

# Modelling spiking neural networks using Brian, Nest and pyNN

Laurent Perrinet



LACONEU 2019: 5th Latin-American Summer School in Computational Neuroscience, 14/1/2019



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# Outline

1. Modelling SNNs
2. Single cells
3. Populations of cells
4. Plasticity

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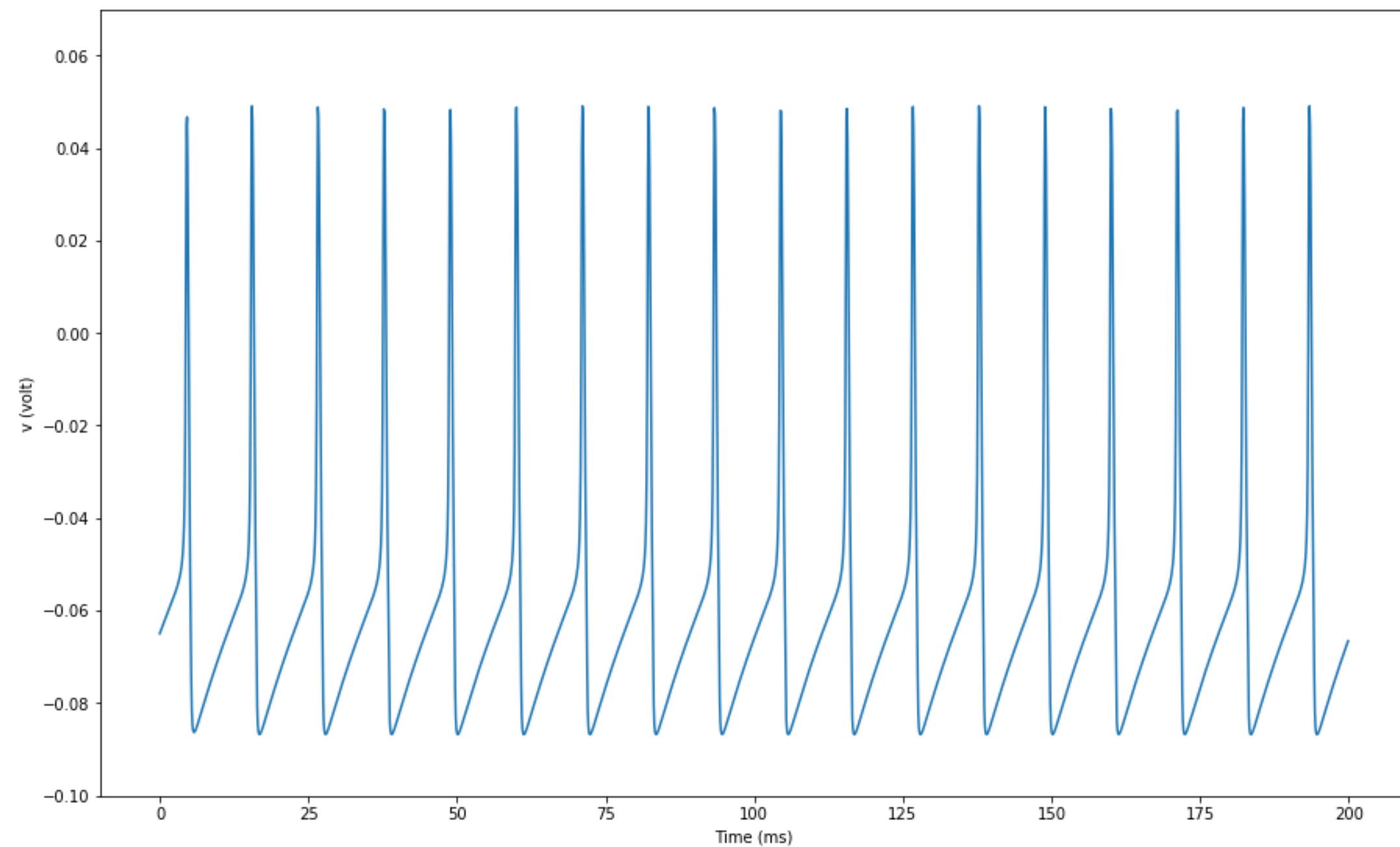
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$$C_m \frac{dV}{dt} = -\overline{g_{Na}} a_{Na}^\infty (V - E_{Na}) - \overline{g_K} a_K (V - E_K) \\ - g_l (V - E_l) + I_{stim}$$

