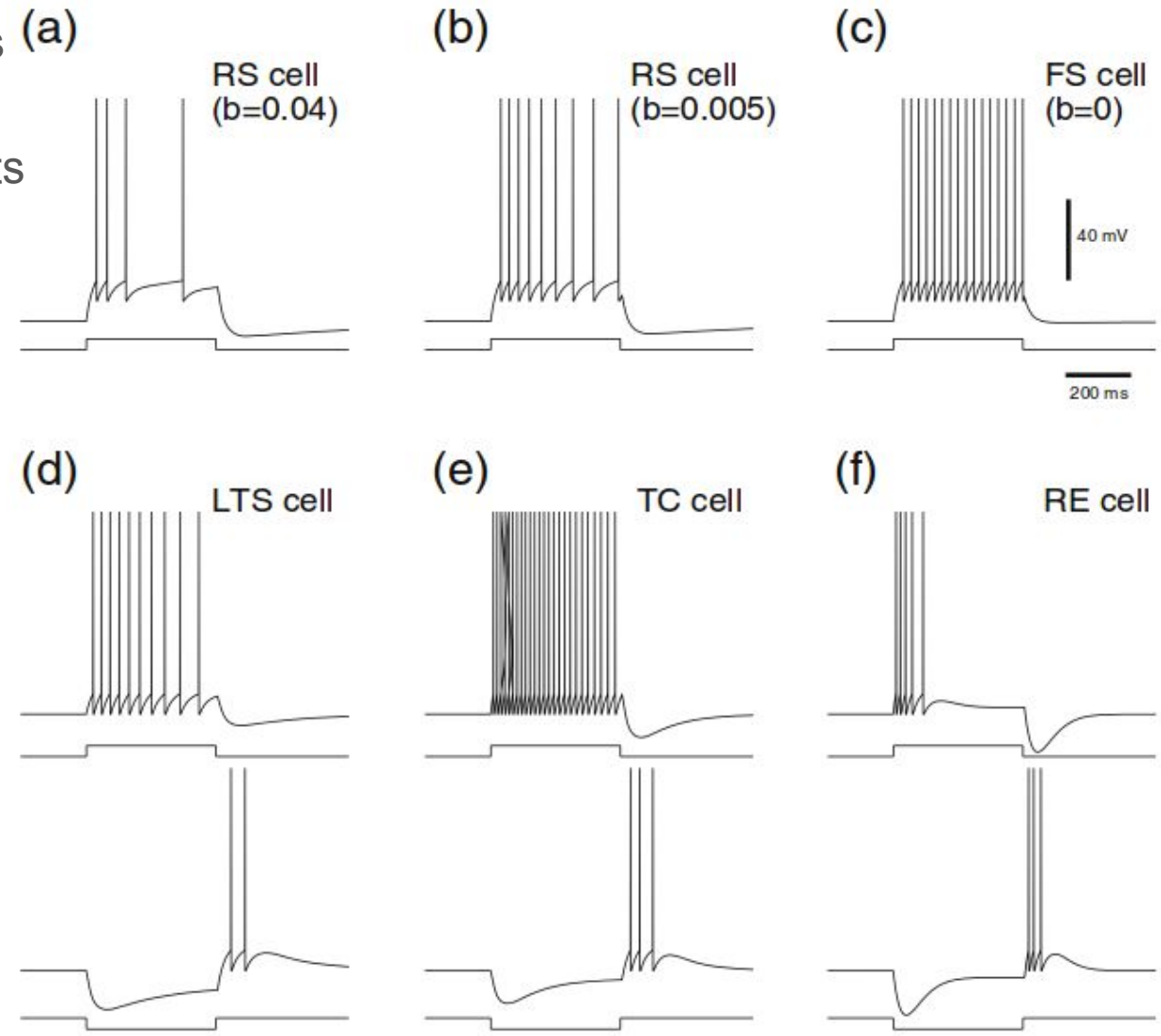
Single neurons

- Reconstructed prominent neuron classes observed in cortex

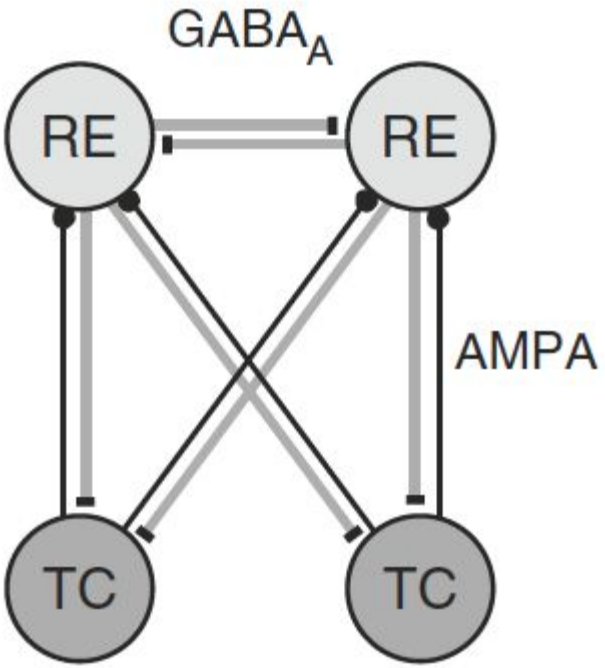


Single neurons

