

Introduction to Experimental Neuroscience: Neurocomputation | July 2021

A mathematical model to investigate temporal processing

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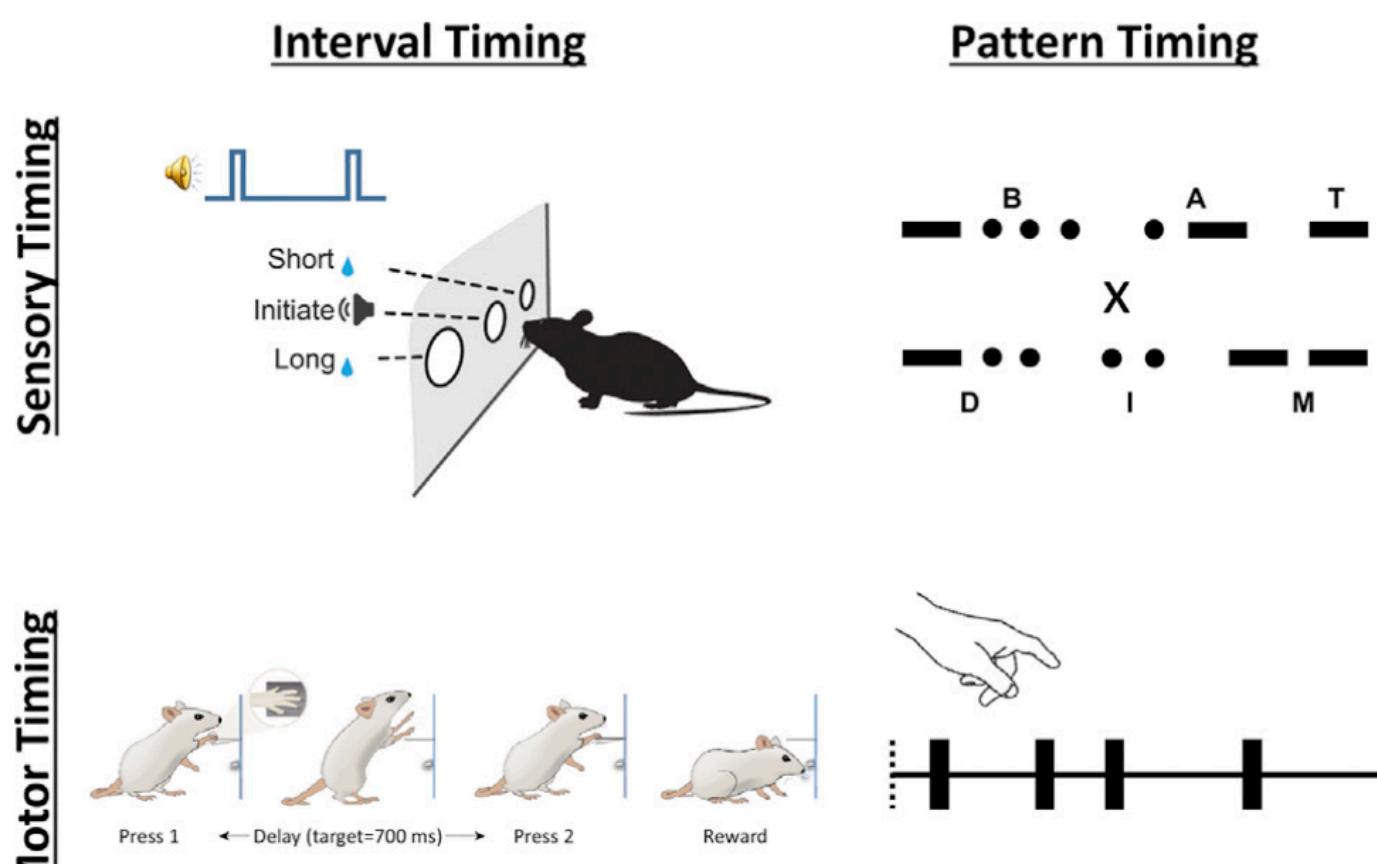
What is timing, what is its importance and examples from our daily lives.



Temporal Processing

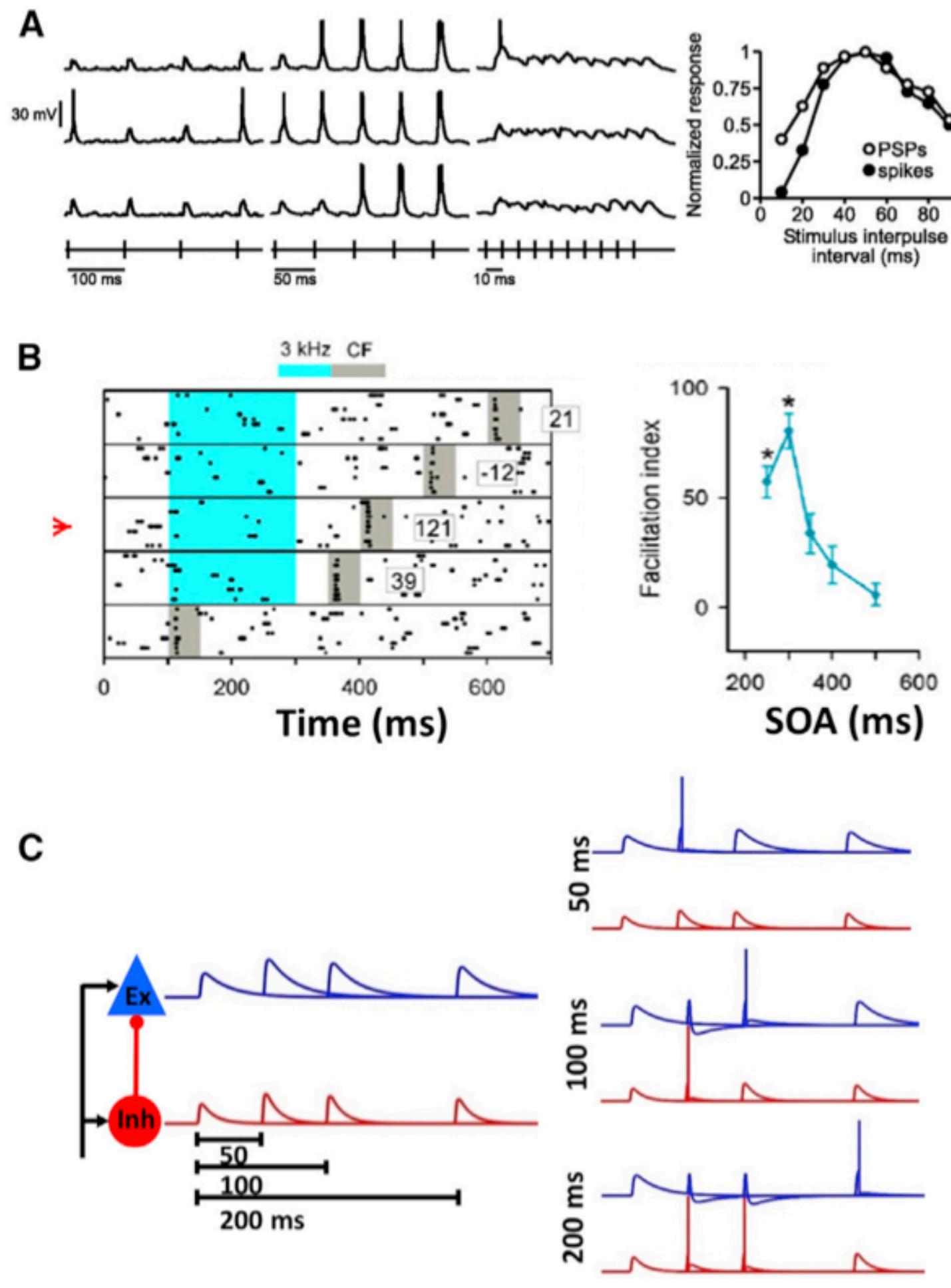
Experiments in Electric fish, mice and a model for duration

Experiments in mice and the Morse code



Gouve^a et al. (2015), Kawai et al. (2015).