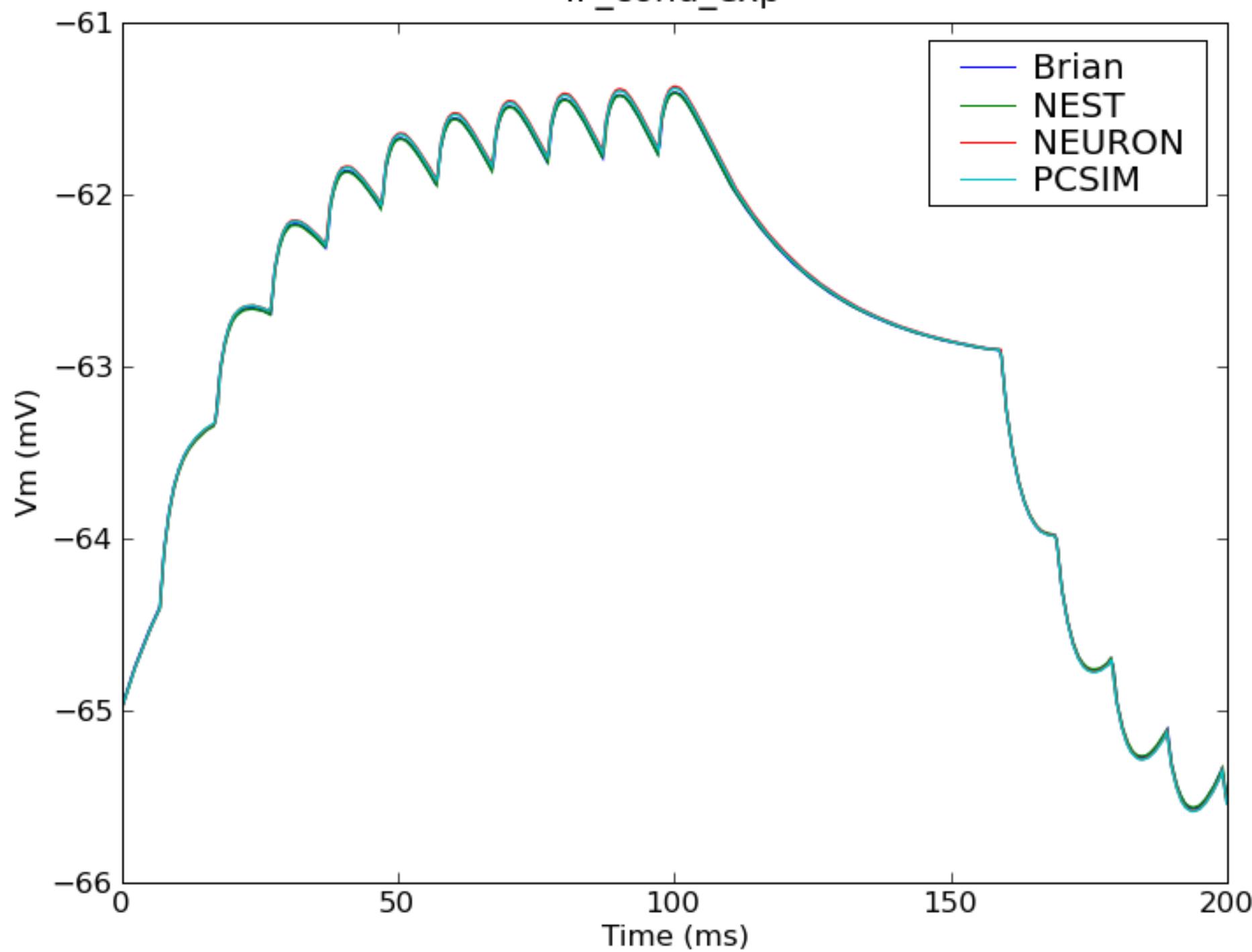
$$\frac{da_K}{dt} = \frac{a_K^\infty (V) - a_K(t)}{\tau_K}$$