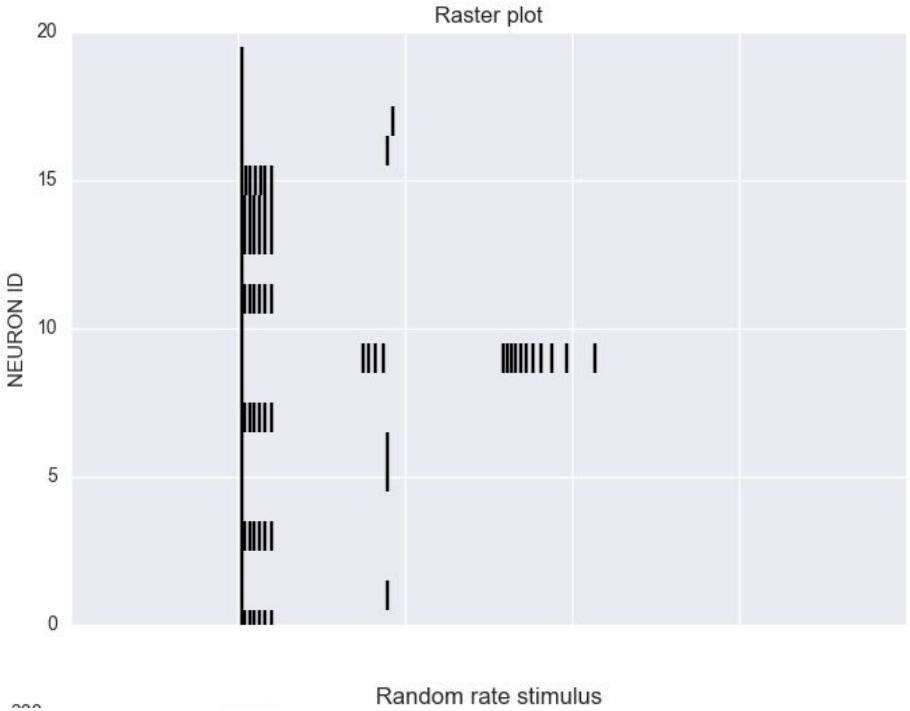
- Varied parameters a and b
- Reproduced results from paper

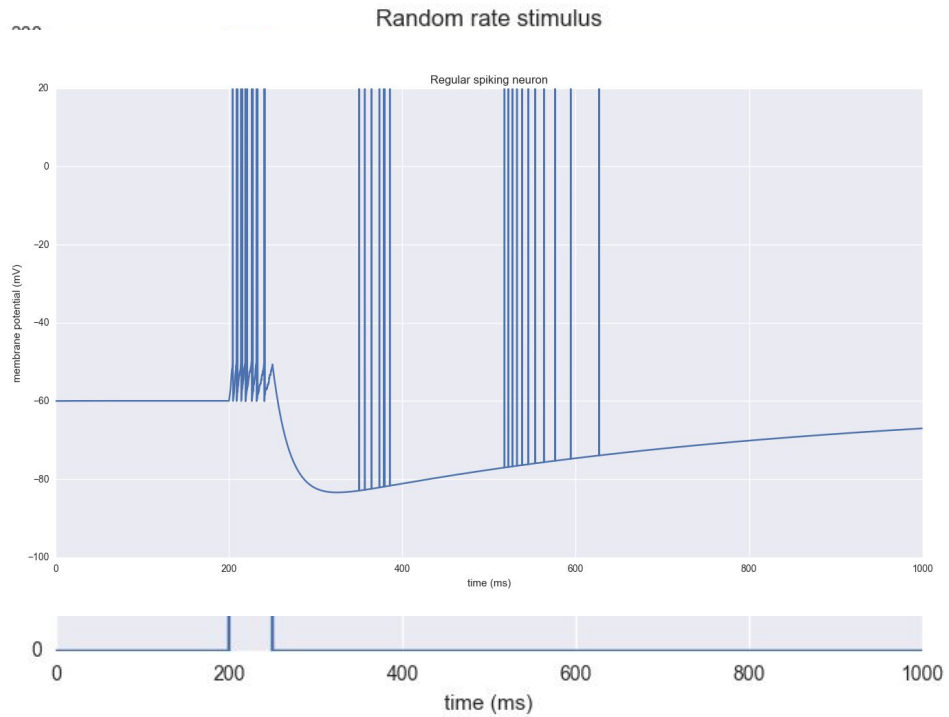


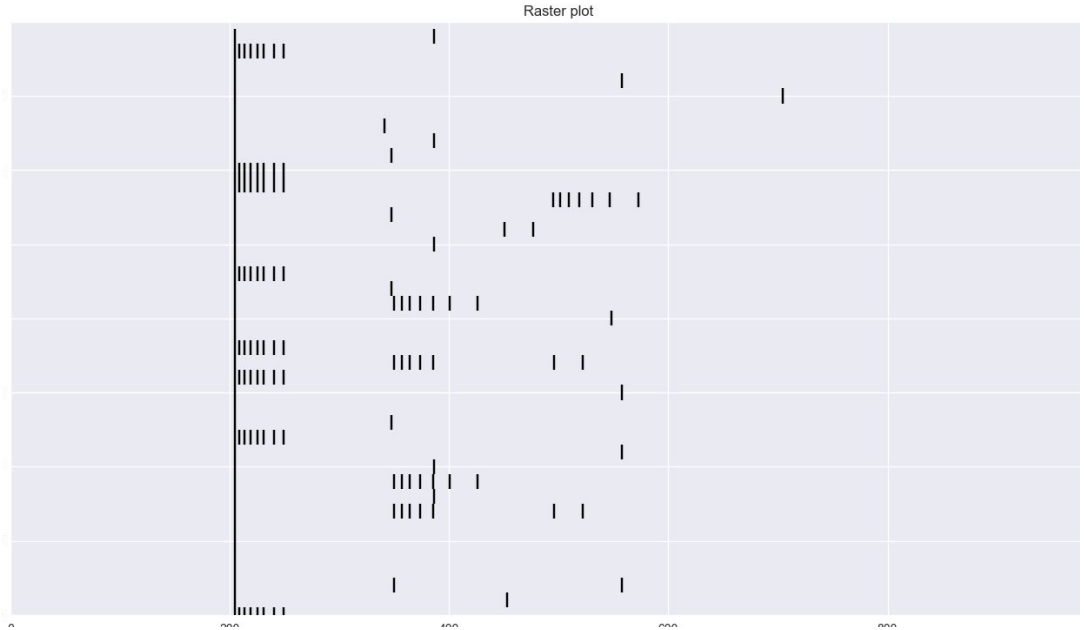
Thalamus Network