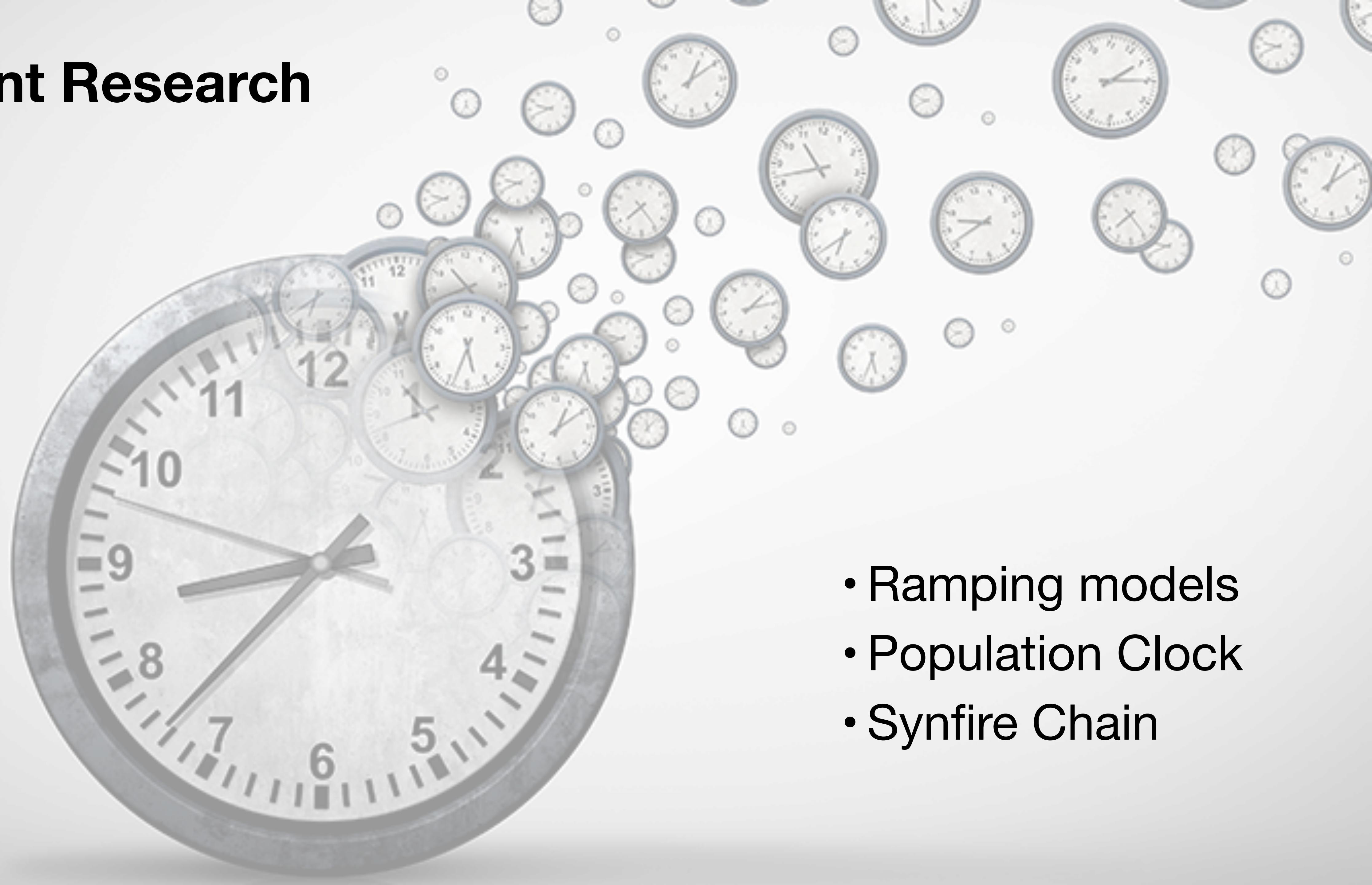
Experiments in cats and songbirds



Carlson (2009), Zhou et al. (2010), Buonomano (2000)

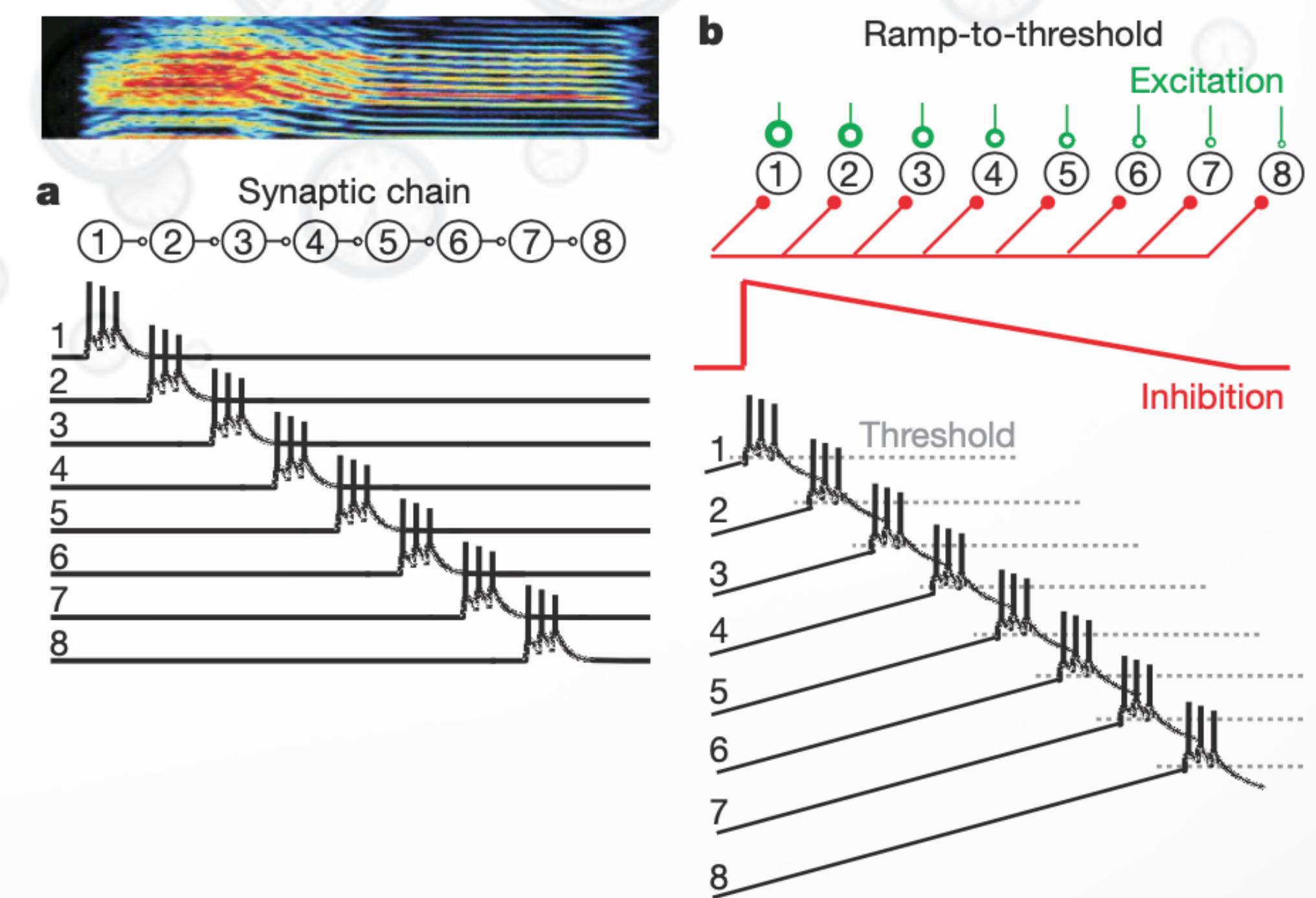
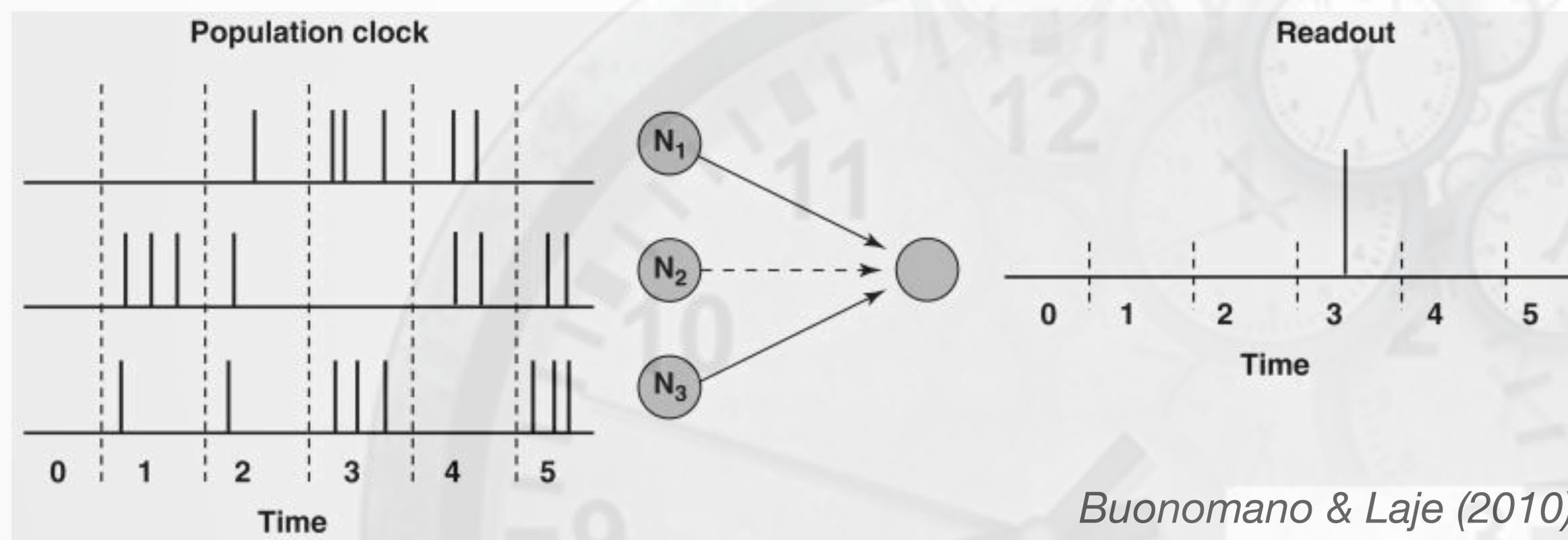
Duysen et al (1996), Doupe (1997)