$$a_K^\infty (V) = \frac{1}{1 + e^{s_K(V - V_K^0)}}$$

$$a_{Na}^\infty (V) = \frac{1}{1 + e^{s_{Na}(V - V_{Na}^0)}}$$



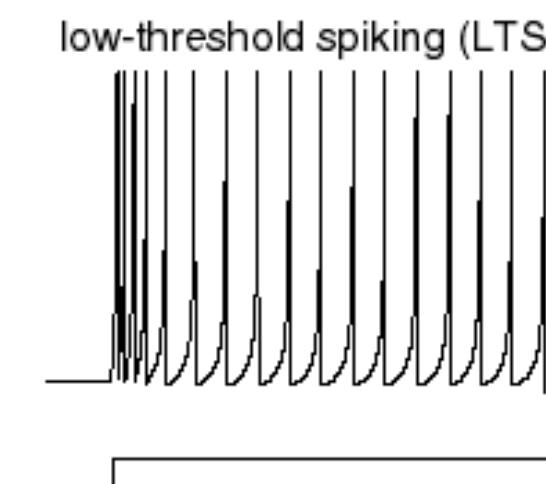
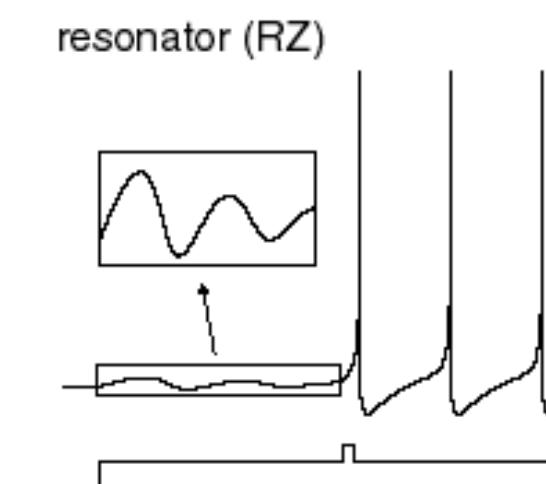
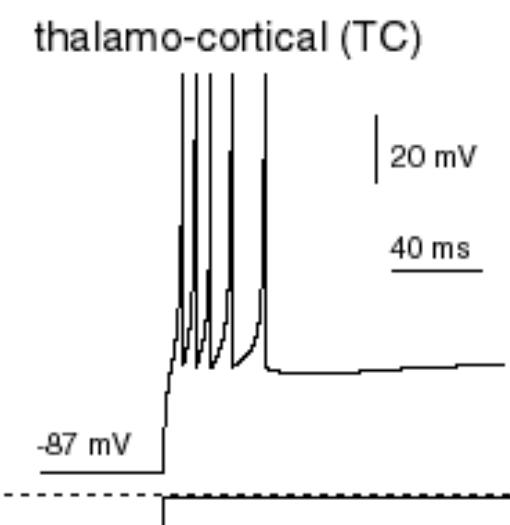
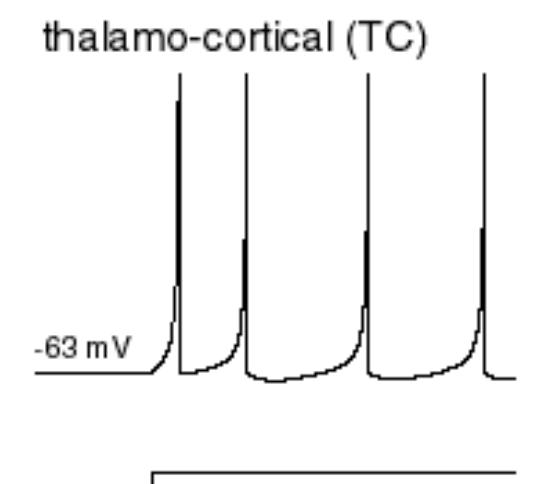
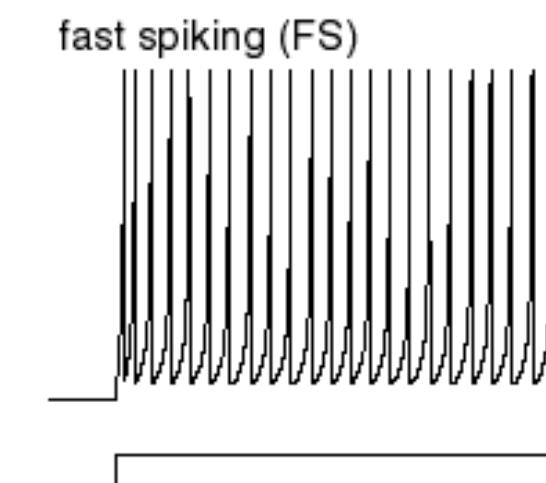
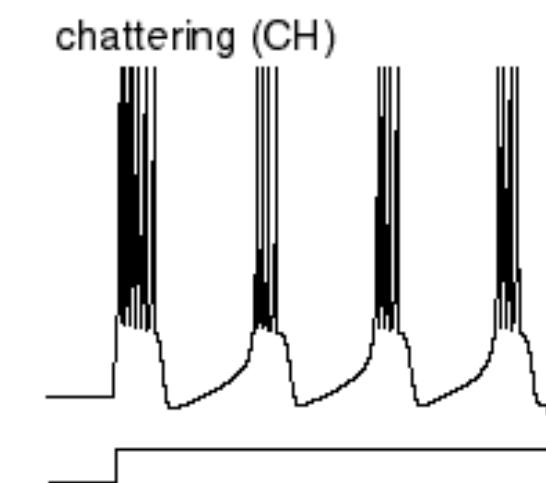
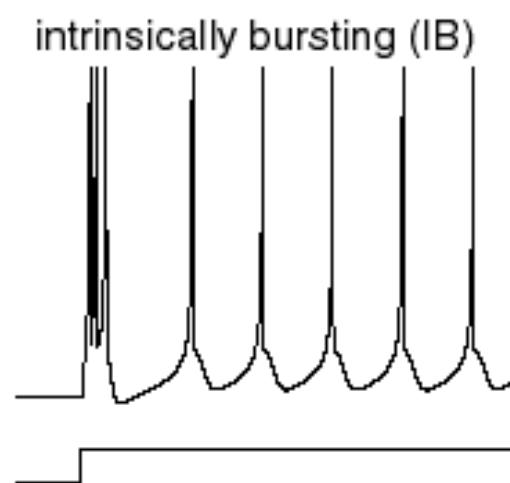
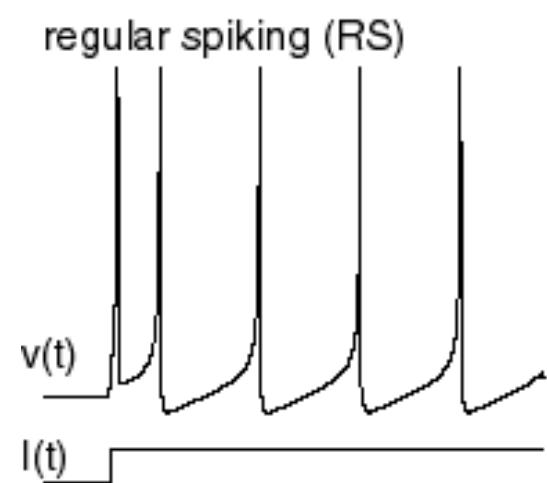
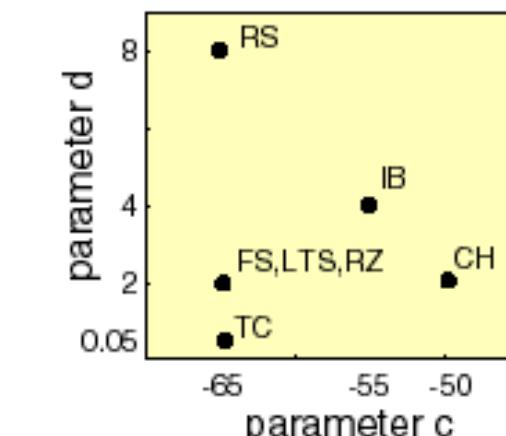
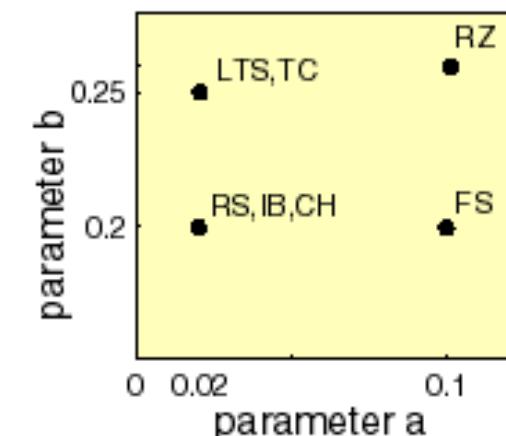
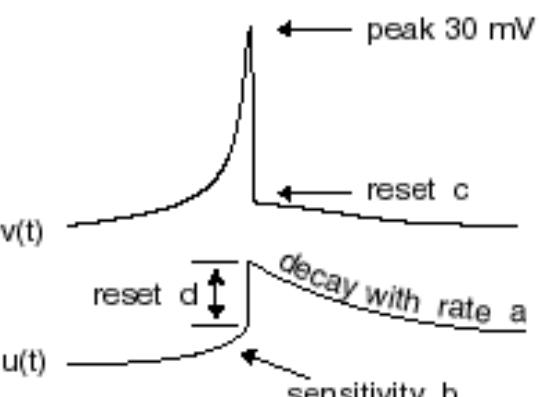
IF\_cond\_exp