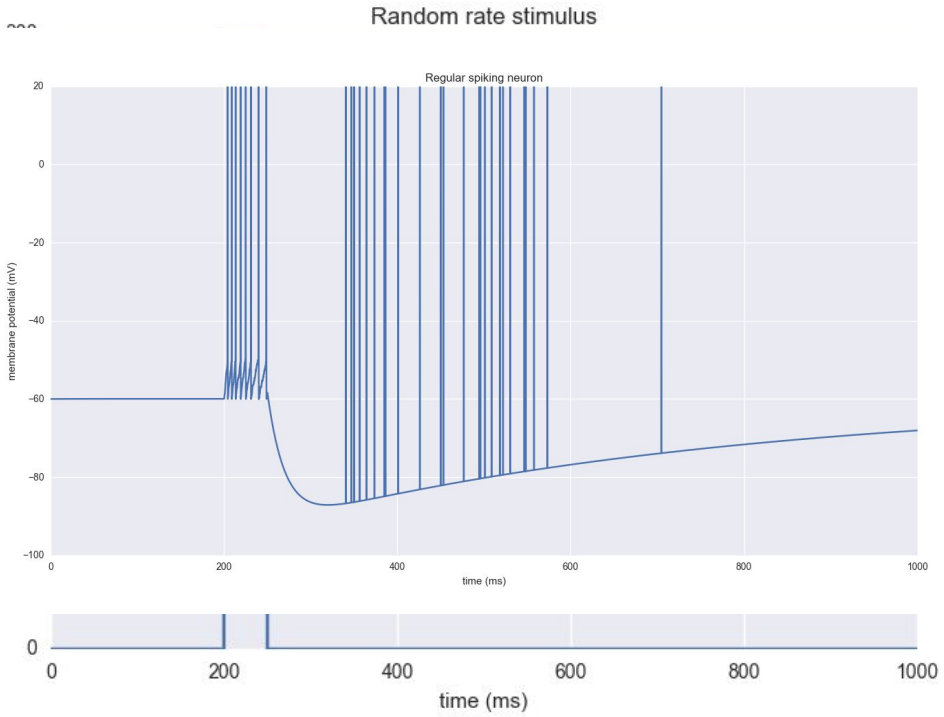


- 50/50 TC/RE cells in 20, 40, 60 group
- 80 and 100 has 10-20% more TC cells
- Neurons are randomly connected
- RE → RE
- RE → TC
- TC → RE


Raster plot
NEURON ID
20