Current Research

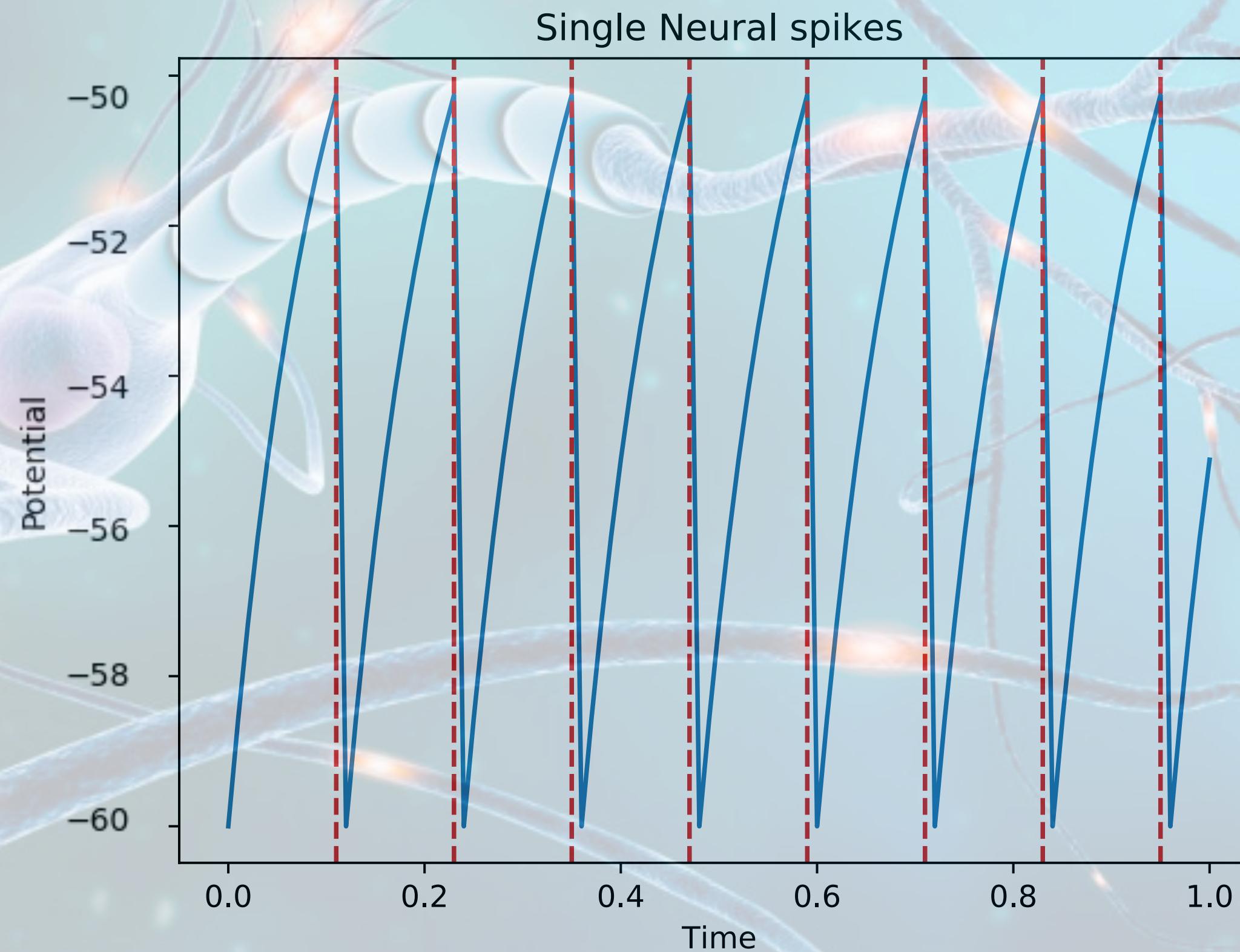


- Ramping models
- Population Clock
- Synfire Chain

Temporal Processing



Integrate and Fire Neuron



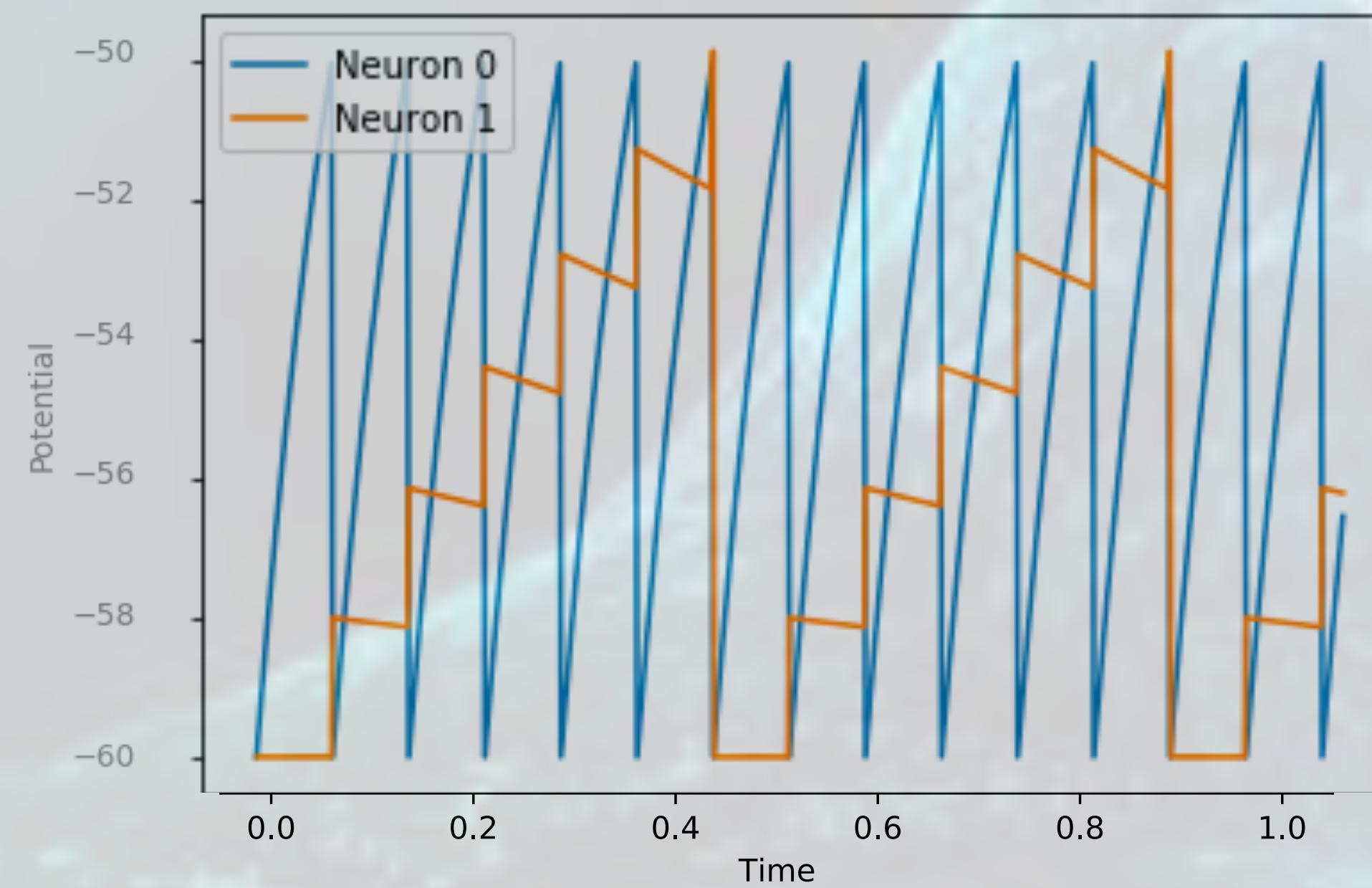
- V_0 : resting potential
- τ : membrane time constant
- I : external current (synaptic)
- G_{tot} : total conductance