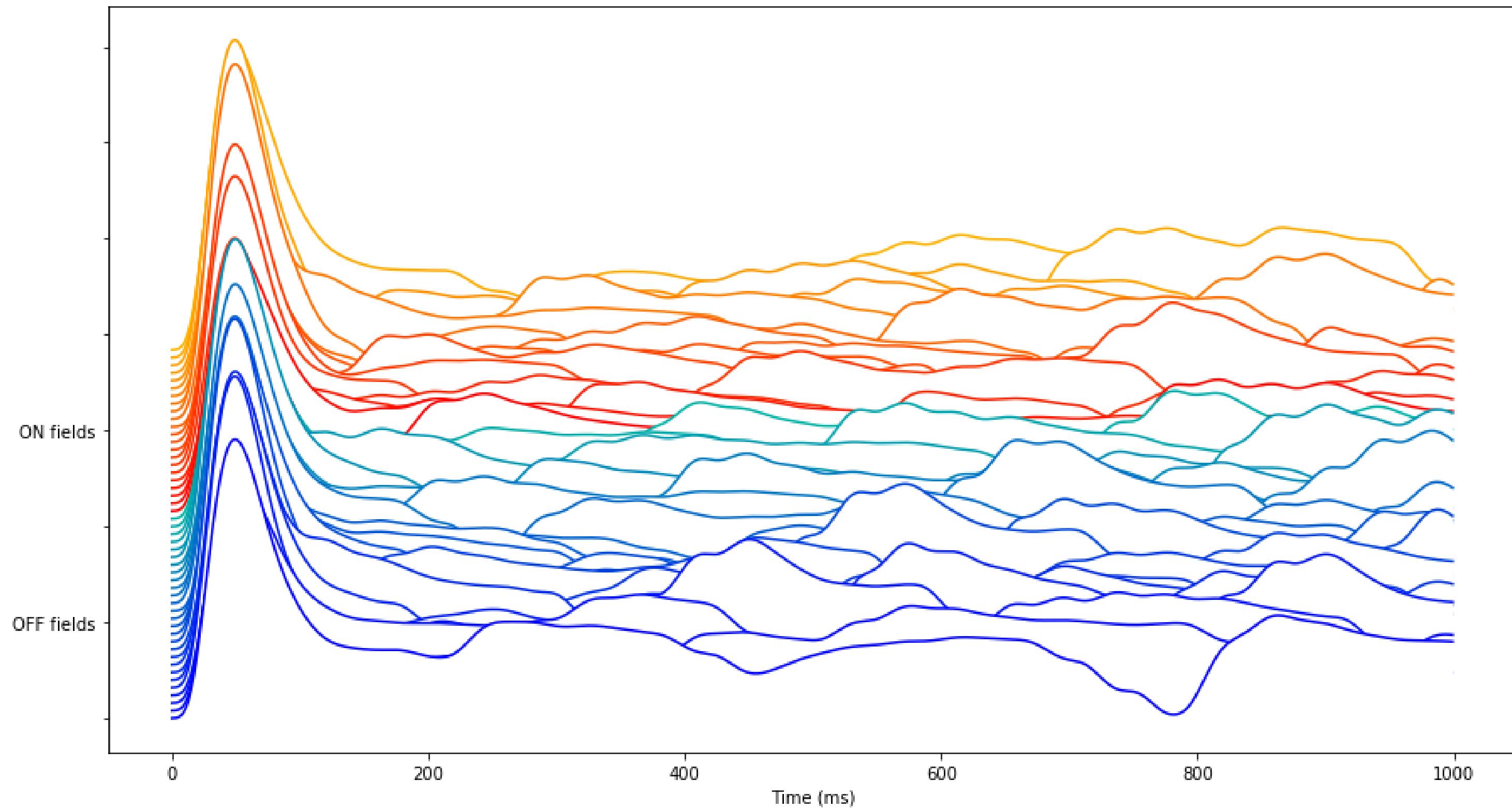


$$v' = 0.04v^2 + 5v + 140 - u + I$$

$$u' = a(bv - u)$$

**if**  $v = 30 \text{ mV}$ ,  
**then**  $v \leftarrow c$ ,  $u \leftarrow u + d$



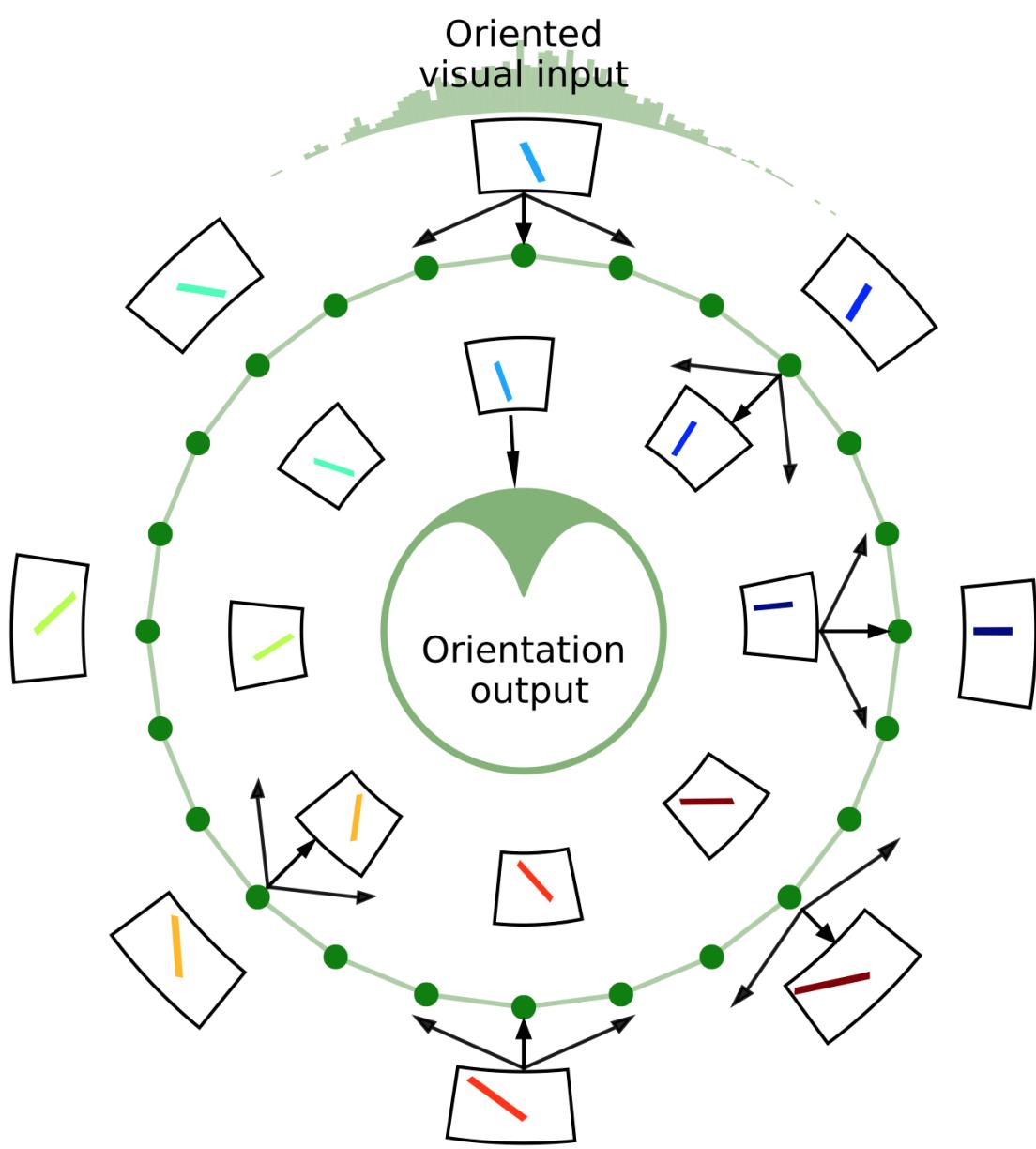


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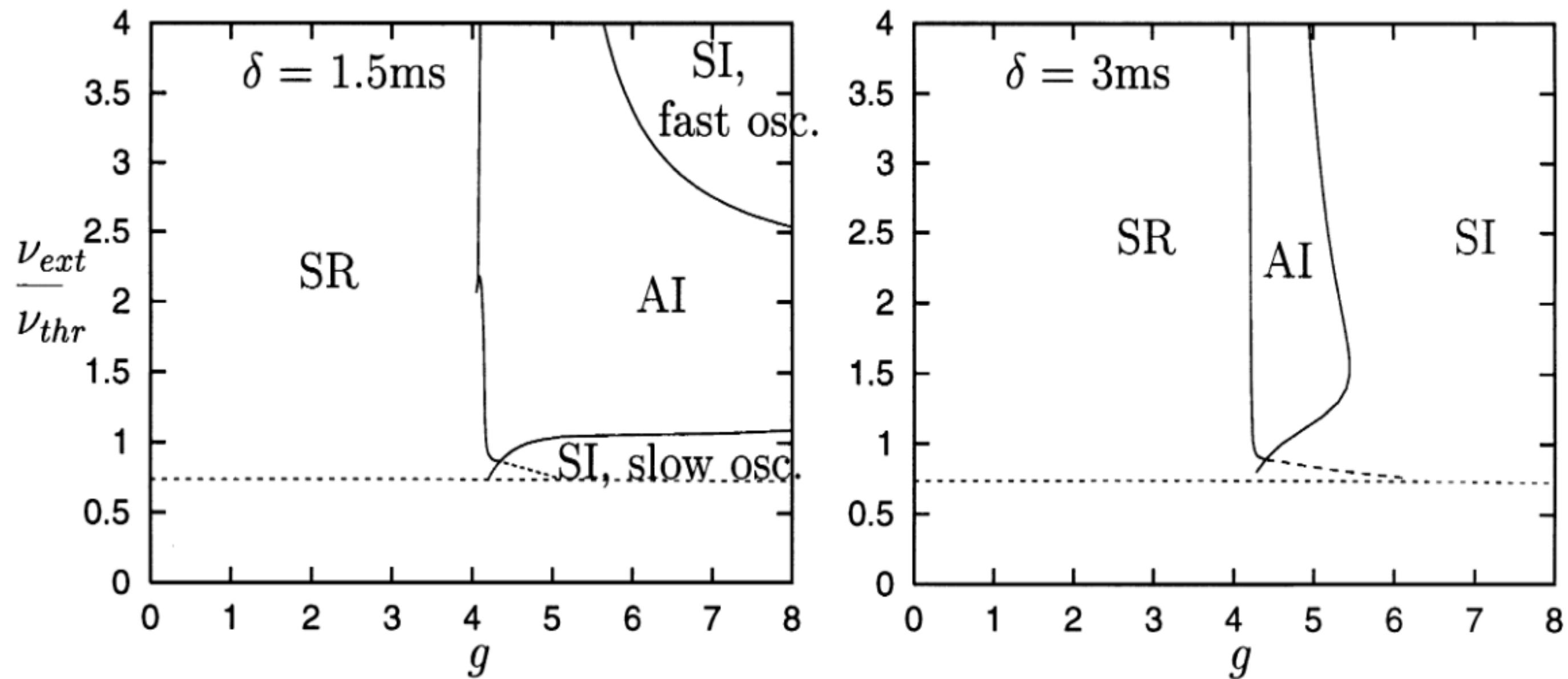


Fig. 1. ‘Phase diagrams’ of the system, for two values of the synaptic time, indicated on the corresponding picture. The remaining parameters are set to  $J = 0.2$  mV;  $C_E = 4000$ ;  $C_I = 1000$ . The asynchronous, stationary state is stable in the region AI, bounded by the Hopf bifurcation curves, indicated by full lines.

