

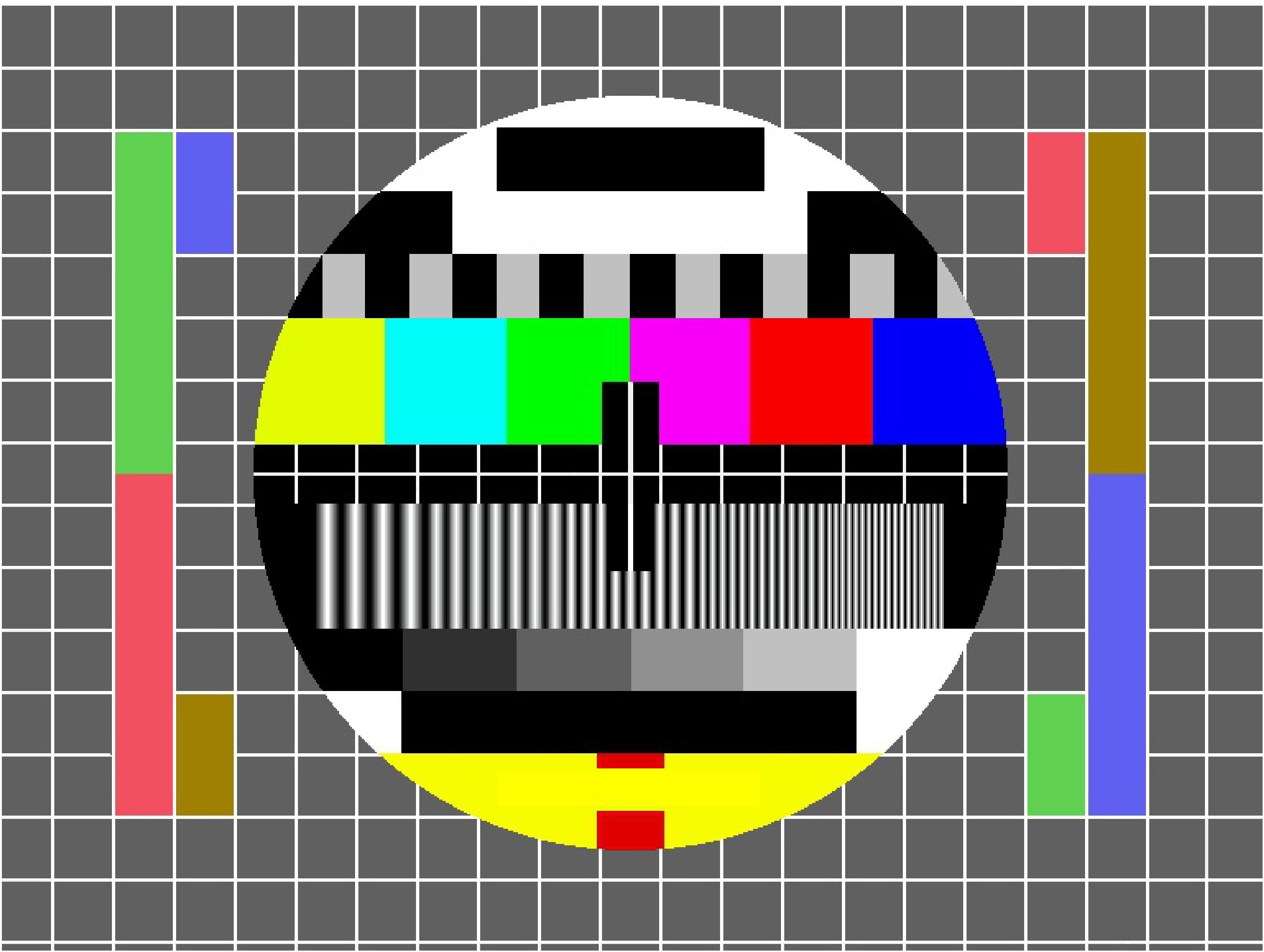
From the retina to action: Understanding visual processing

Laurent Perrinet



Licence Sciences & Humanité, 3/4/2019

This work was supported by ANR project "Horizontal-V1" N° ANR-17-CE37-0006".





<https://laurentperrinet.github.io/talk/2019-04-03-a-course-on-vision-and-modelization>

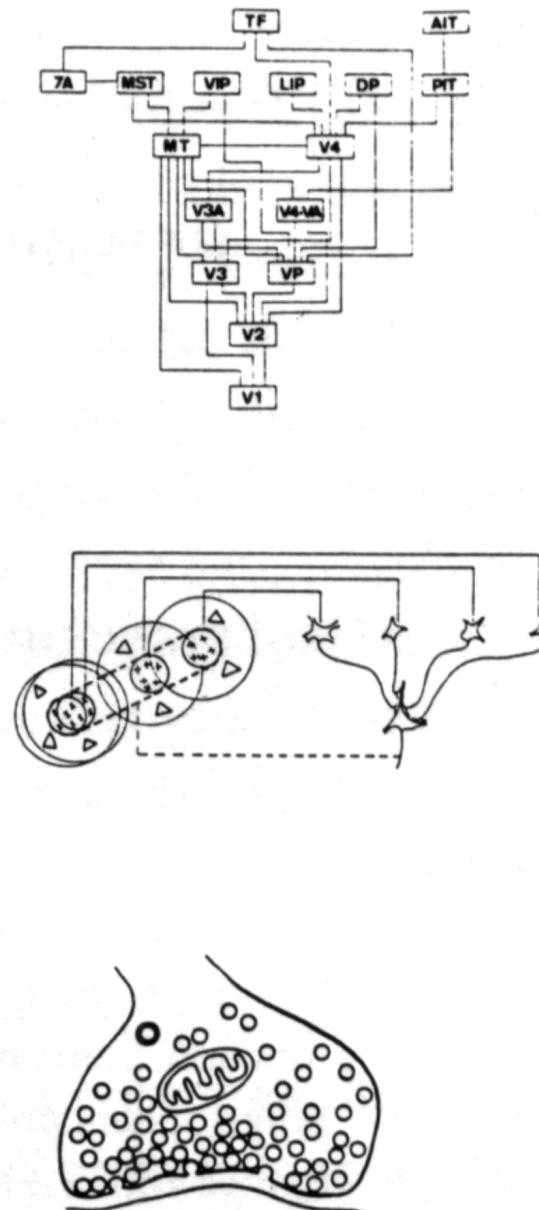
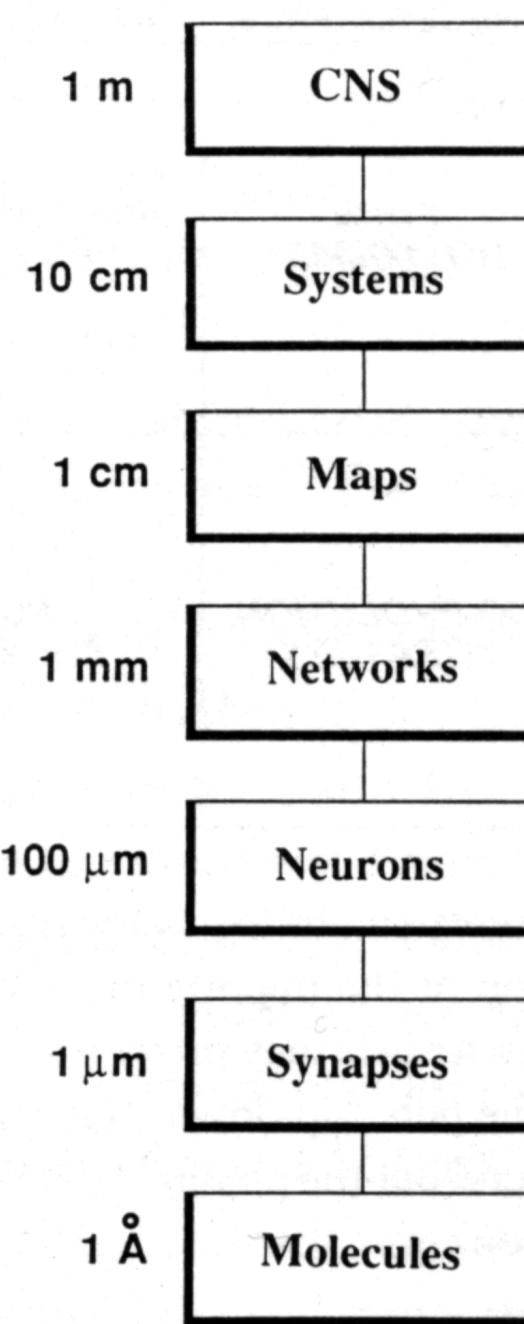
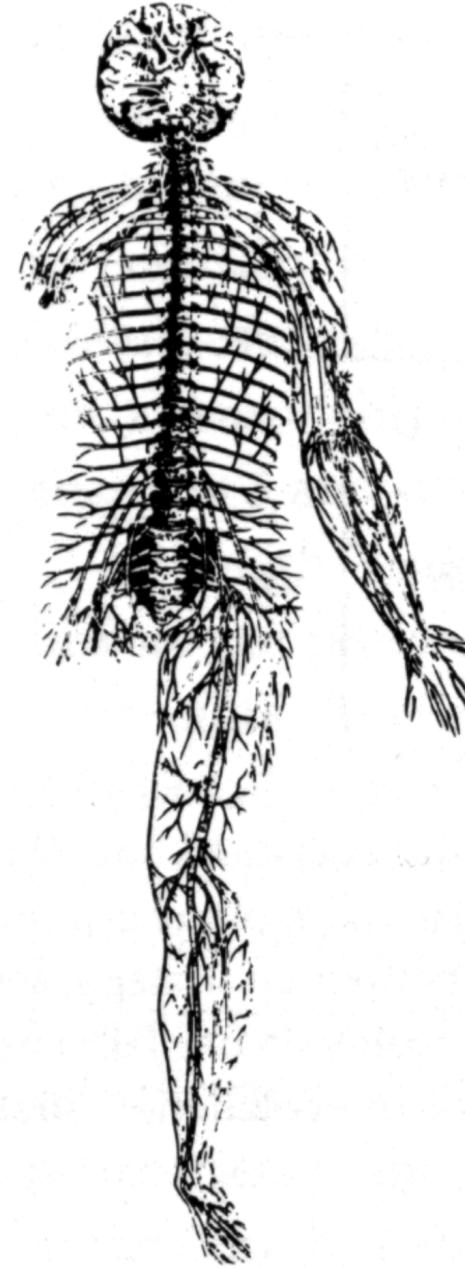
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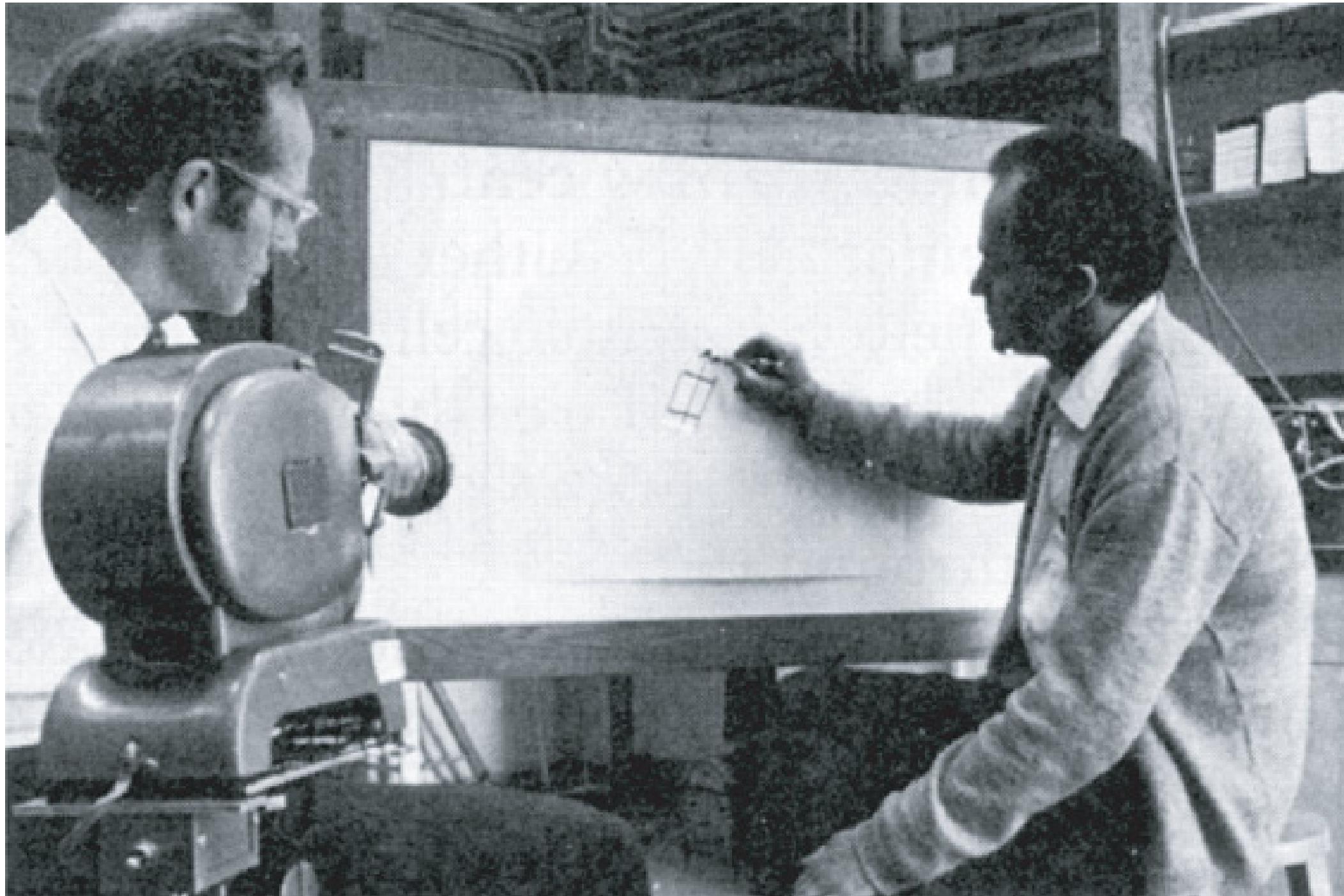
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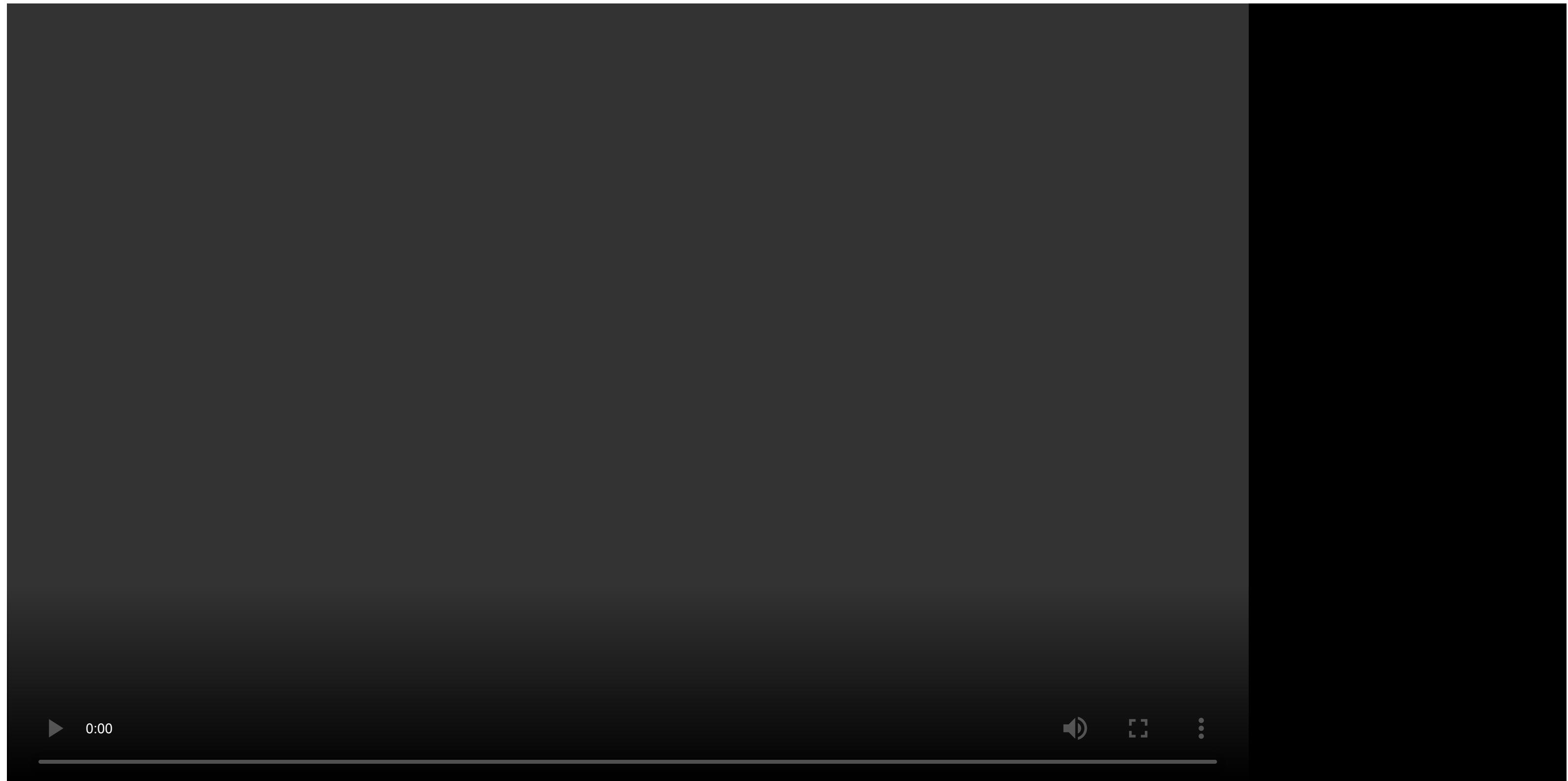