15
10
5
0


Random rate stimulus
Regular spiking neuron
membrane potential (mV)
20
0
−20
−40
−60
−80
−100
0
200
400
600
800
1000
time (ms)
0
0
200
400
600
800
1000
time (ms)


Raster plot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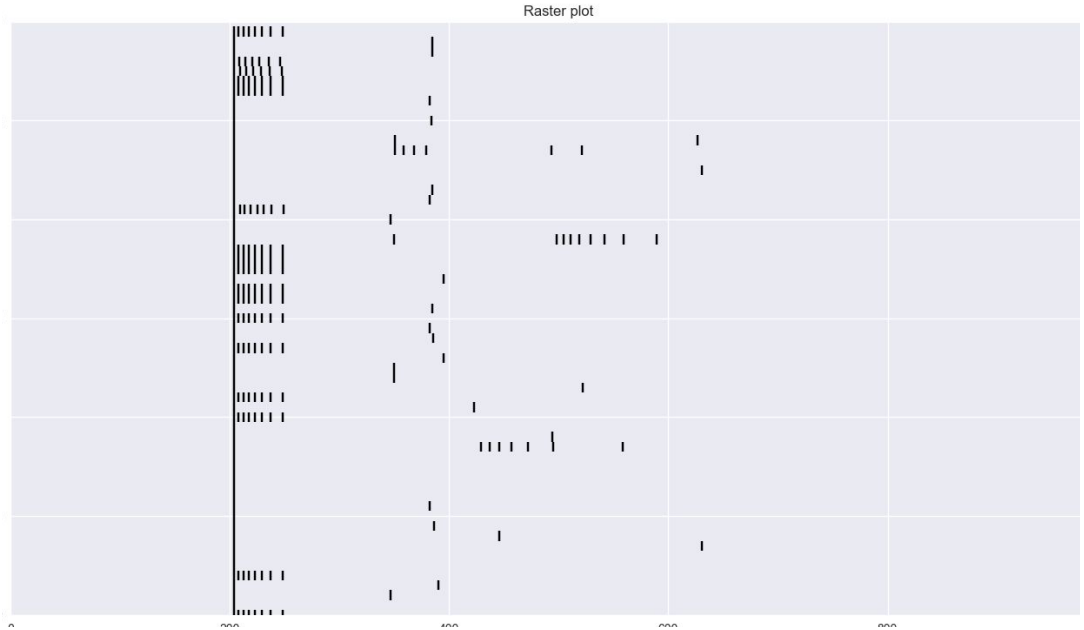
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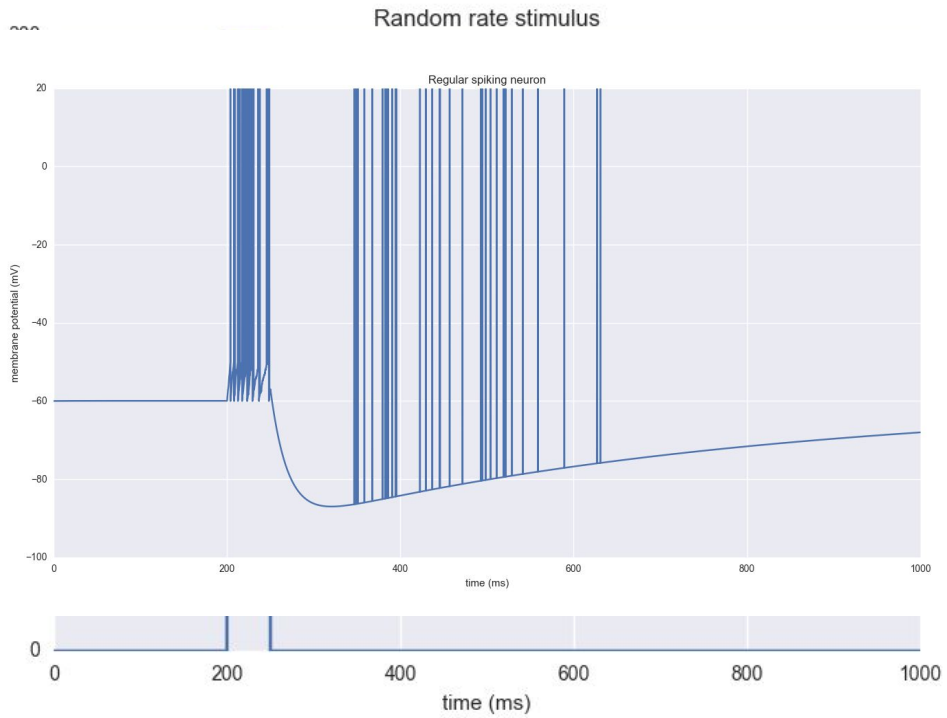