$$\tau \frac{dV}{dt} = (V_0 - V) + \frac{I_{ext}}{G_{tot}}$$

If $V=V_t$ (threshold), neuron spikes and V goes to V_0

$$V = V_0 + \frac{I_0}{G_{tot}} \left(1 - e^{-\frac{t-t_0}{\tau}}\right)$$

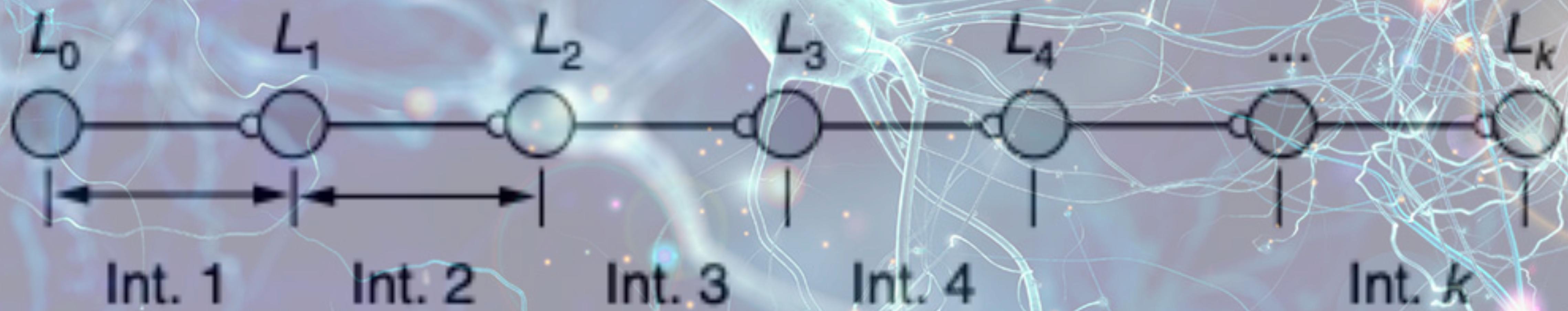
Simplest Synapse



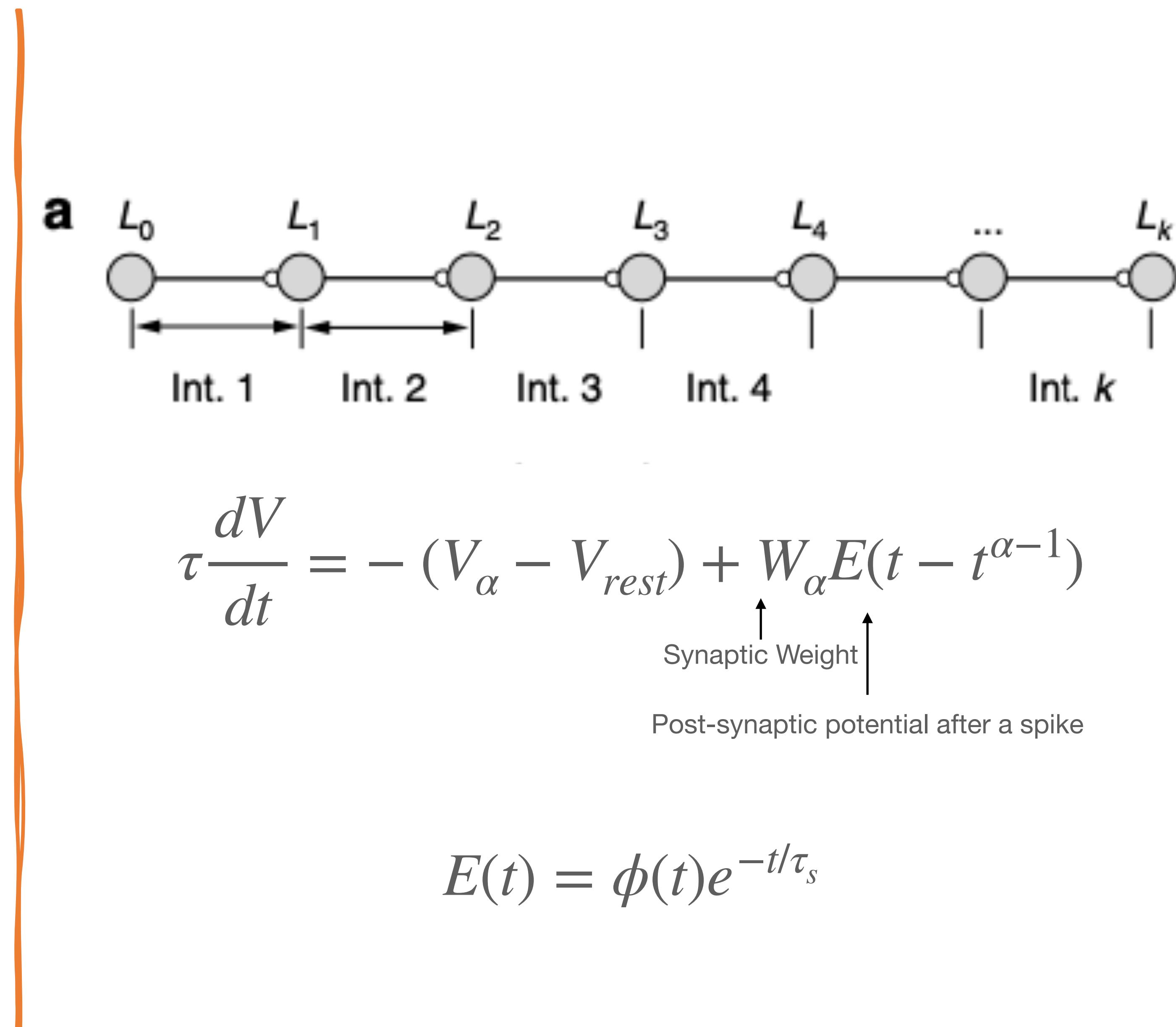
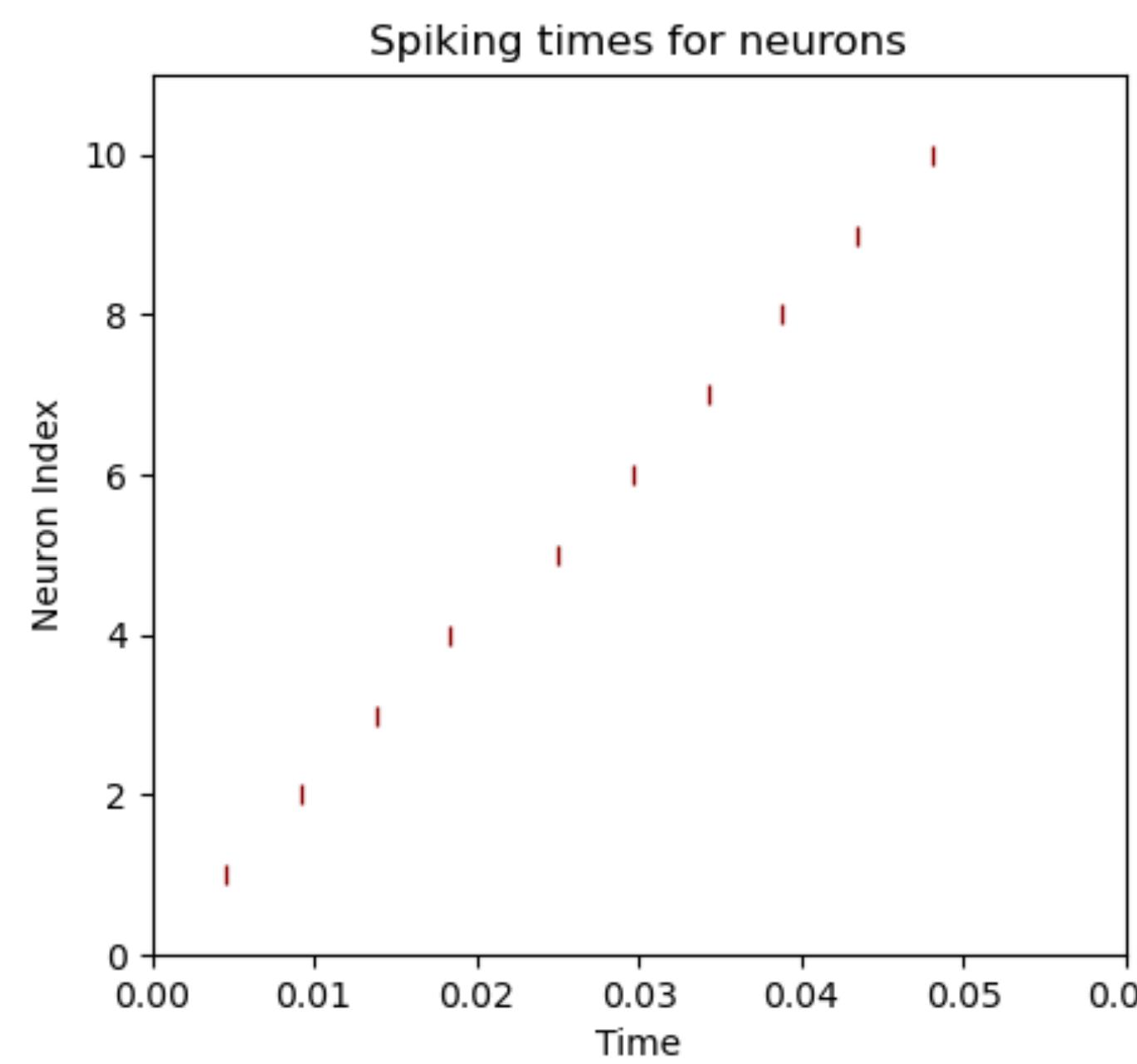
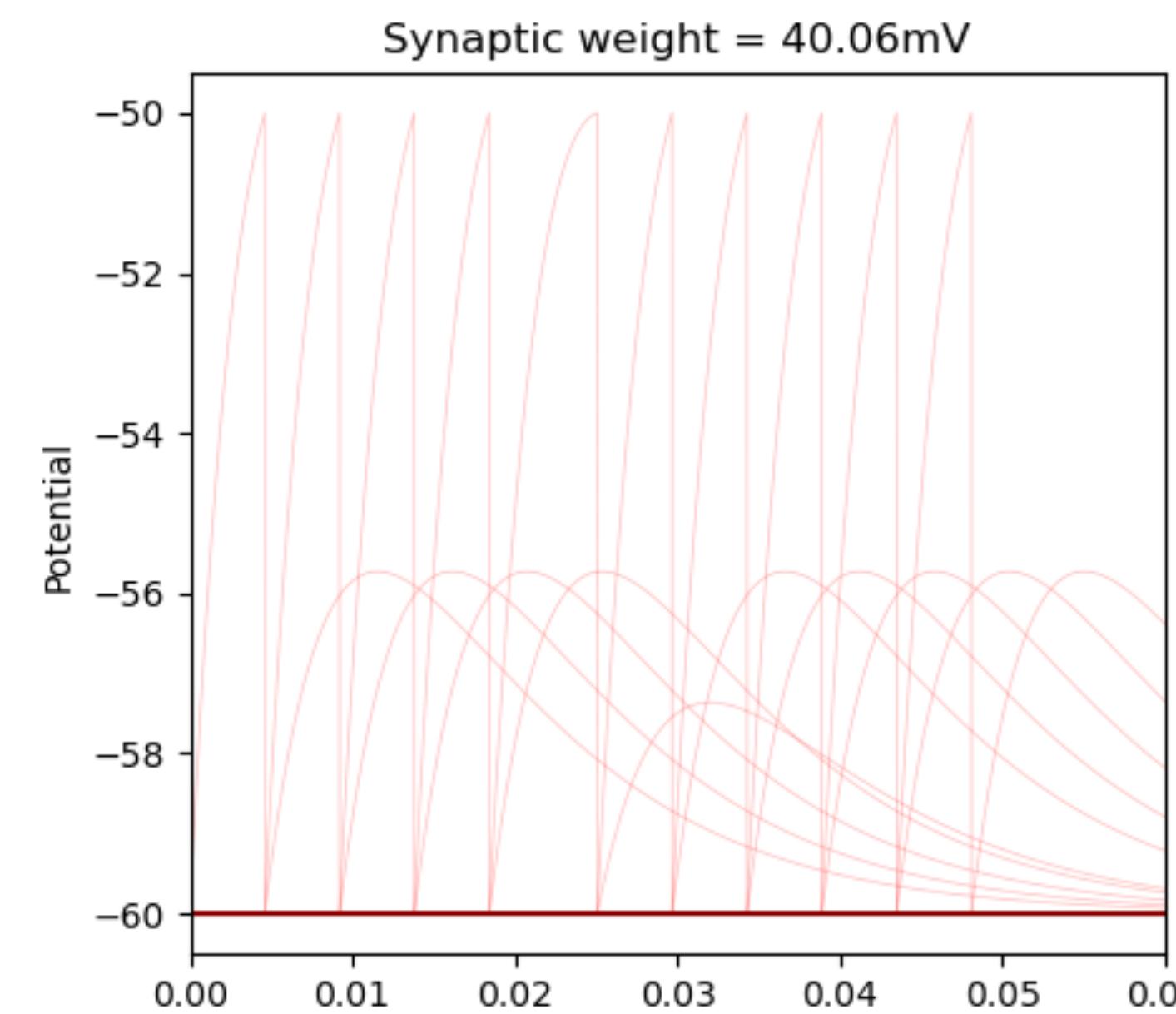
Total synaptic current in neuron i at time t :

