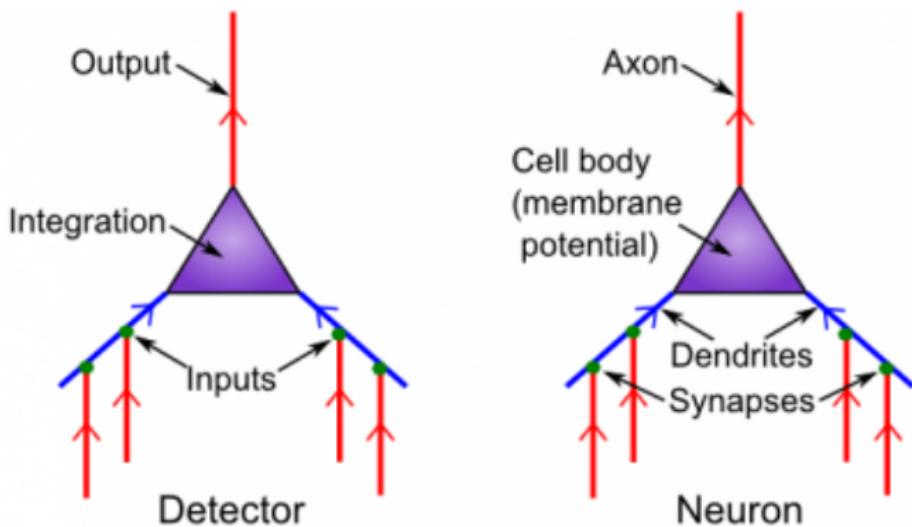


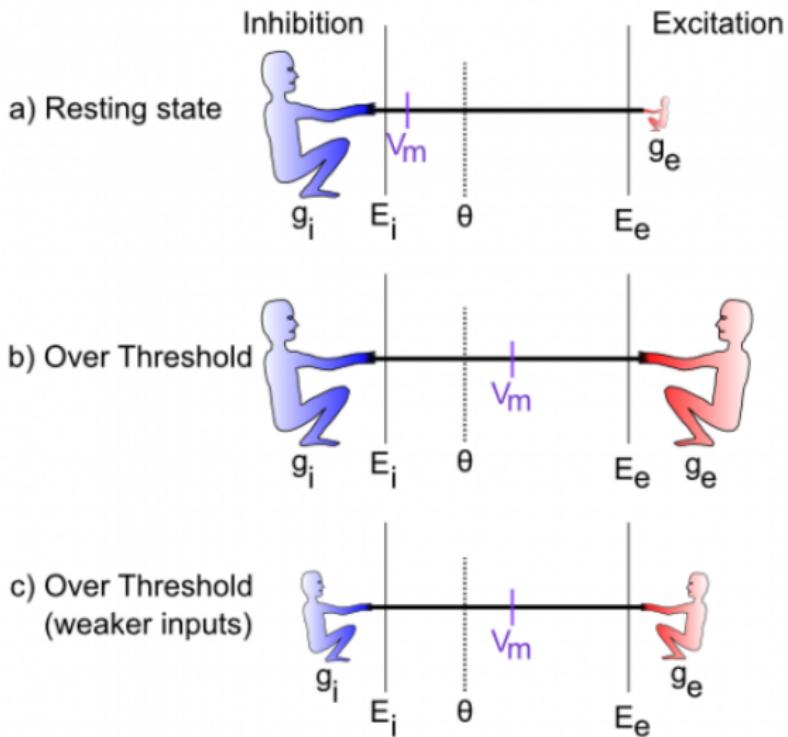
Computational Cognitive Neuroscience: Individual Neuron

Kristína Malinovská

Neuron as detector

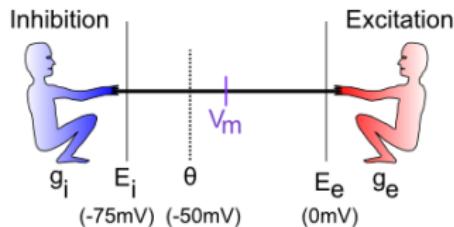


Dynamics of Integration: tug-of-war



Neurons variables

- g_i : inhibitory conductance
- E_i : inhibitory driving potential
- Θ : action potential threshold
- V_m : membrane potential
- E_e : excitatory driving potential
- g_e : excitatory conductance
- E_e : leak driving potential
- g_e : leak conductance
- \bar{g} : maximum conductance