Churchland, P. S. & Sejnowski, T. J. (1992) *The computational brain*. Cambridge, MA: MIT Press.

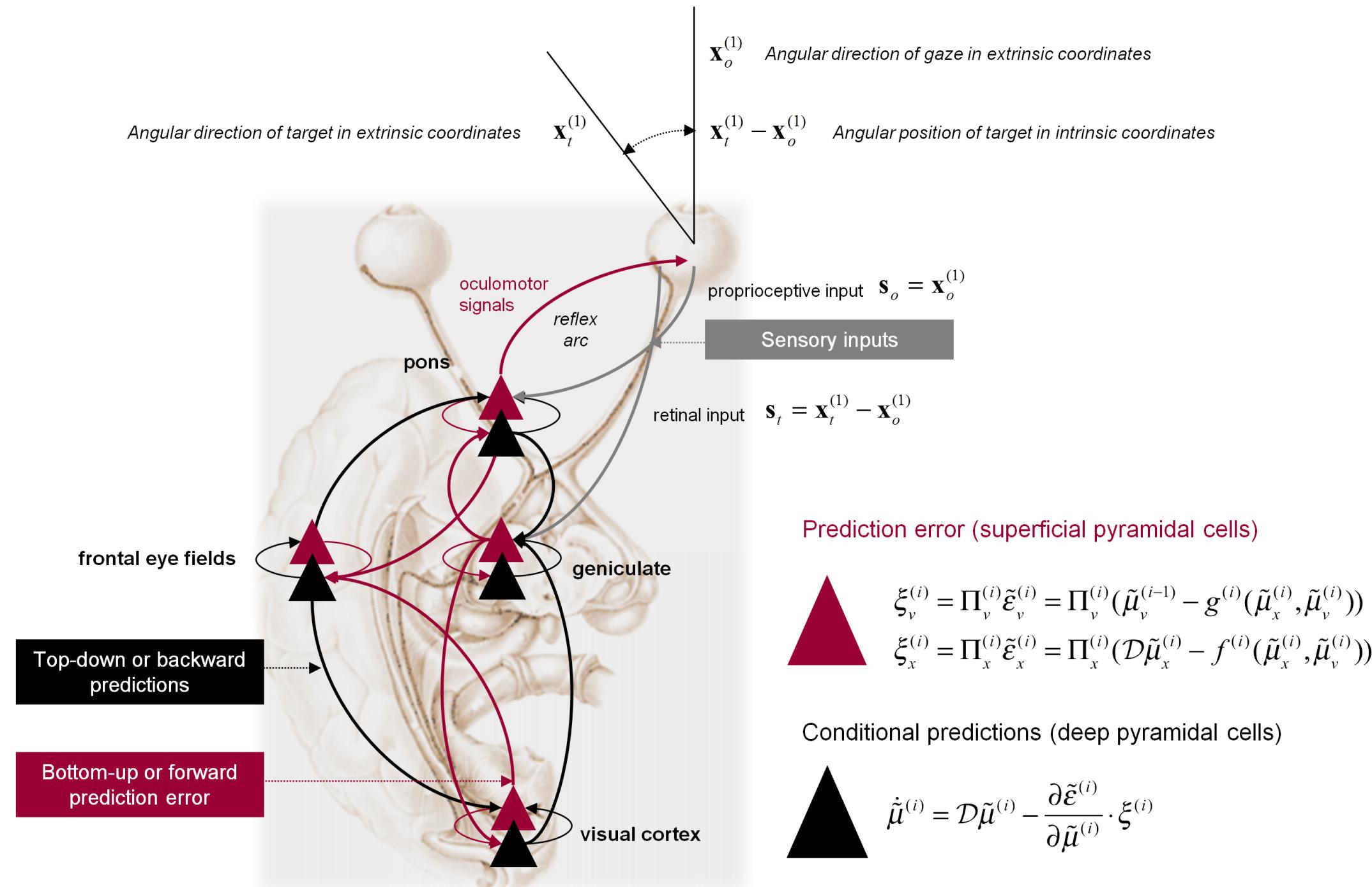
From the retina to action: Levels of modeling



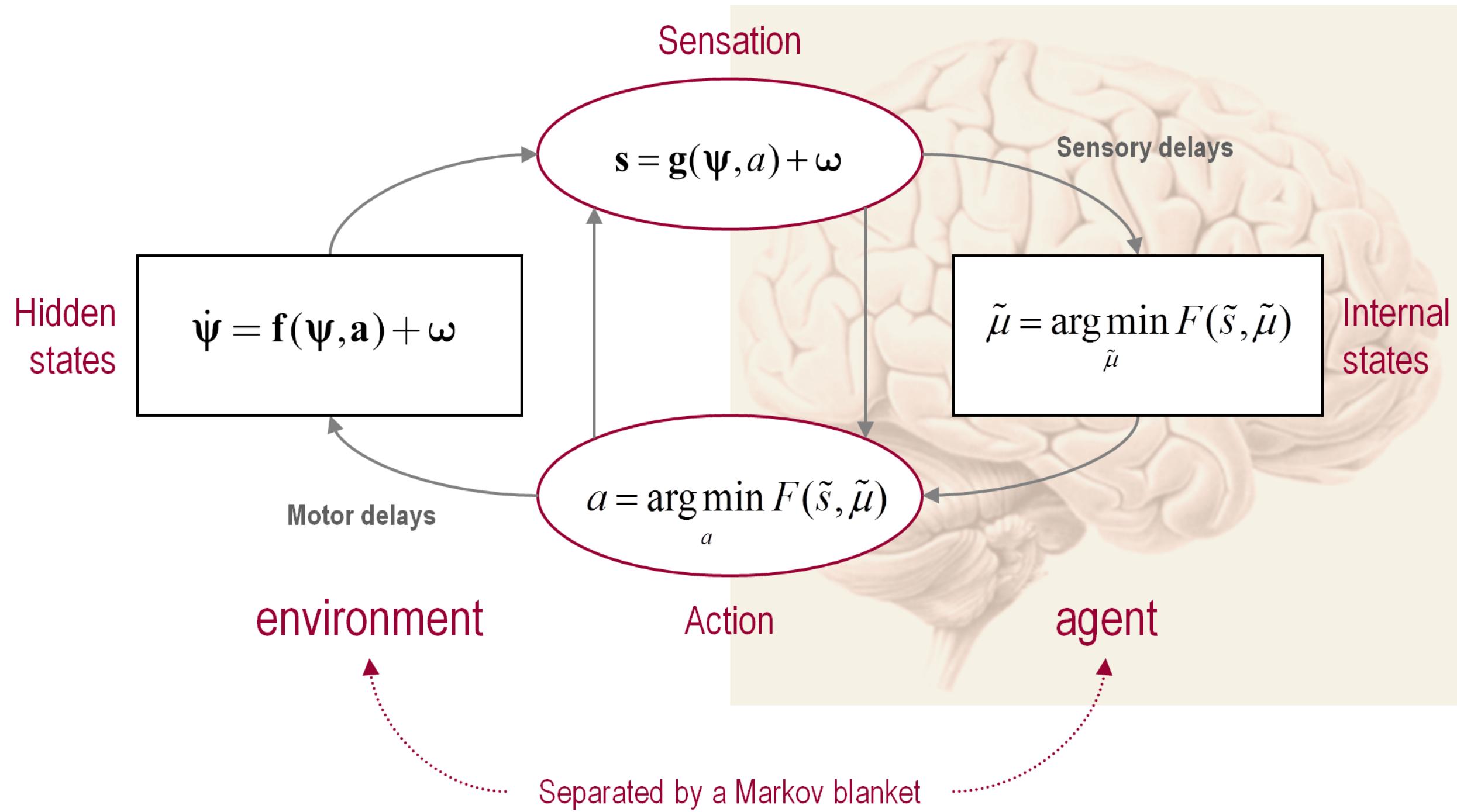
(see this [viperlib](#) page)