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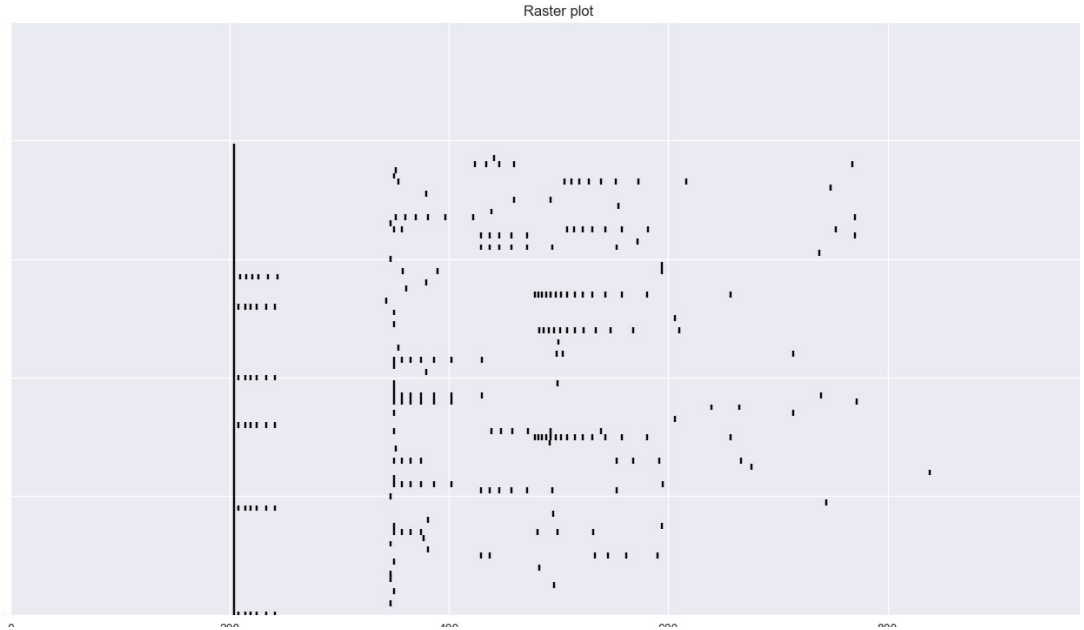
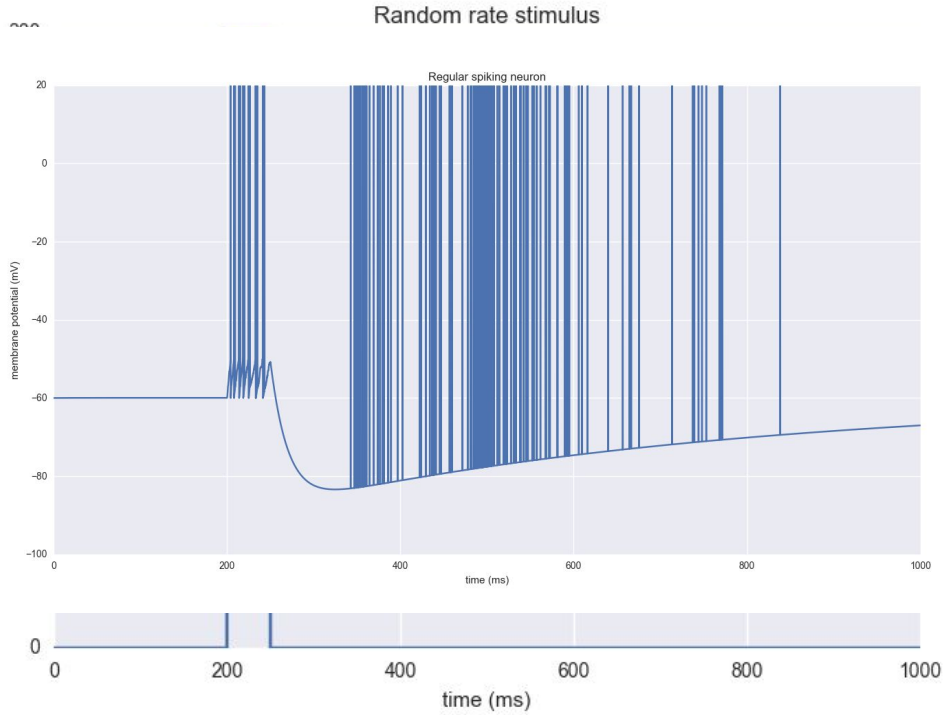

Raster plot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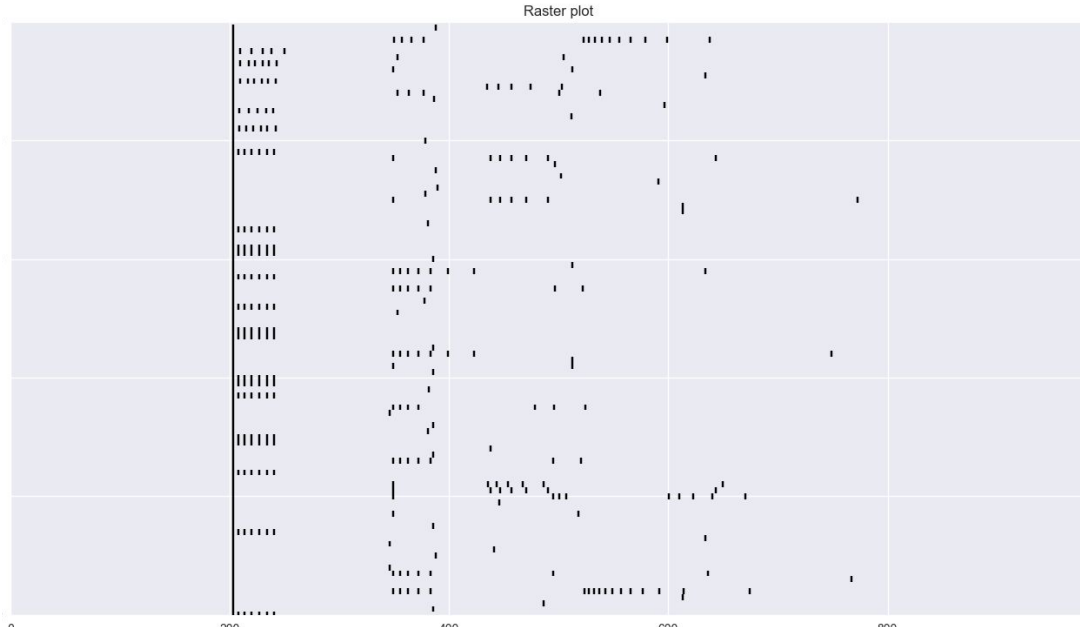