Neural integration

Update of membrane potential due to net current

$$V_m(t) = V_m(t-1) + dt_{vm} [g_e(E_e - V_m) + g_i(E_i - V_m) + g_l(E_l - V_m)]$$

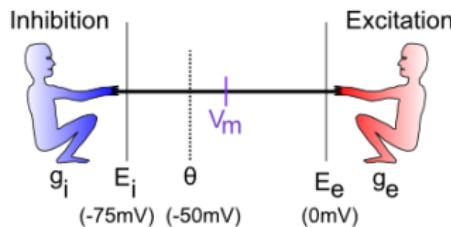
$$I_e = g_e(E_e - V_m)$$

$$I_i = g_i(E_i - V_m)$$

$$I_l = g_l(E_l - V_m)$$

$$I_{net} = I_e + I_i + I_l$$

$$V_m(t) = V_m(t-1) + dt_{vm} I_{net}$$



Equilibrium Membrane Potential

$$g_e(t) = \frac{1}{n} \sum_i x_i w_i$$

- x_i = input to the neuron
- w_i = weight of the neuron
- a weight defines how much unit listens to given input
- weights determine what the neuron detects = everything is encoded in weights

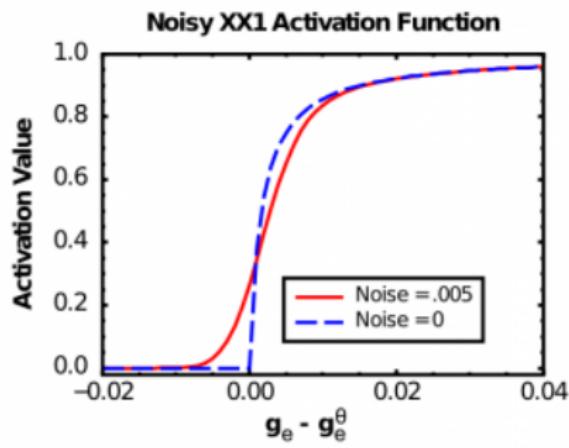
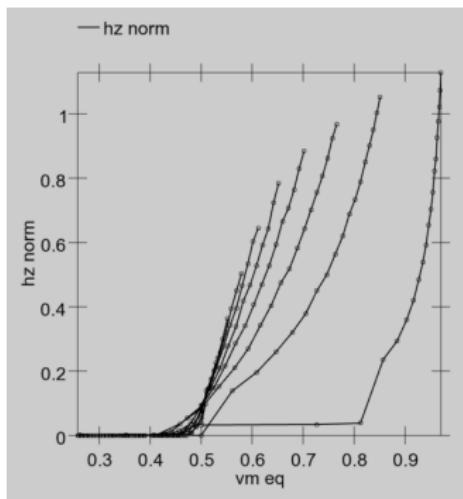
$$V_m = \frac{\bar{g}_e g_e(t)}{\bar{g}_e g_e(t) + \bar{g}_i g_i(t) + \bar{g}_I} E_e + \frac{\bar{g}_i g_i(t)}{\bar{g}_e g_e(t) + \bar{g}_i g_i(t) + \bar{g}_I} E_i + \frac{\bar{g}_I}{\bar{g}_e g_e(t) + \bar{g}_i g_i(t) + \bar{g}_I} E_I$$

Generating Output

- If V_m gets over threshold, neuron fires a spike.
- Spike resets membrane potential back to rest.
- V_m has to climb back up to threshold to spike again
- Discrete spiking:
if ($V_m > \Theta$) then: $y = 1$; $V_m = V_{m_r}$; else $y = 0$

Rate Code Approximation to Spiking

- spikes to rates (how many spikes per time unit)
- instantaneous and steady – smaller, faster models
- definitely lose several important things
- to find an equation* that makes good approximation of actual spiking rate for same sets of inputs
- (Noisy) X-over-X-plus-1 (XX1) function



The end

Thank you for your attention

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