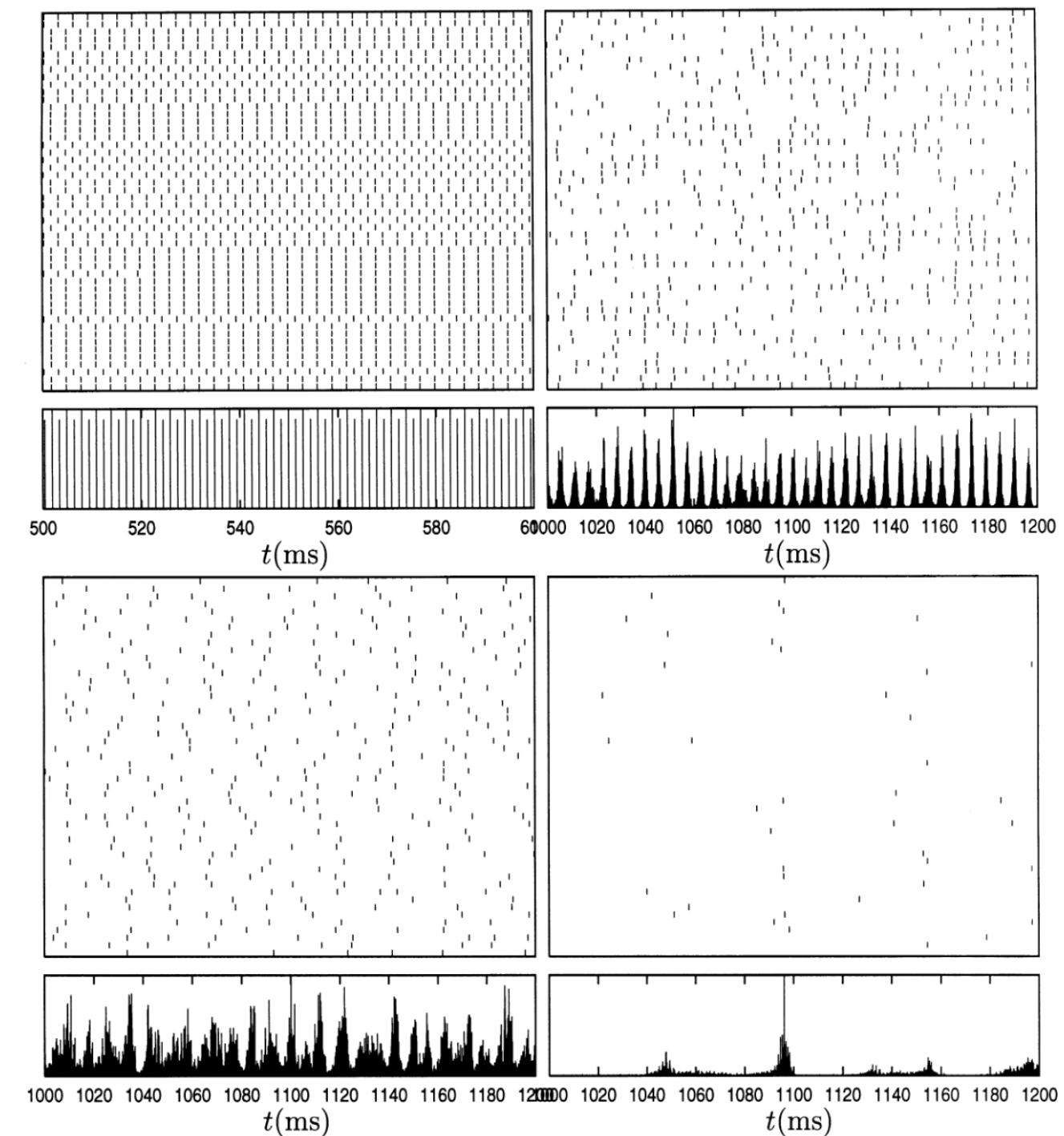


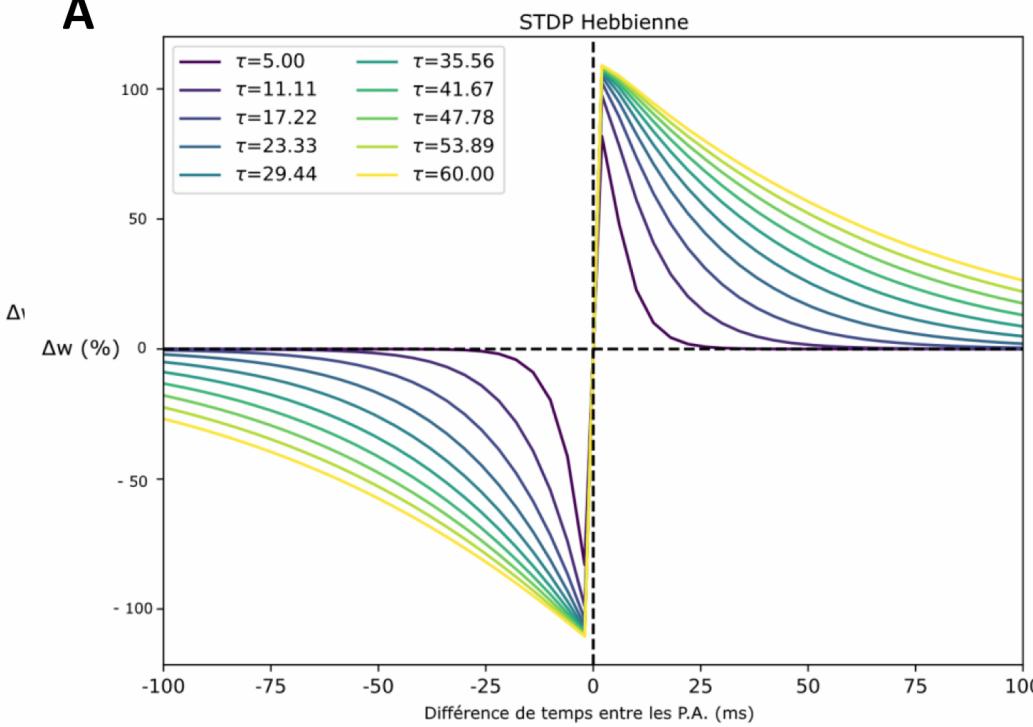
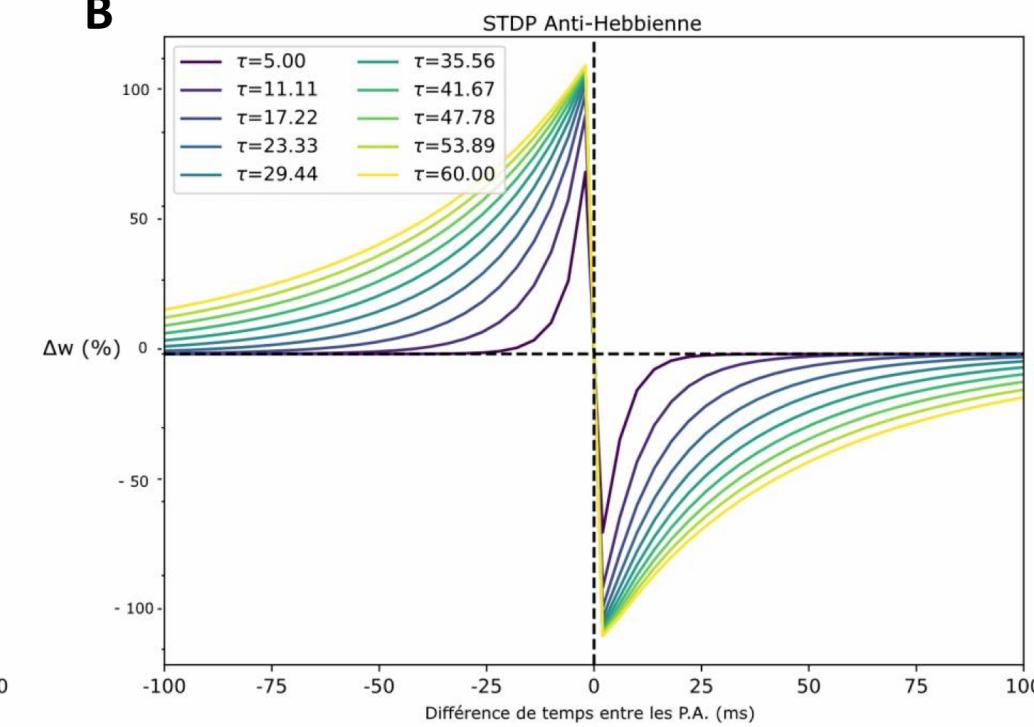
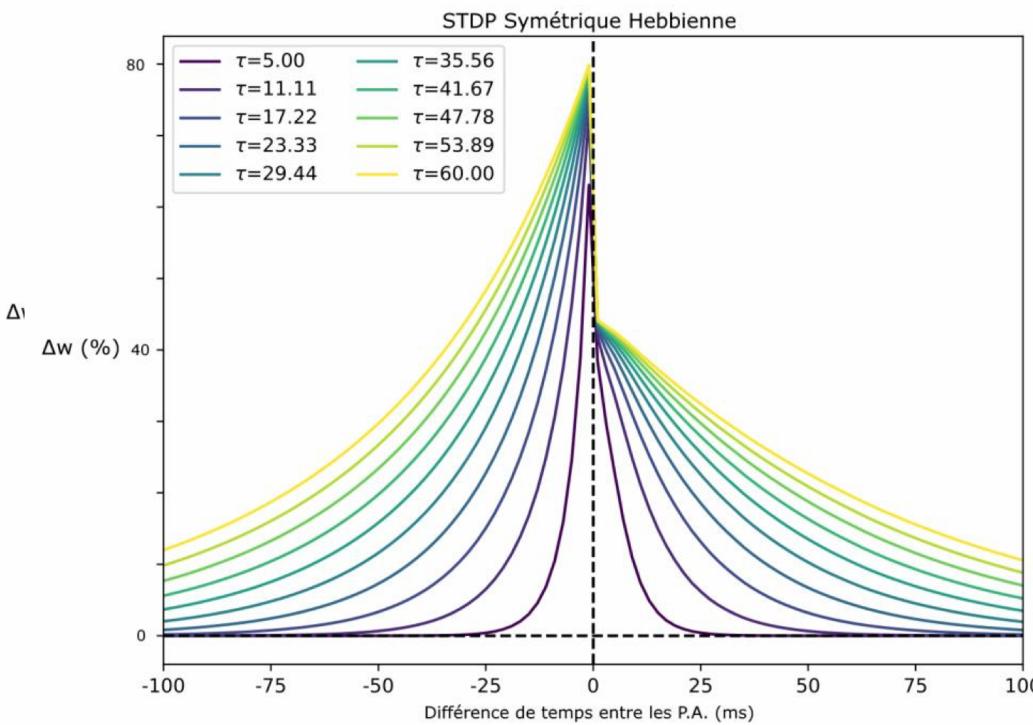