$$I_{syn}^i(t) = \sum_j w_{ij} \sum_k \alpha(t - t_j^{(k)})$$

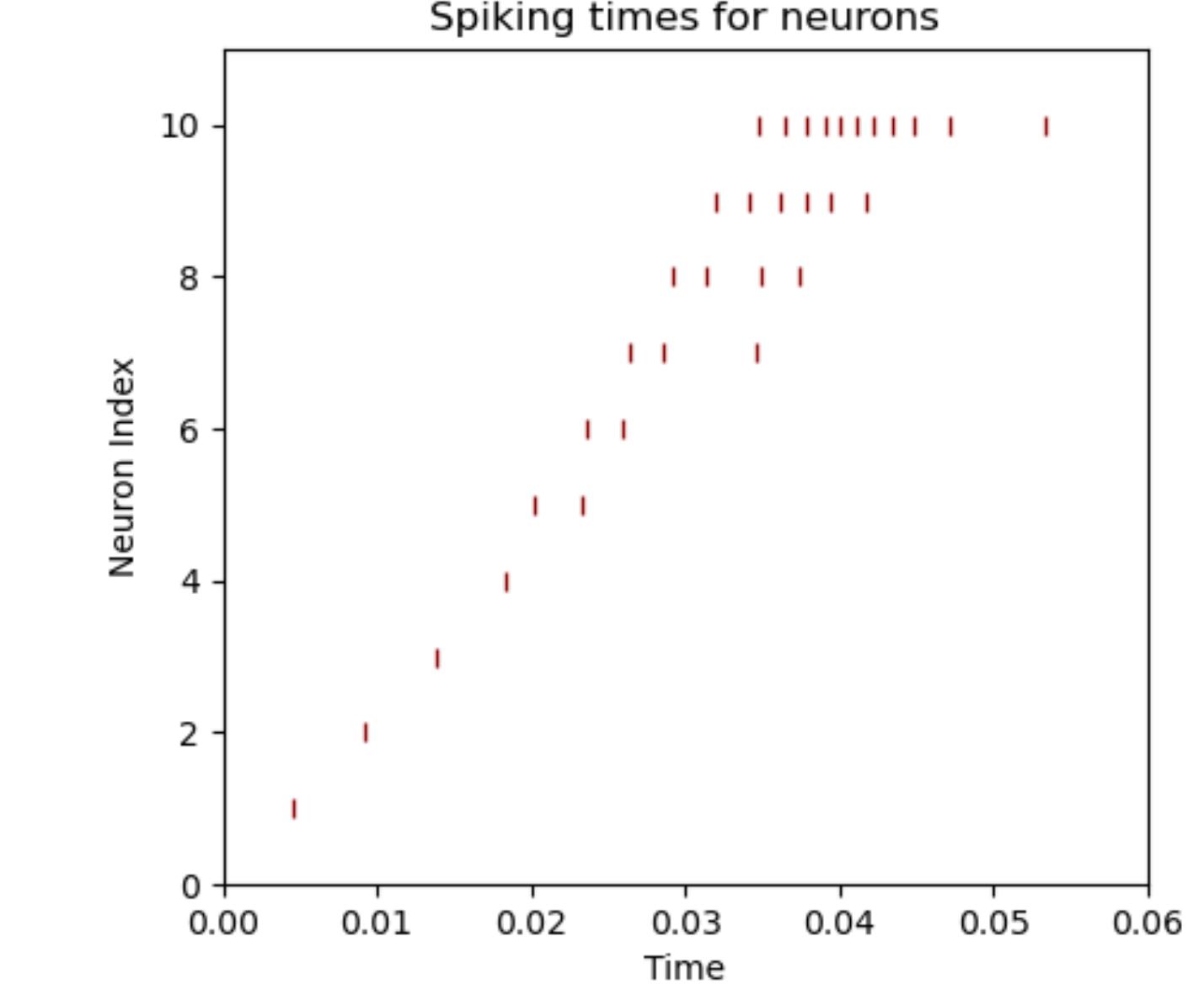