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LP, Adams and Friston (2015) *Biological Cybernetics*



LP, Adams and Friston (2015) *Biological Cybernetics*

Outline

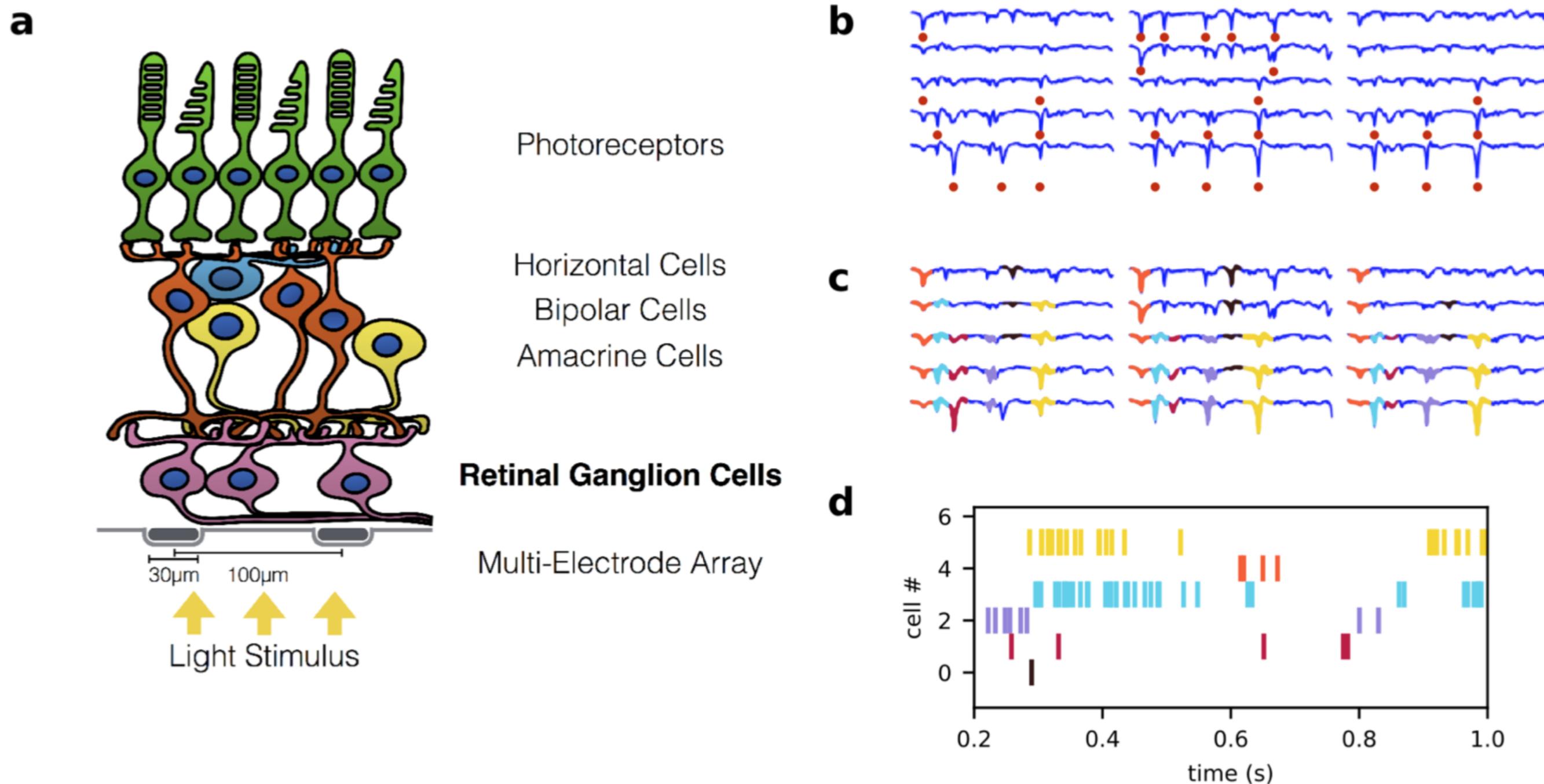
1. From the retina to action: Levels of modeling
2. Sparse coding in Neurophysiology and neural processing
3. Modeling Spiking Neural Networks
4. A model of Sparse Deep Predictive Coding

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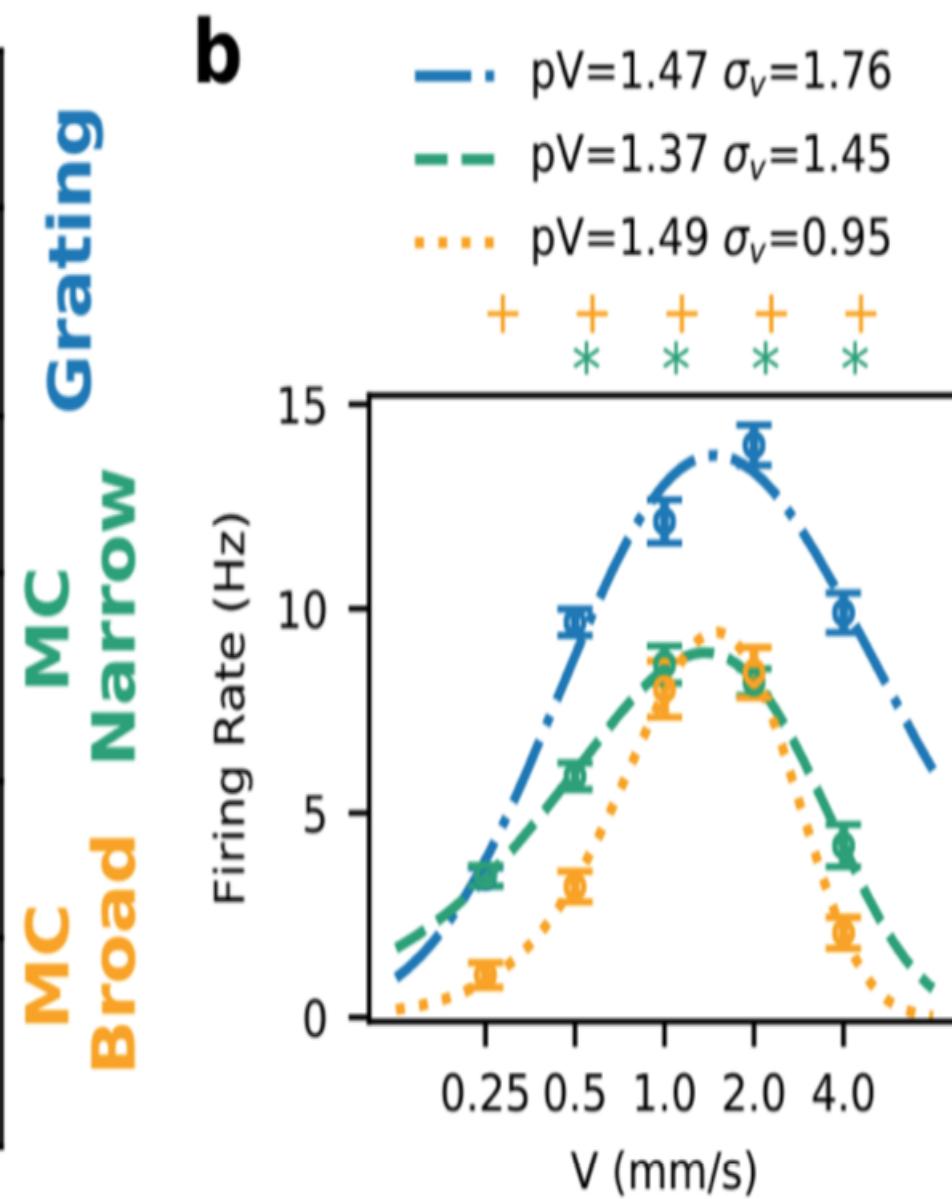
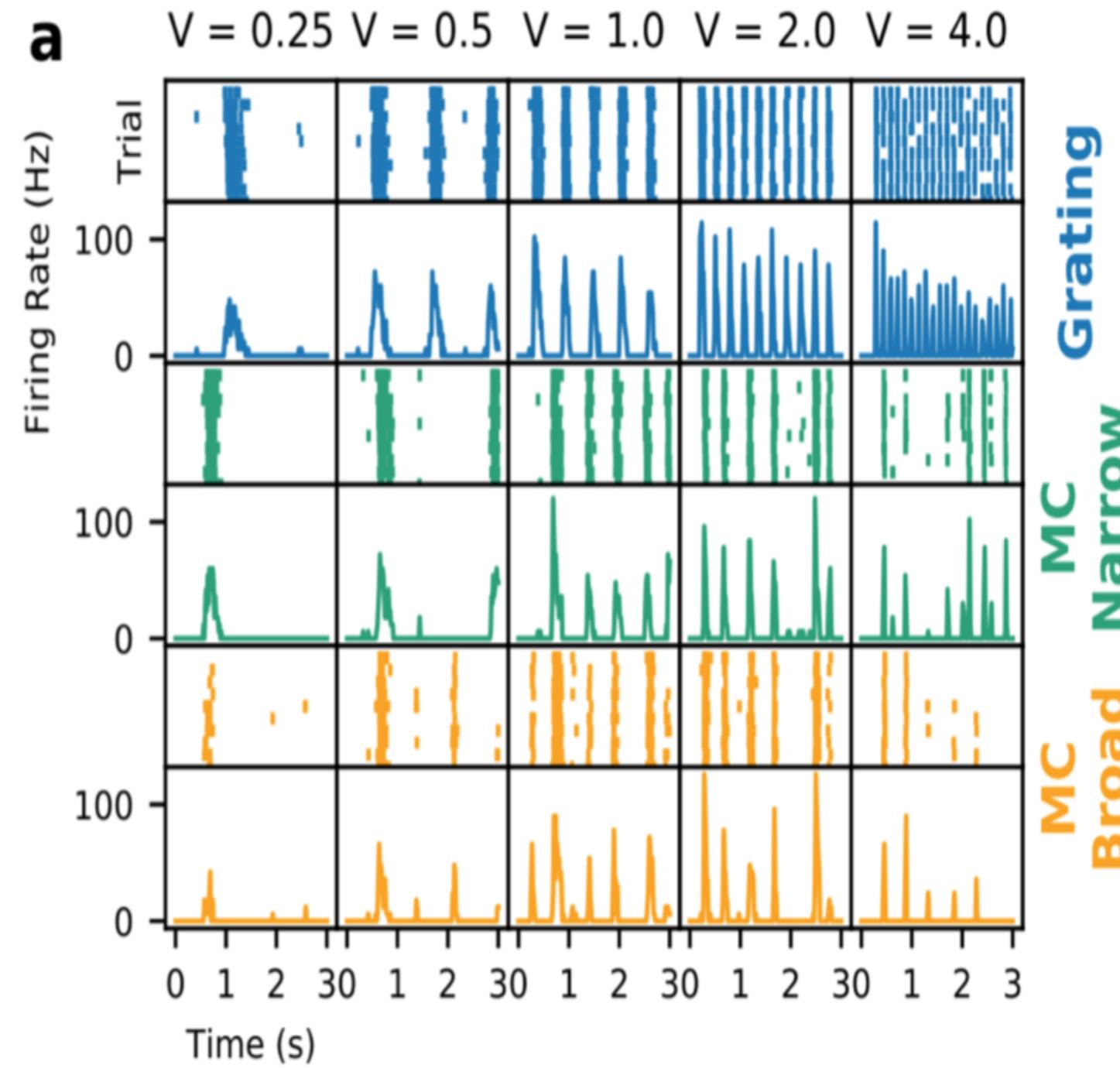
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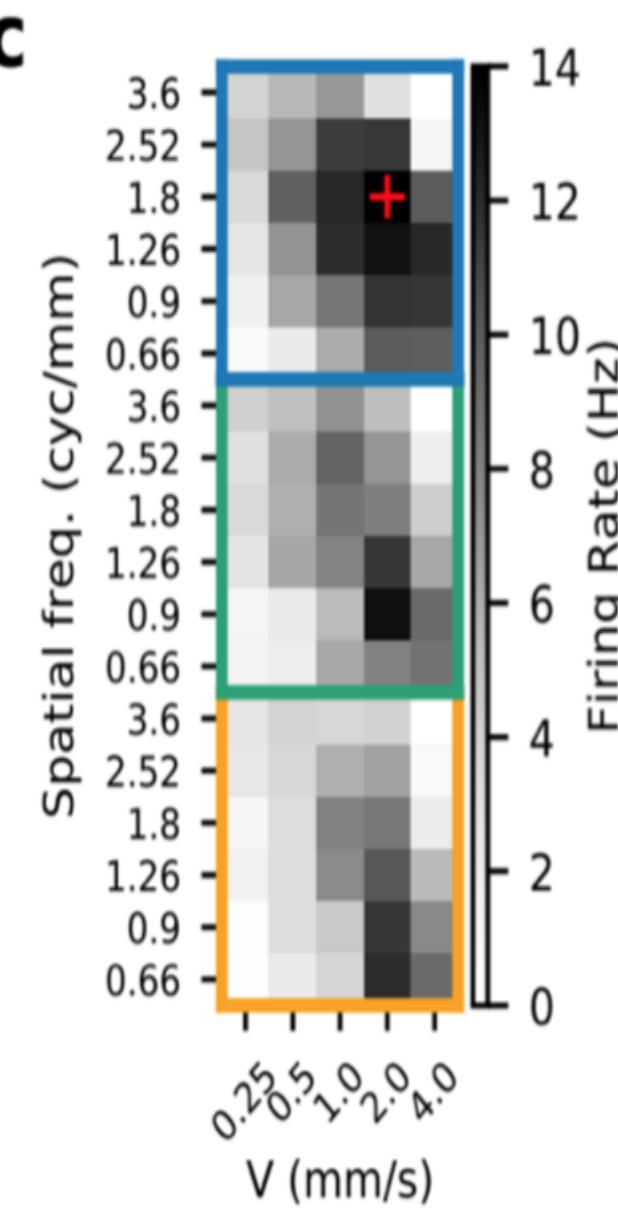
LP (2015) "Sparse models" in *Biologically Inspired Computer Vision*