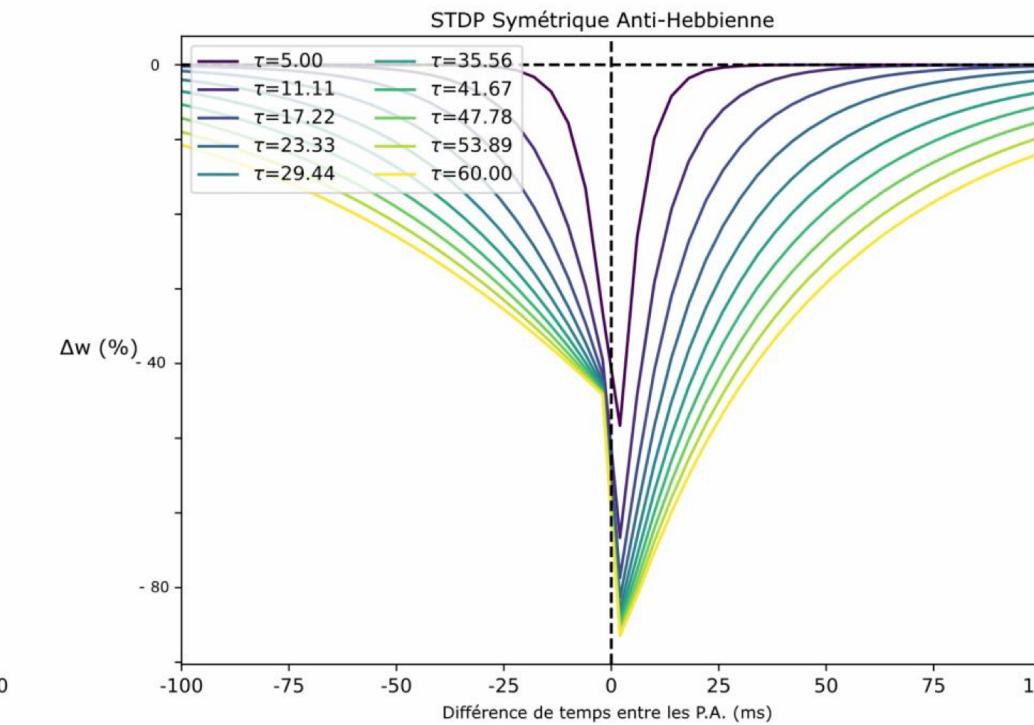
Fig. 2. The dynamics of the network depends on the balance between excitation and inhibition, and on the