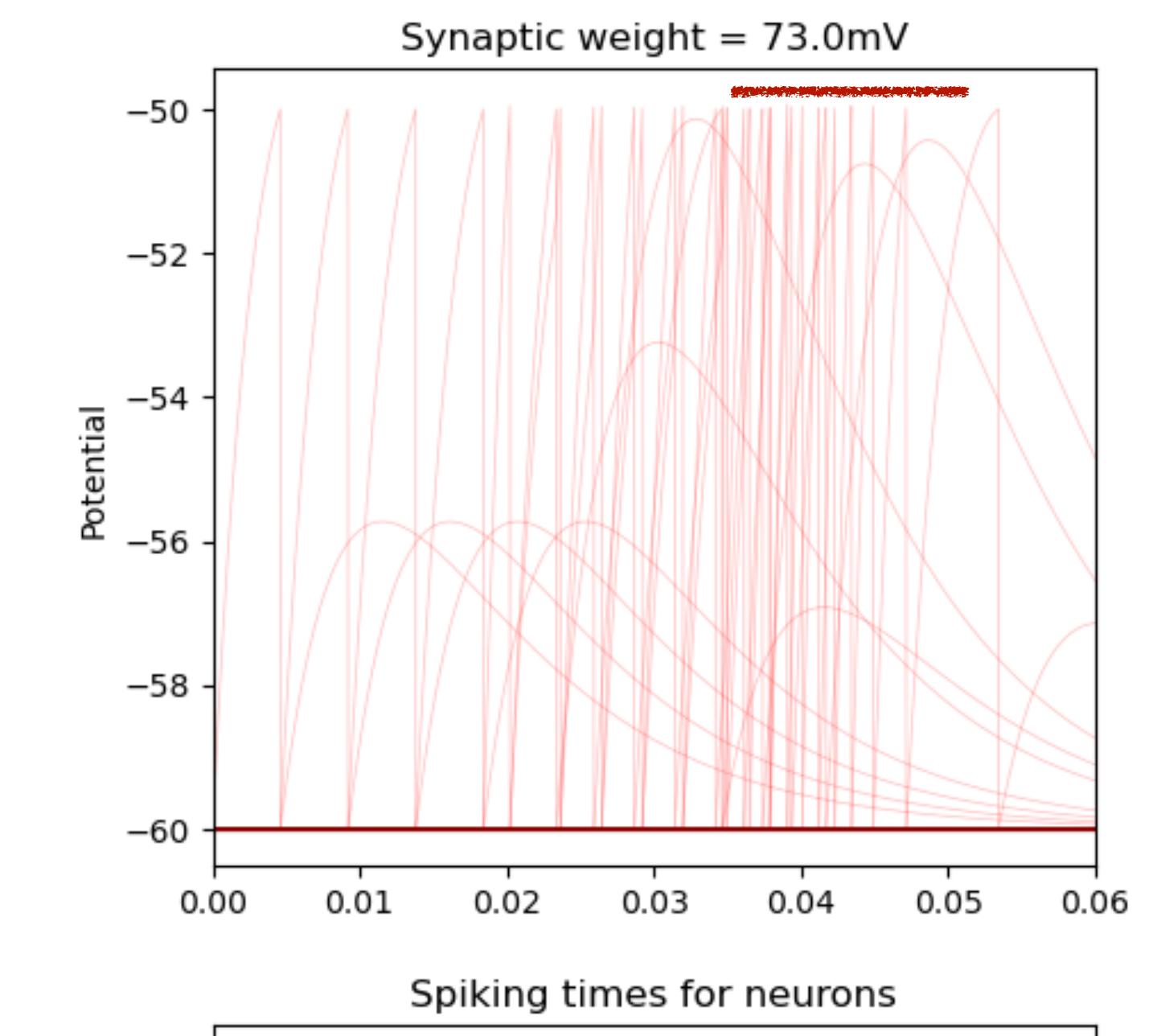
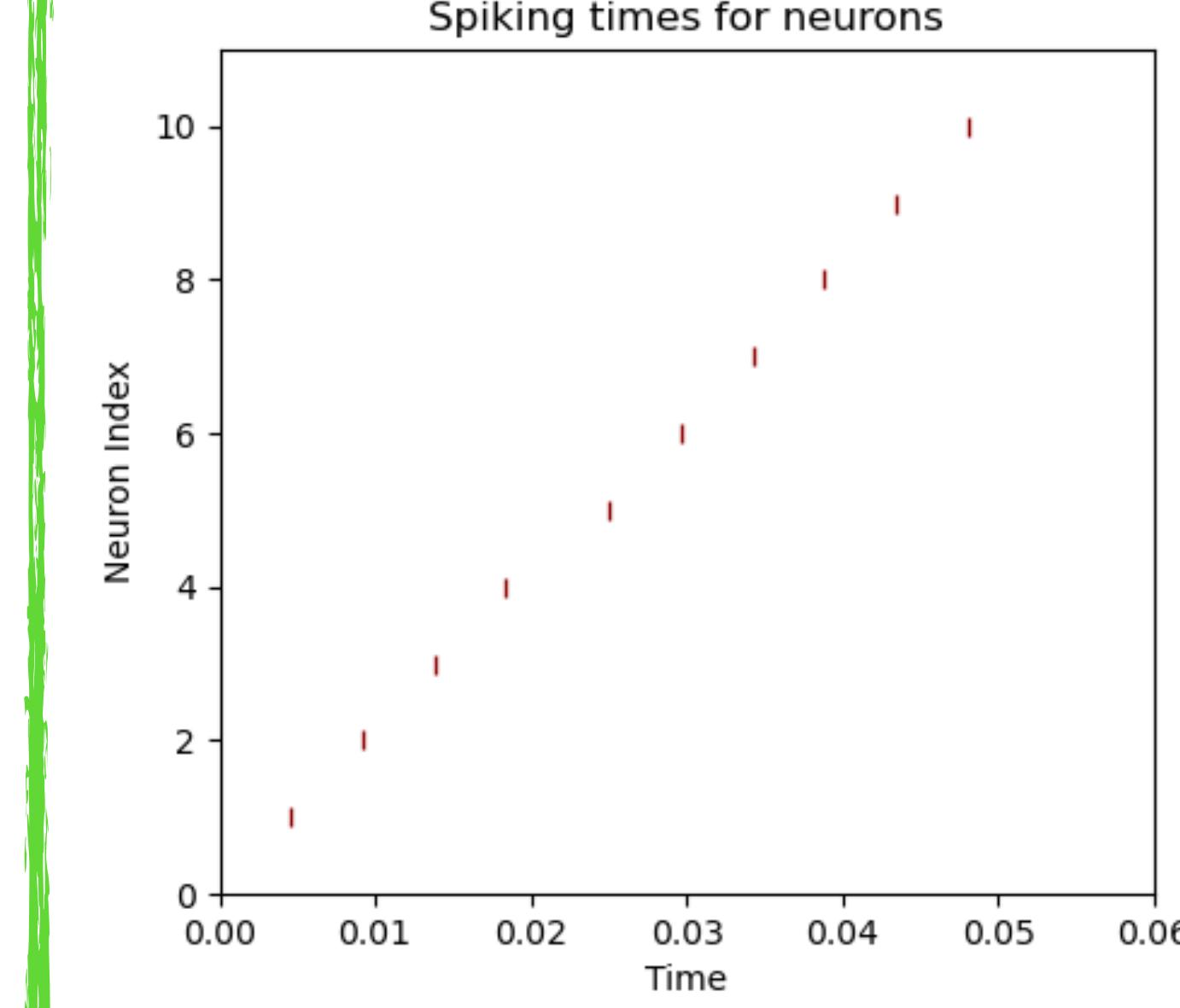
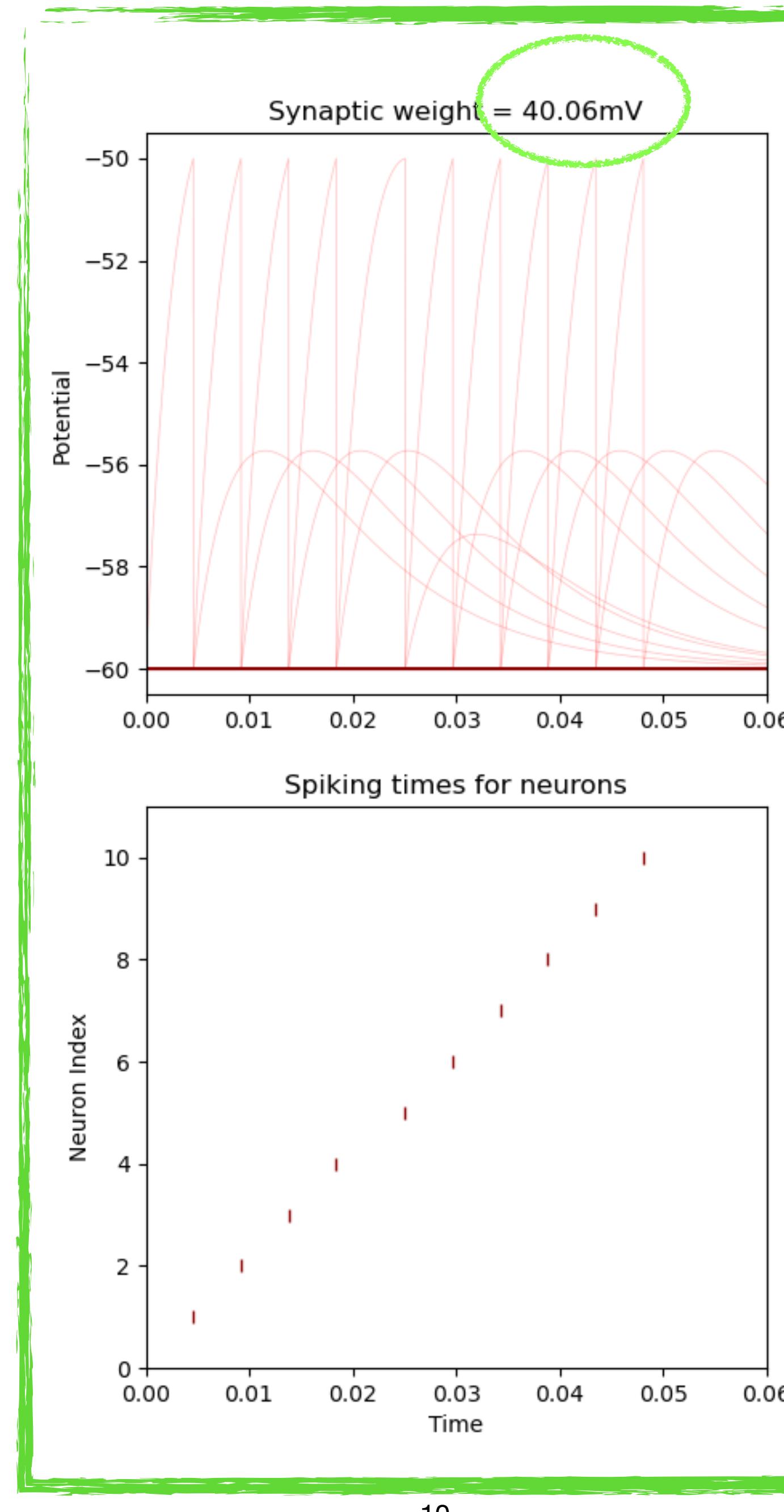