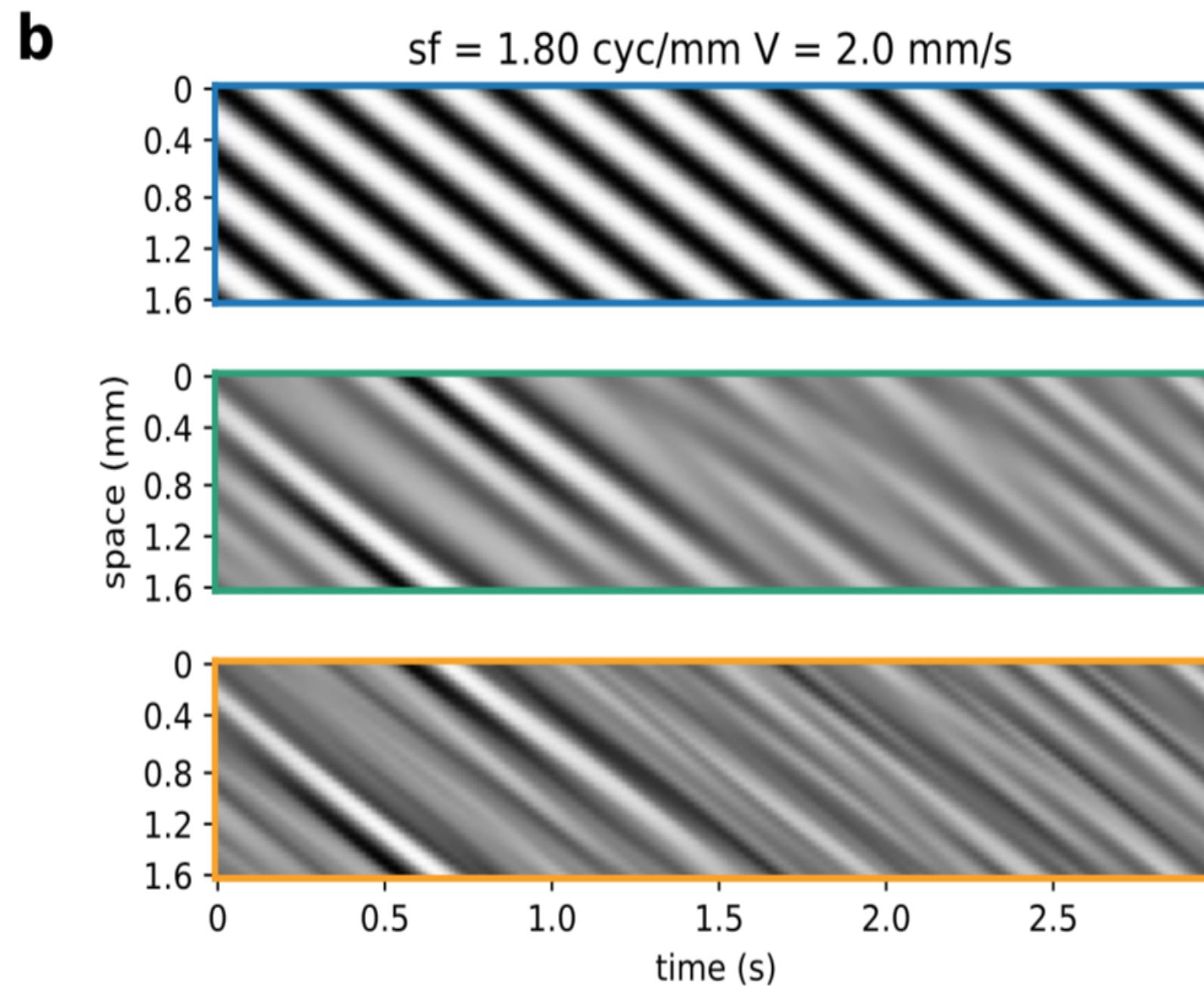
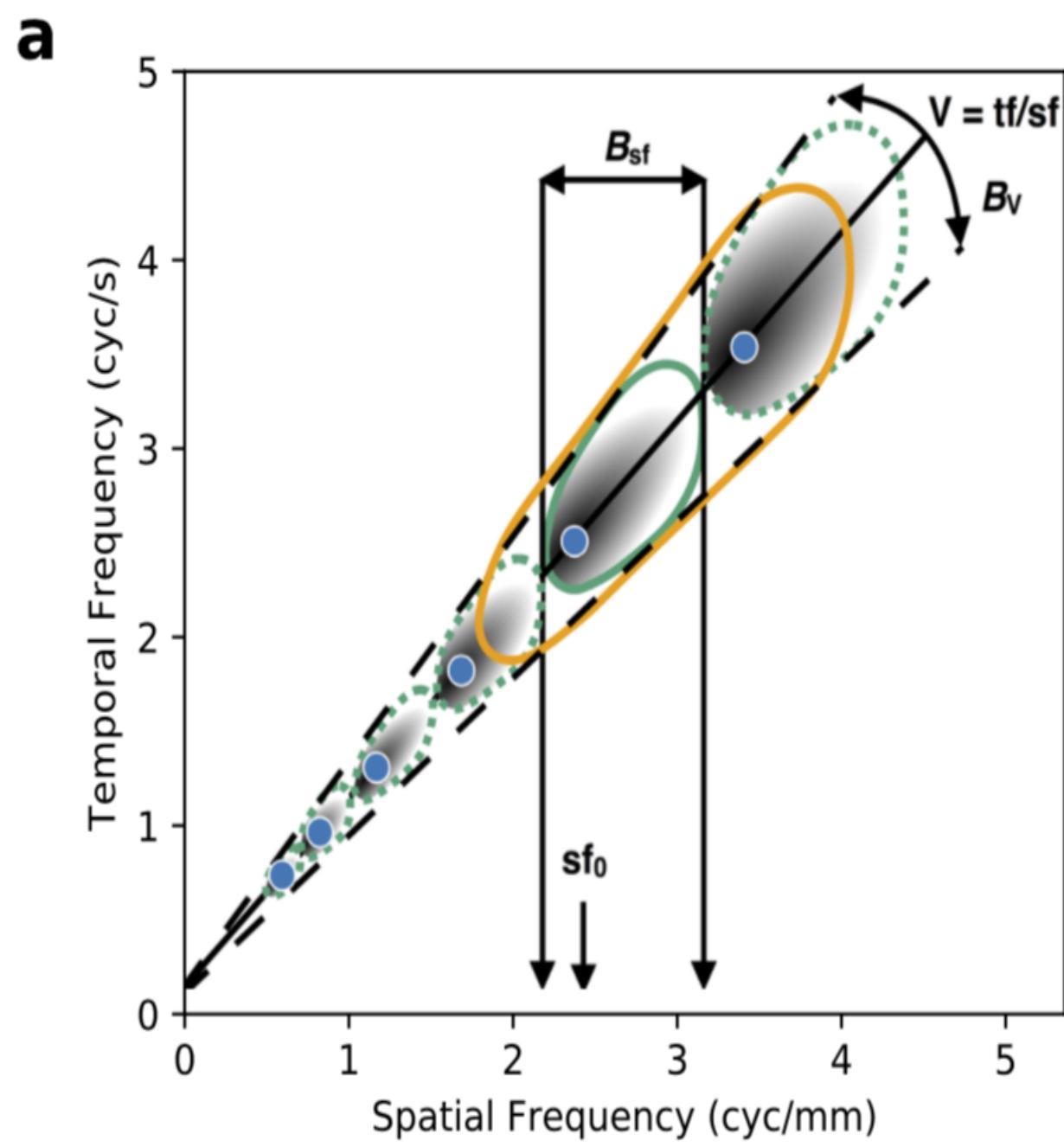
Ravello, LP, Escobar, Palacios (2019) *Scientific Reports*