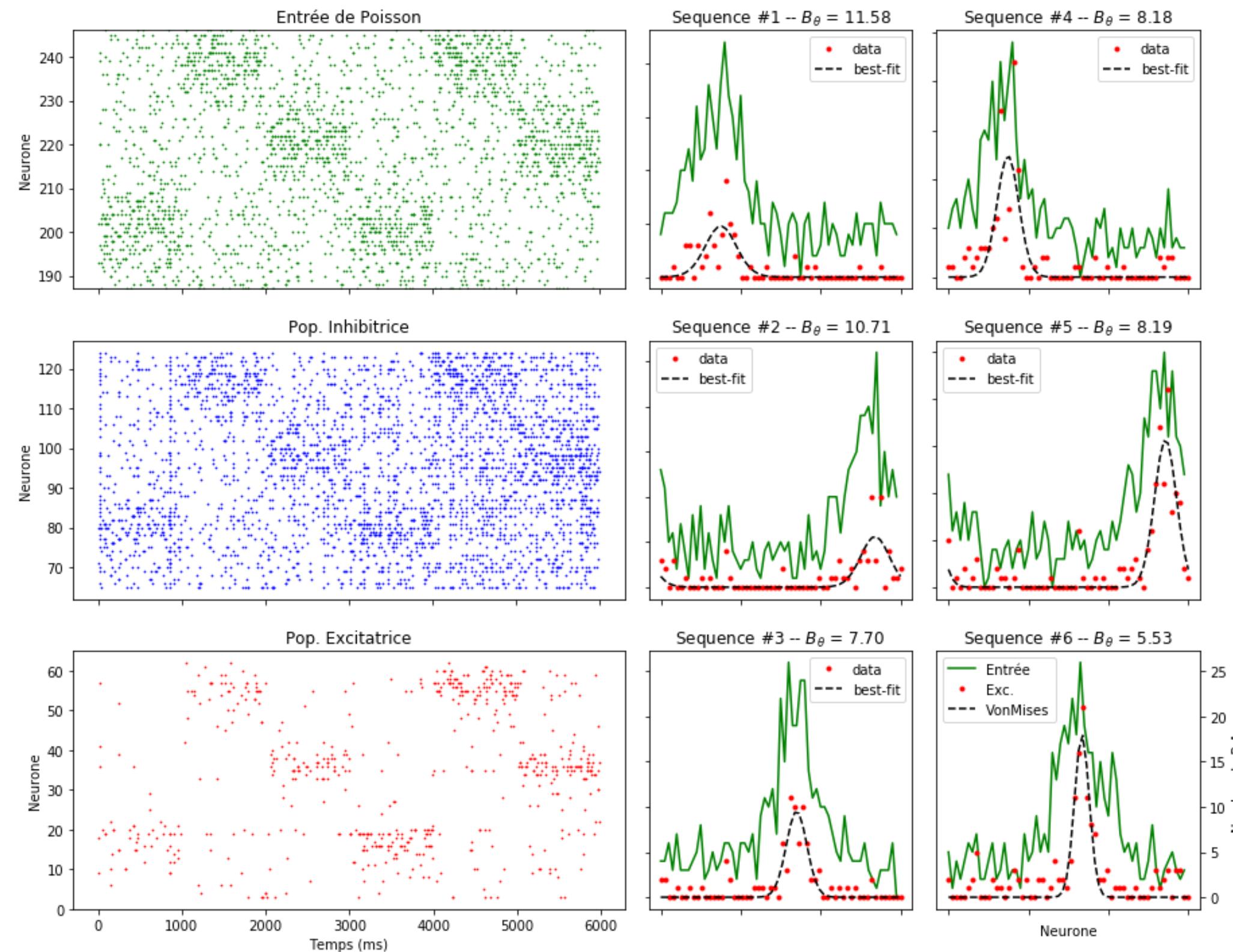
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**A****B****C****D**



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