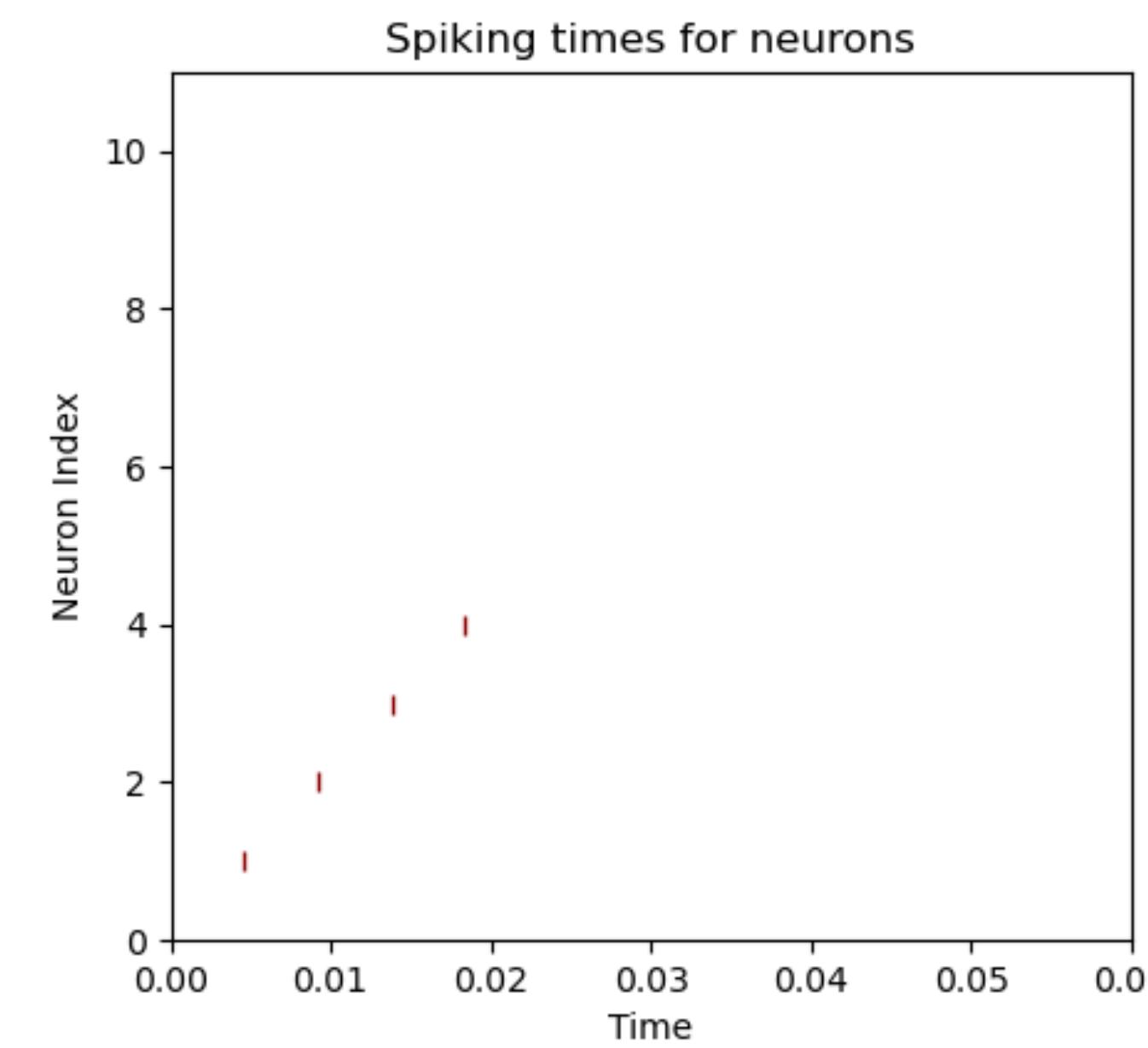
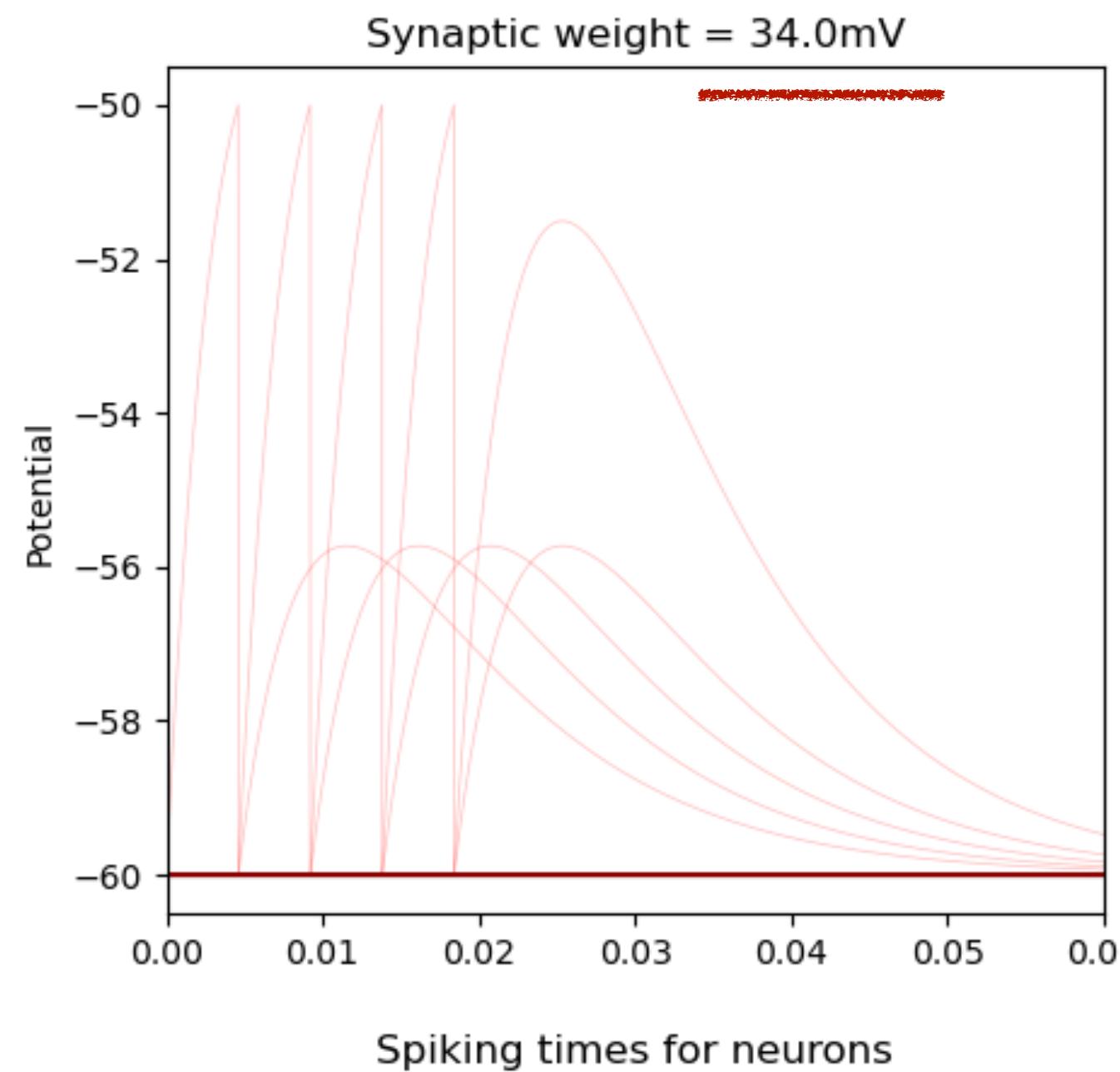
Chain of Single Neurons