MC
Narrow
**MC
Broad**

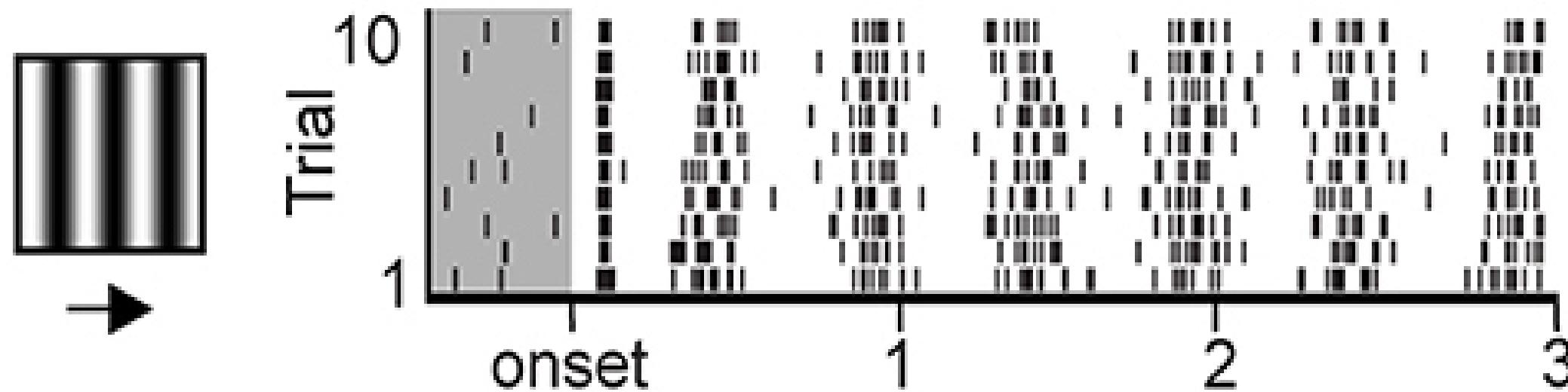


Ravello, LP, Escobar, Palacios (2019) *Scientific Reports*

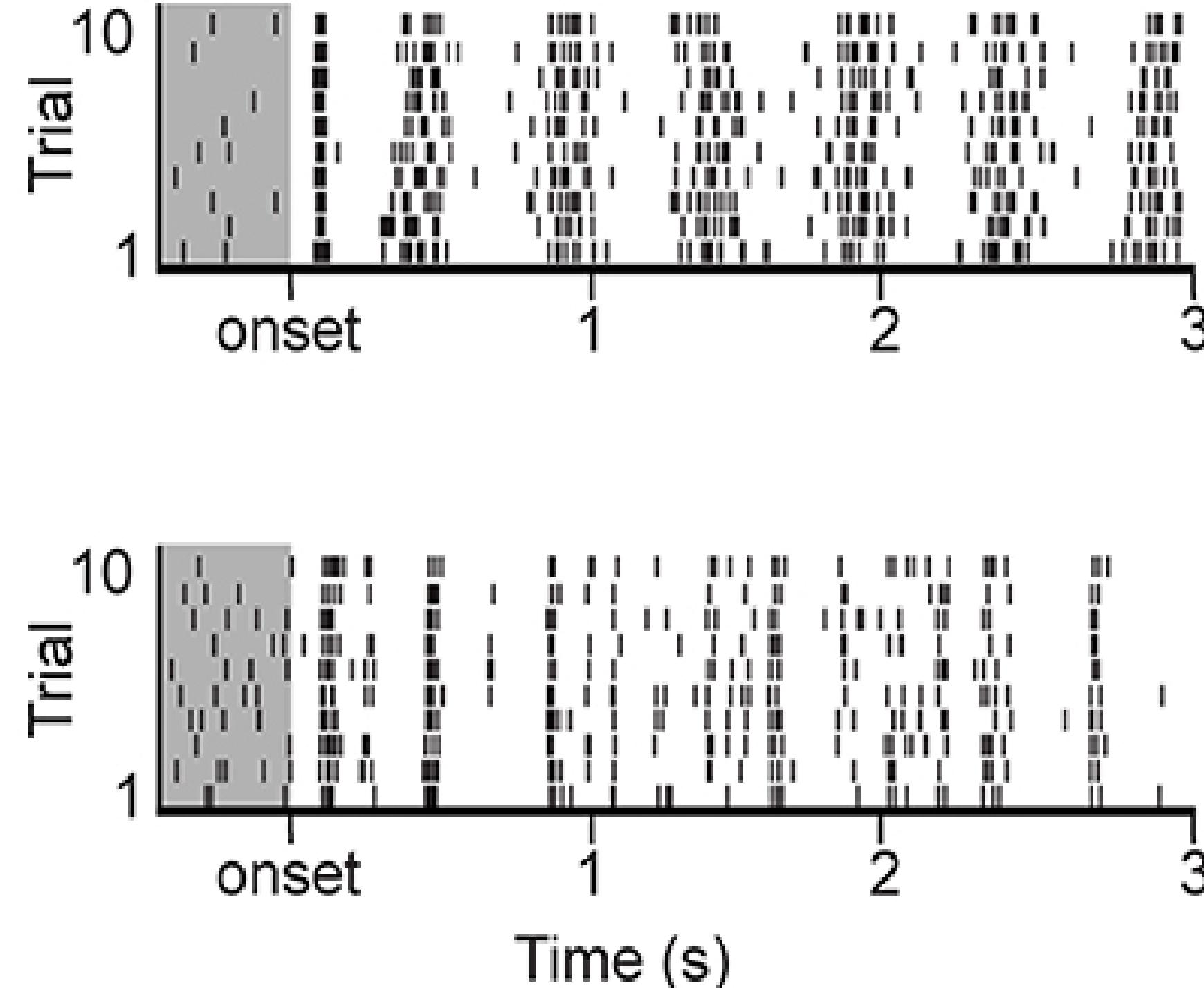
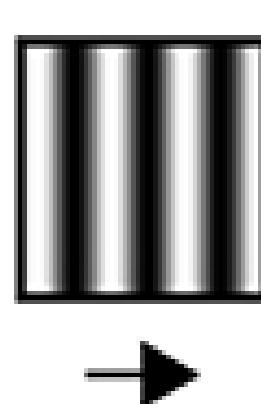
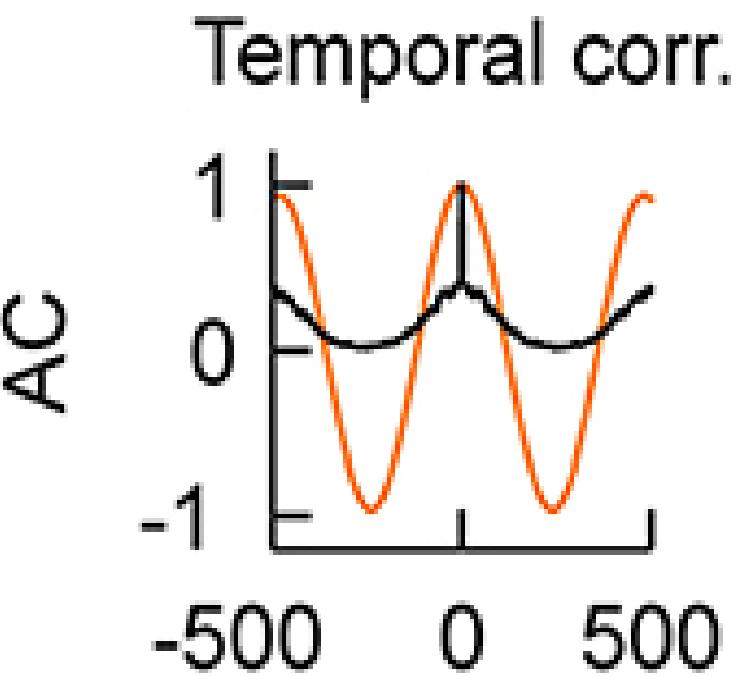


Ravello, LP, Escobar, Palacios (2019) *Scientific Reports*

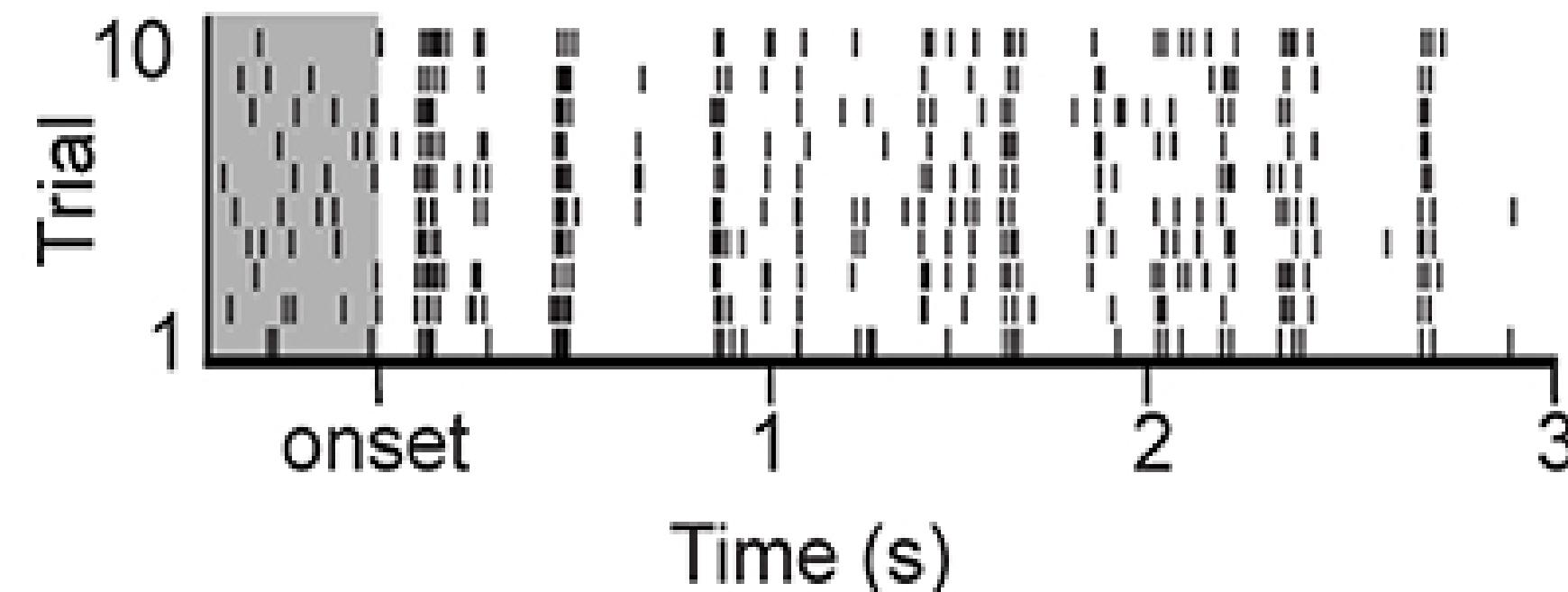
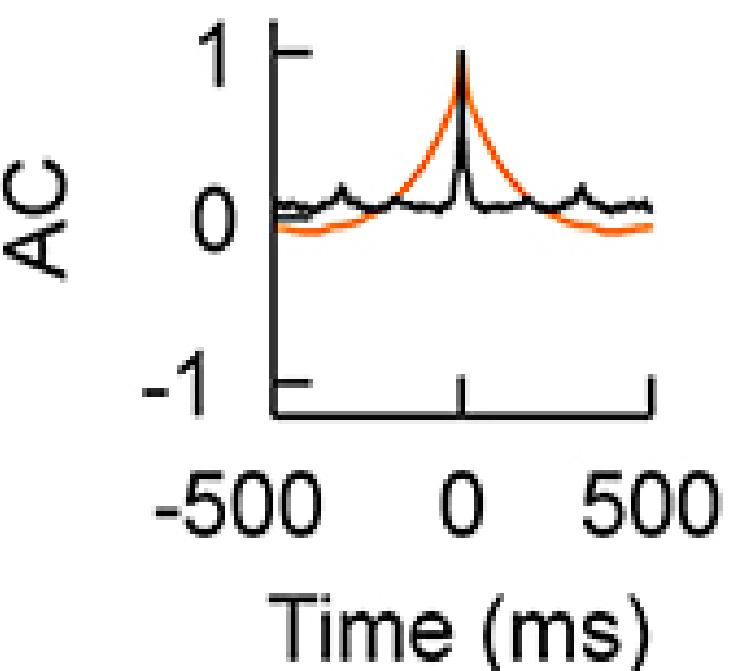
A



Kremkow, LP, Monier, Alonso, Aertsen, Fregnac, Masson (2016) *Push-pull receptive field organization and synaptic depression: Mechanisms for reliably encoding naturalistic stimuli in V1*

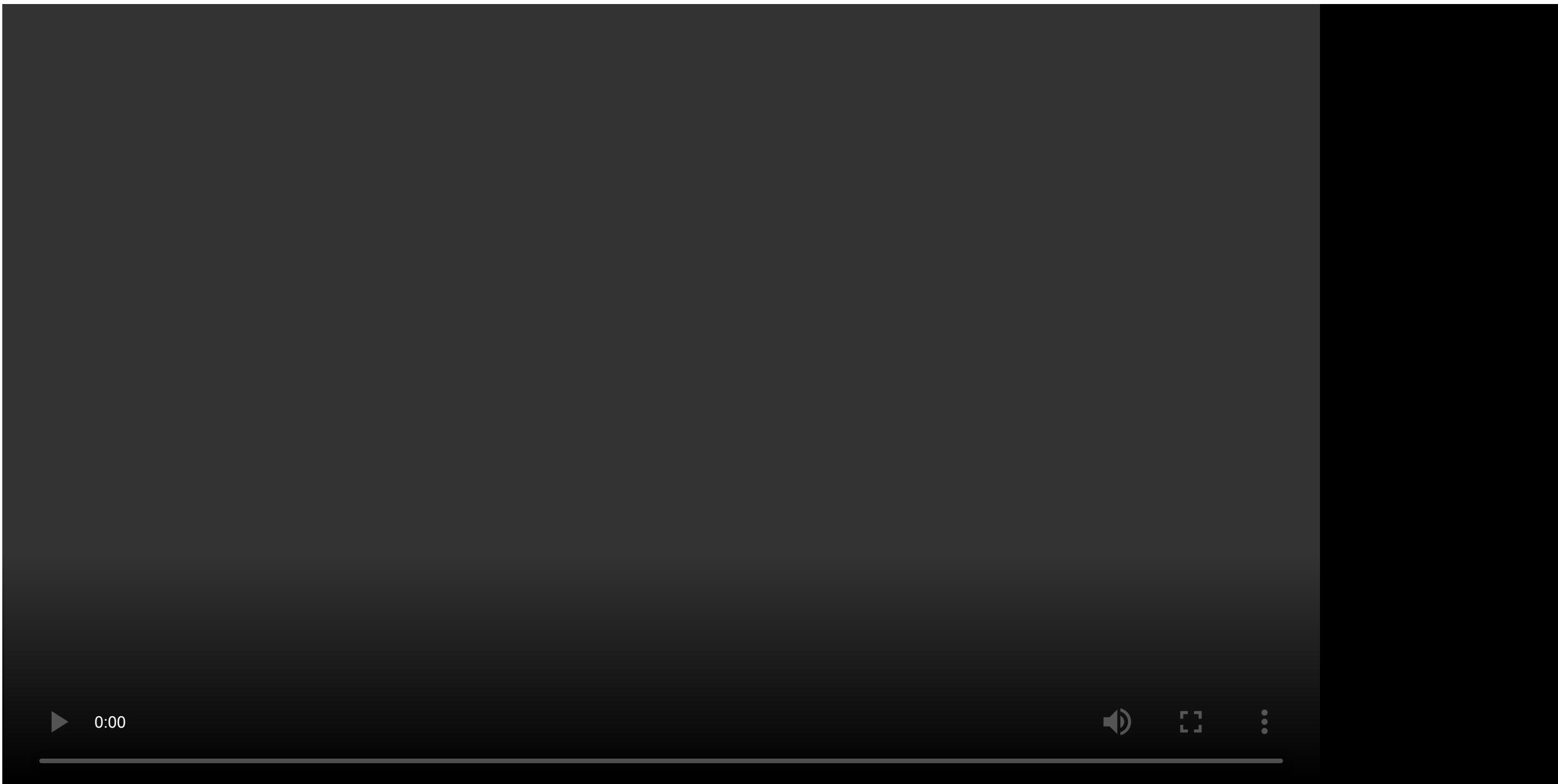
A**B**

Temporal corr.
— Stimulus
— Spikes

C**D**

Time (ms)