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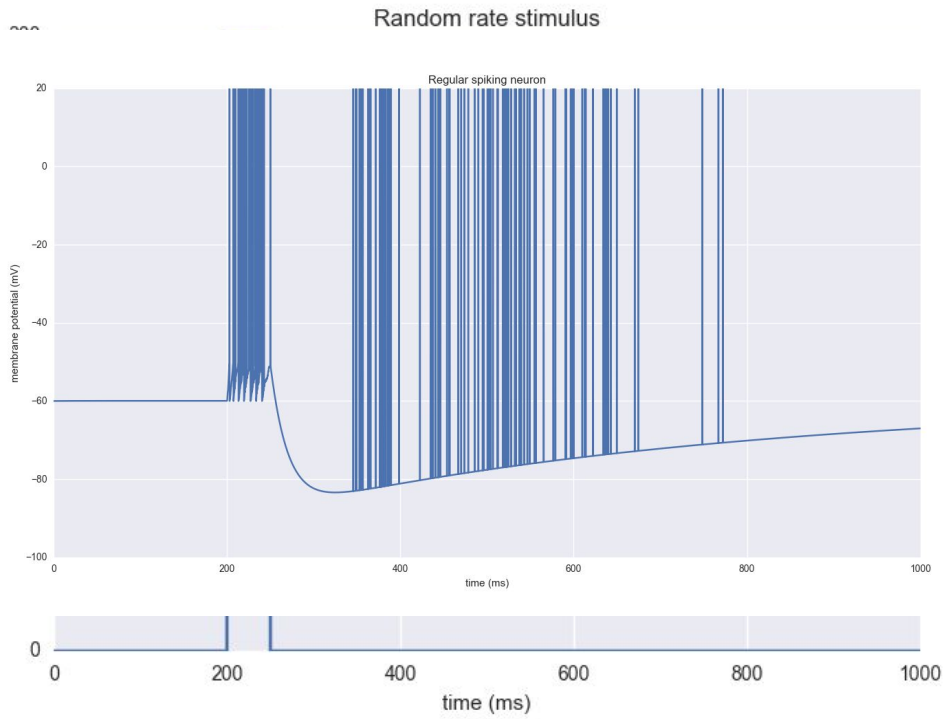
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Thanks for your attention