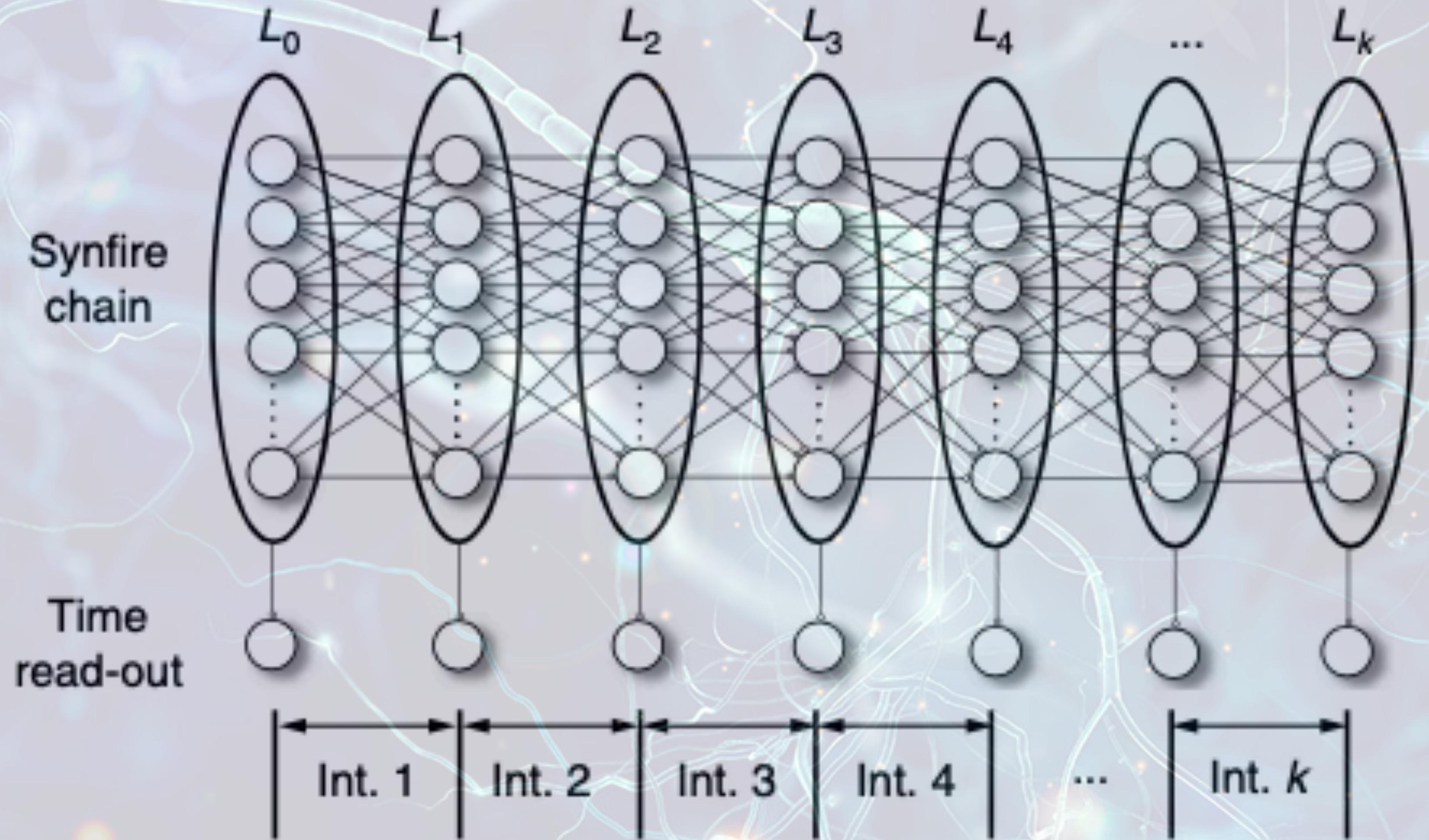
Chain of Single Neurons



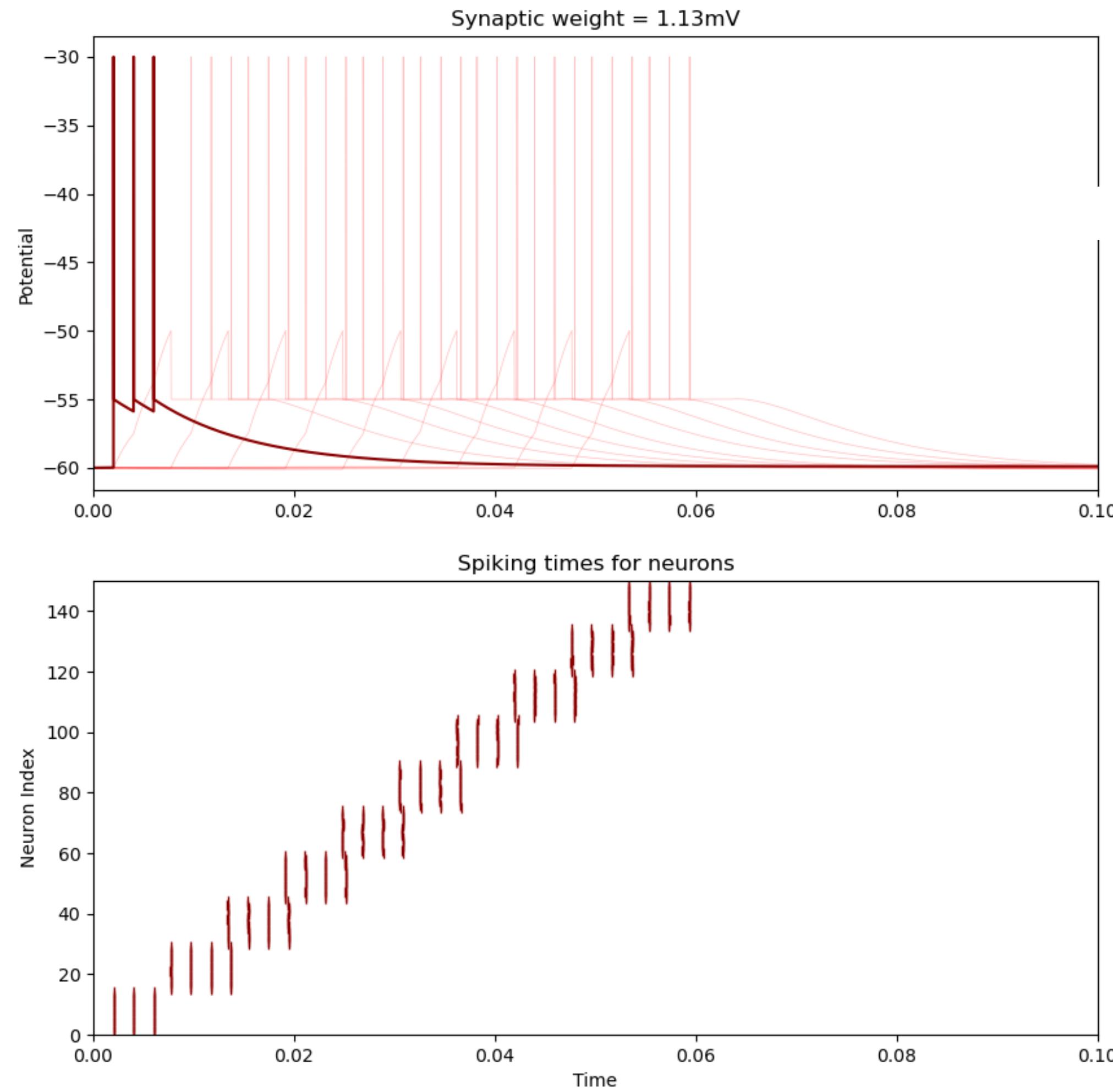
Synfire Chain- Chain of Single Neurons



Synfire Chain



Synfire chain, 10 layers of 15 neurone, simulation duration =100 ms



$$\tau_{IF} \frac{dV_i}{dt} = -(V_i - V_{rest}) + I_{syn,i}(t) + I_{ext,i}(t) + \sqrt{\tau_n} \sigma \eta_i(t)$$

$$I_{syn,i}(t) = \sum_j W_{ij} \sum_k E(t - t_j^k)$$

$$E(t) = \phi(t) e^{-t/\tau_s}$$



Thank you for your attention!