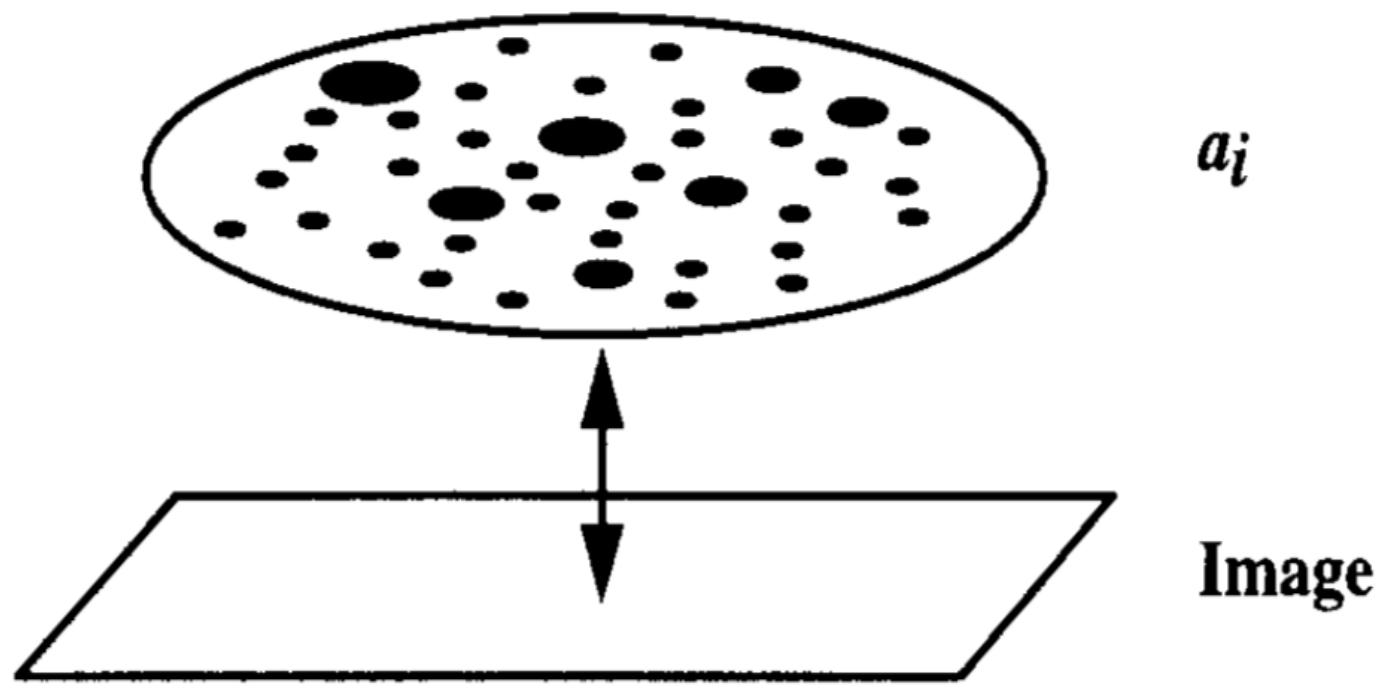
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LP (2015) "*Sparse models*" in *Biologically Inspired Computer Vision*

a.

Sparse representation



b.

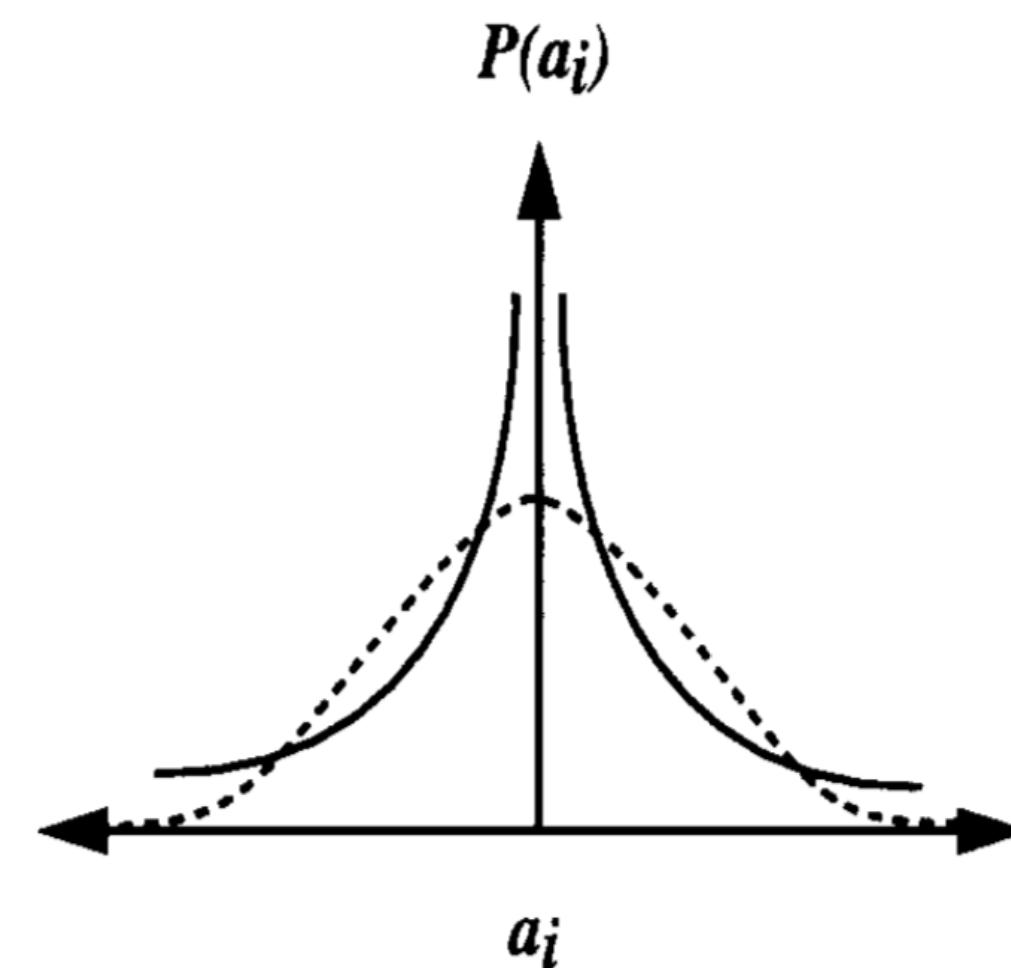
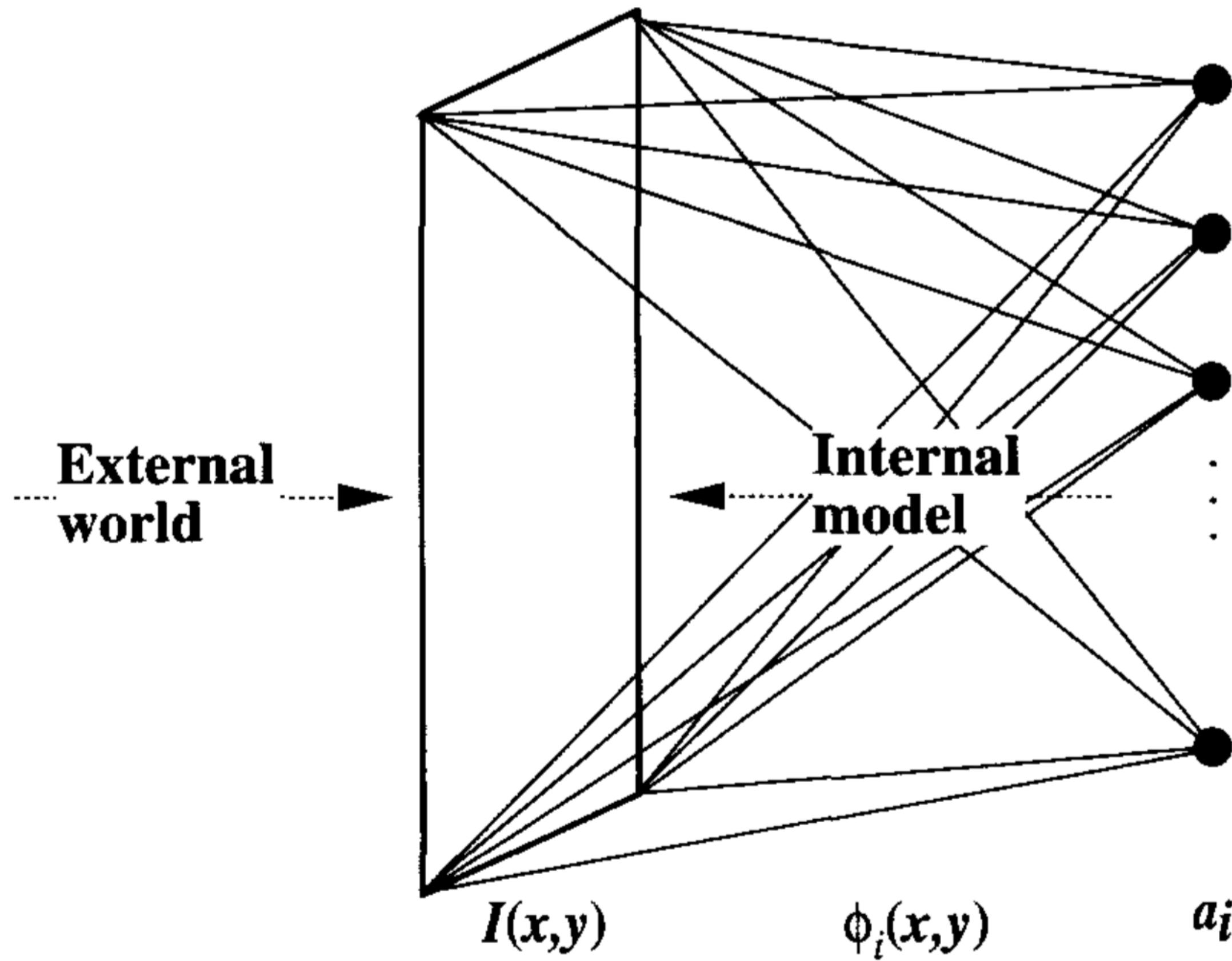
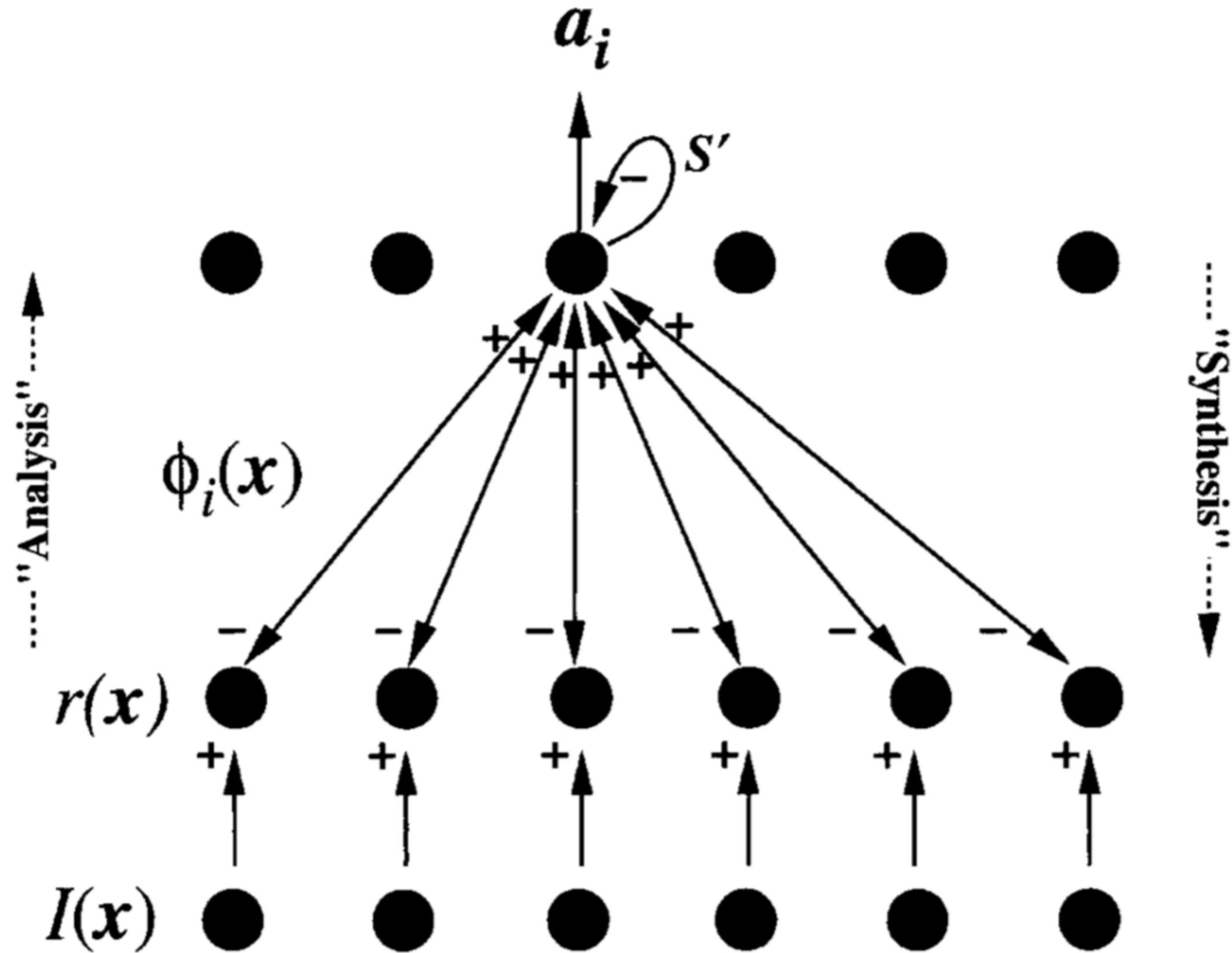


FIGURE 1. Sparse coding. (a) An image is represented by a small number of “active” code elements, a_i , out of a large set. Which elements are active varies from one image to the next. (b) Since a given element in a sparse code will most of the time be inactive, the probability distribution of its activity will be highly peaked around zero with heavy tails. This is in contrast to a code where the probability distribution of activity is spread more evenly among a range of values (such as a Gaussian).

Olshausen and Field (1997) *Sparse coding with an overcomplete basis set: A strategy employed by V1?*



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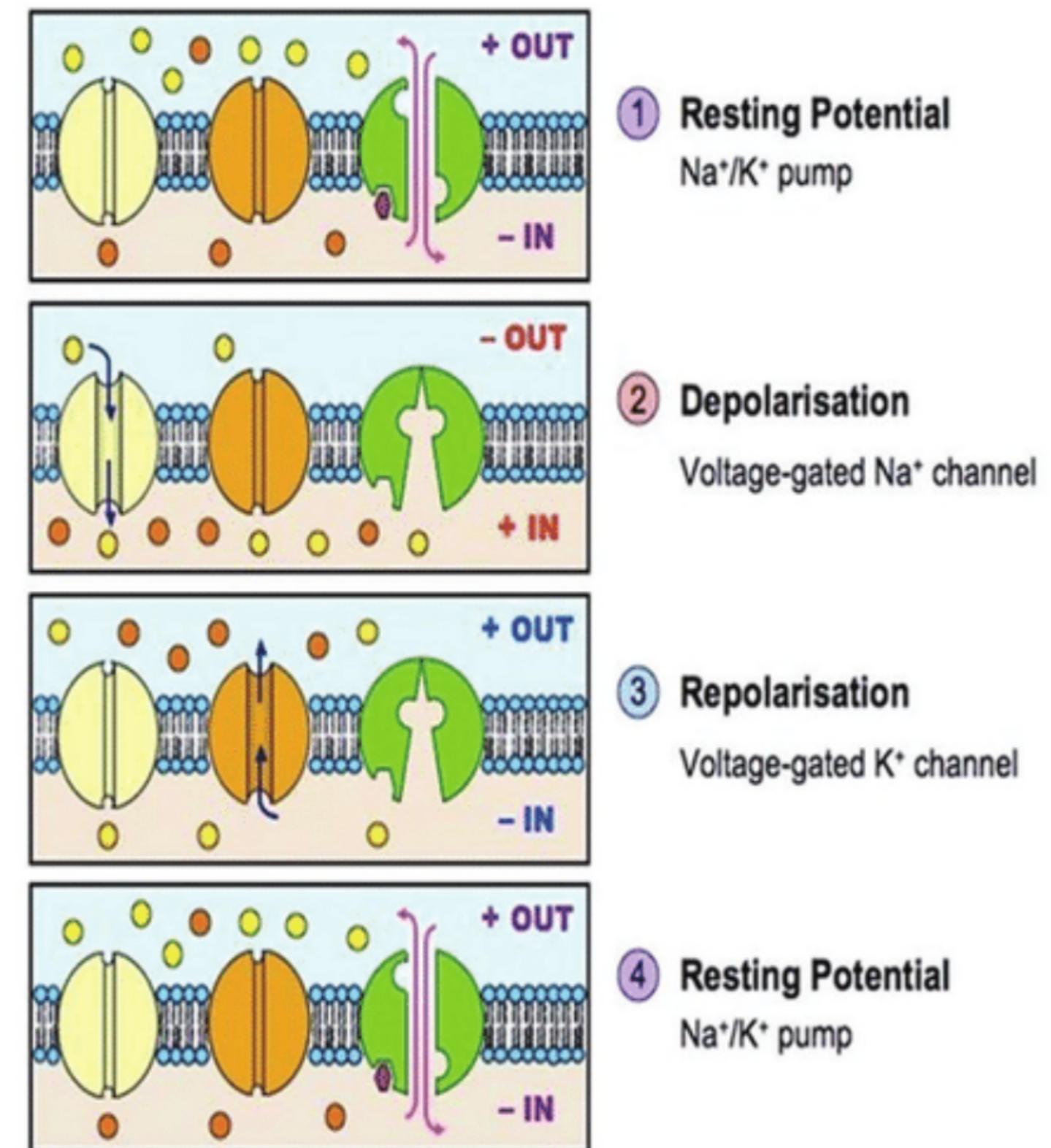
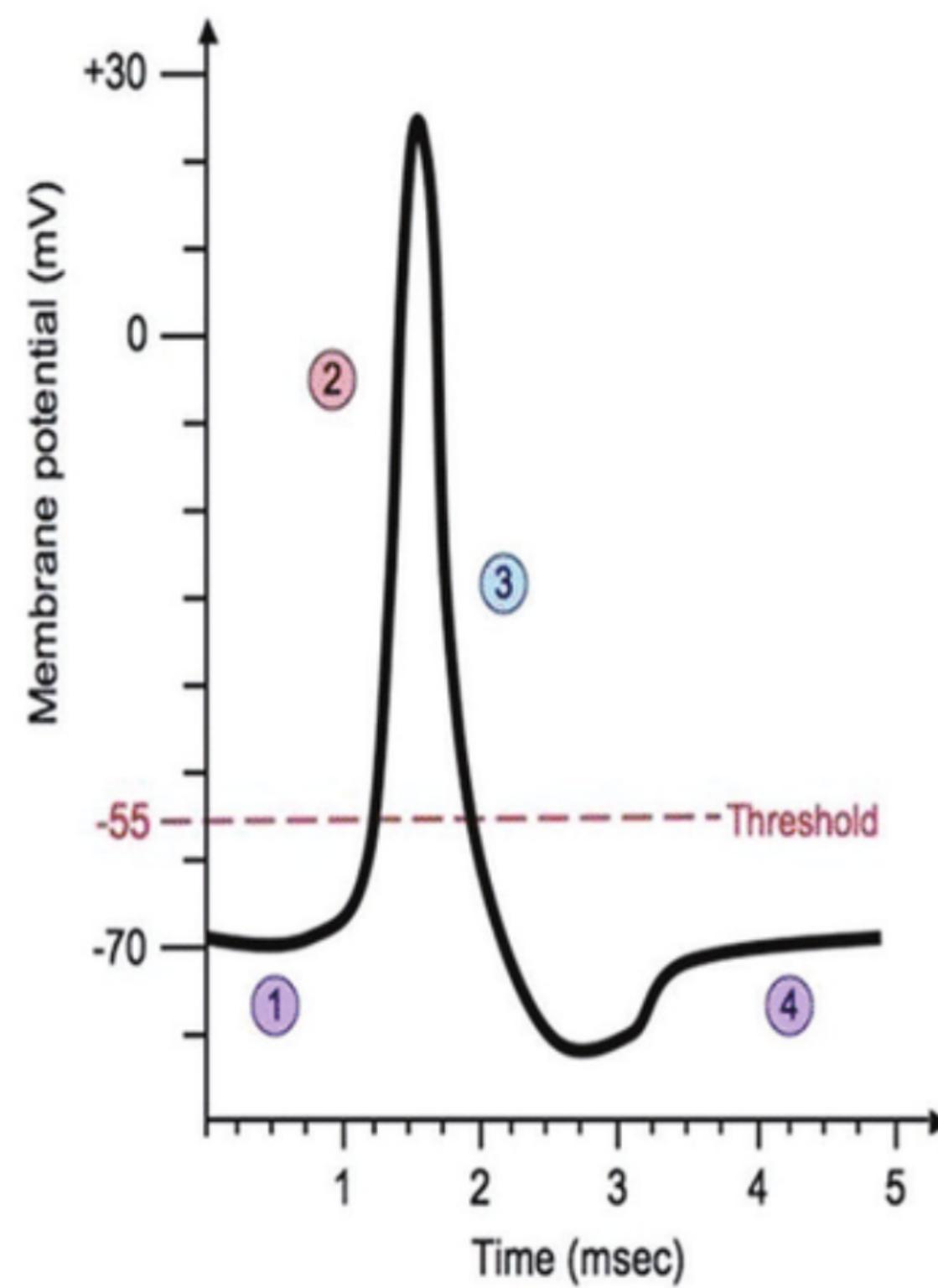
LP (2010) *Neural Computation*

Outline

1. From the retina to action: Levels of modeling
2. Sparse coding in Neurophysiology and neural processing
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$$C_m \frac{dV}{dt} = -\overline{g_{Na}} a_{Na}^\infty (V - E_{Na}) - \overline{g_K} a_K (V - E_K) \\ - g_l (V - E_l) + I_{stim}$$

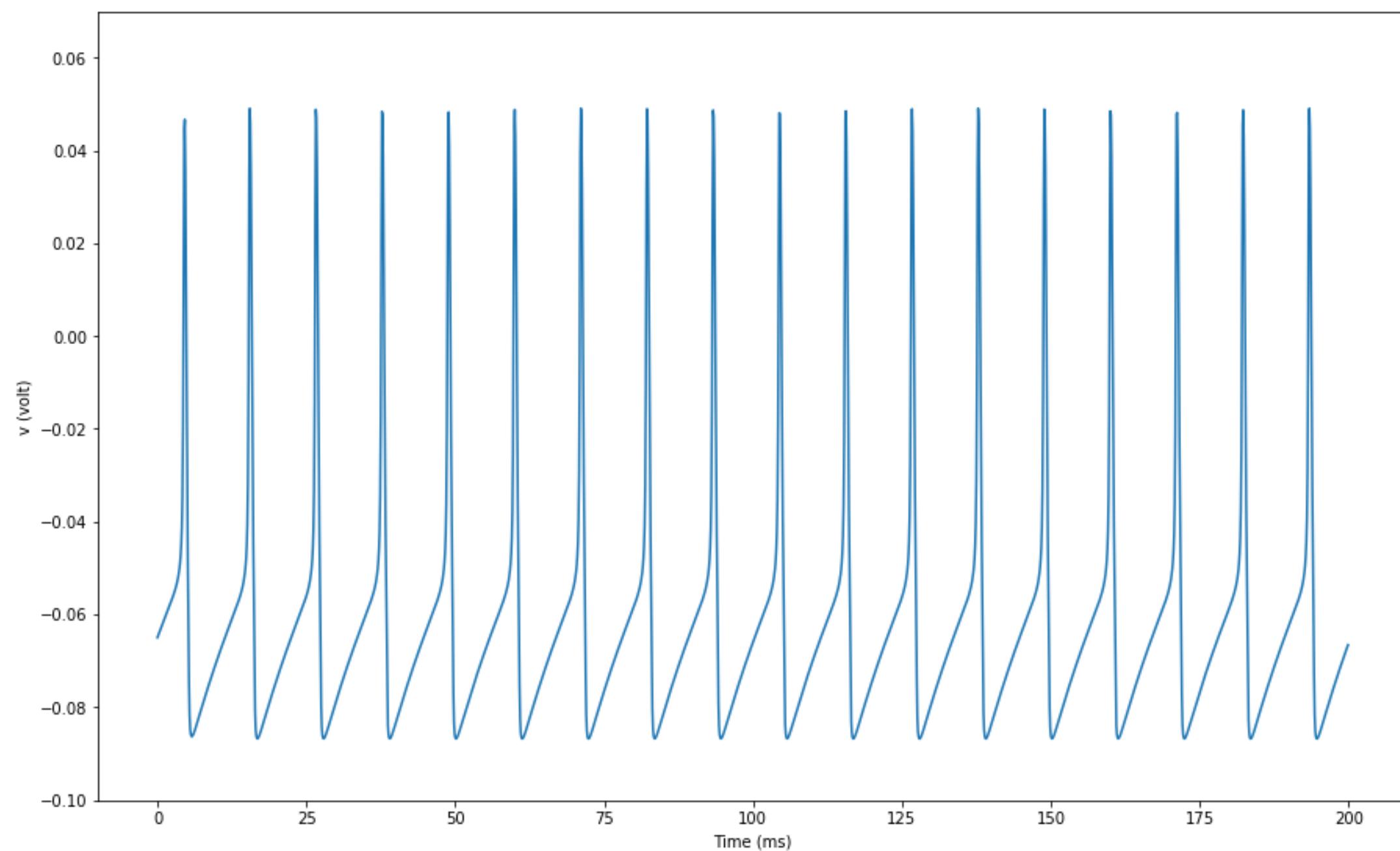
$$\frac{da_K}{dt} = \frac{a_K^\infty (V) - a_K(t)}{\tau_K}$$

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

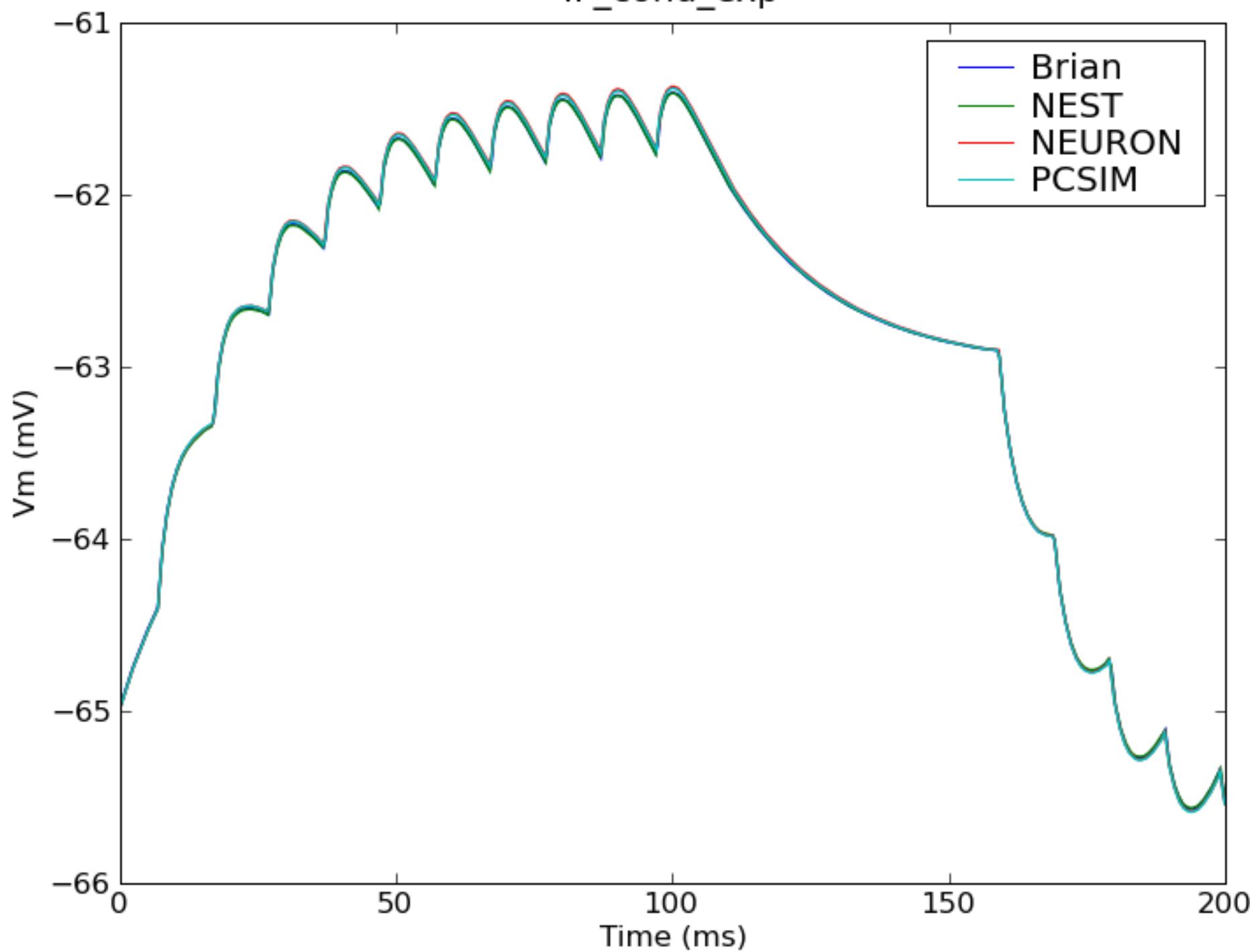
$$a_{Na}^\infty (V) = \frac{1}{1 + e^{s_{Na}(V - V_{Na}^0)}}$$

BRIAN





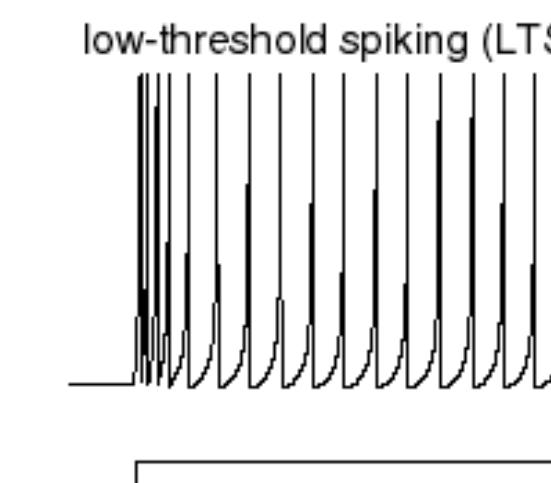
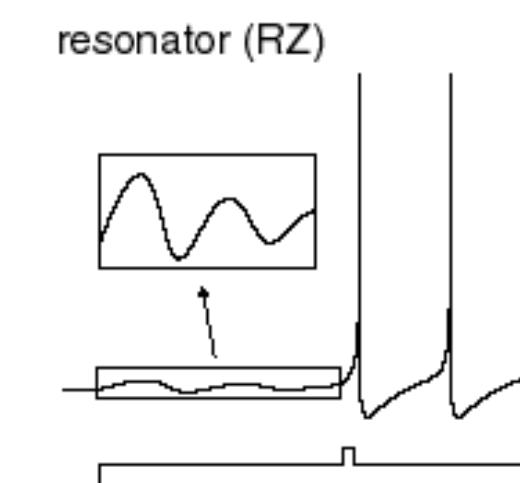
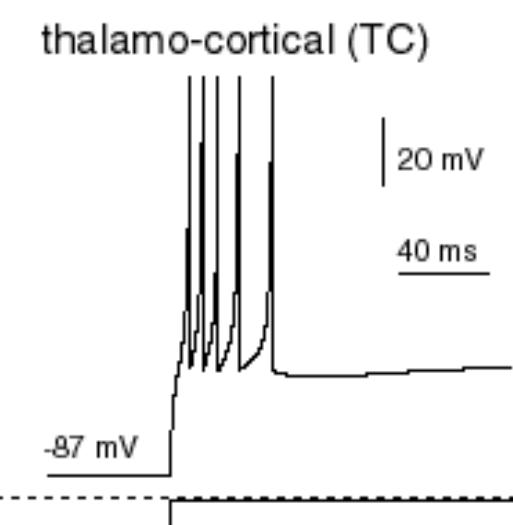
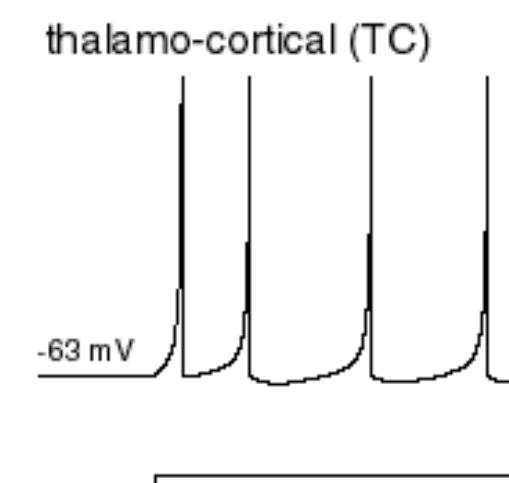
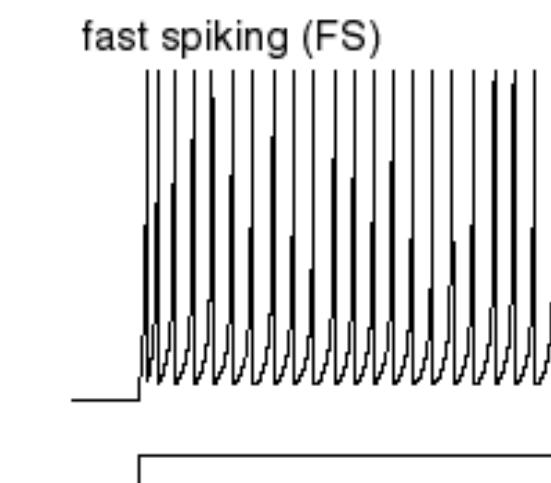
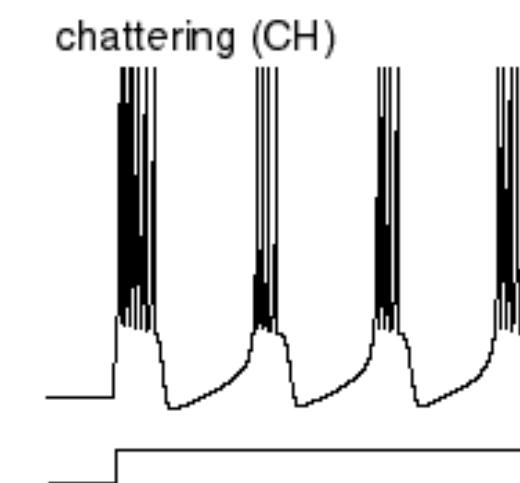
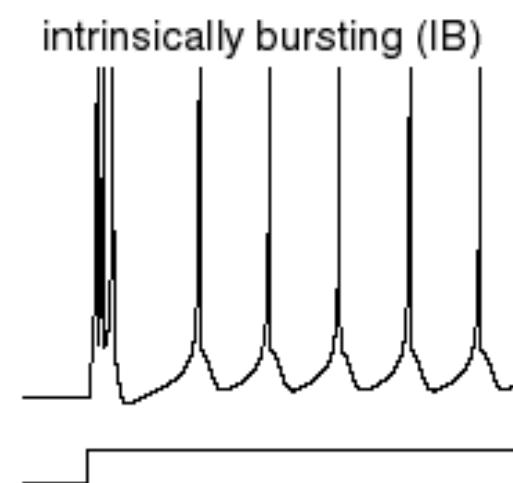
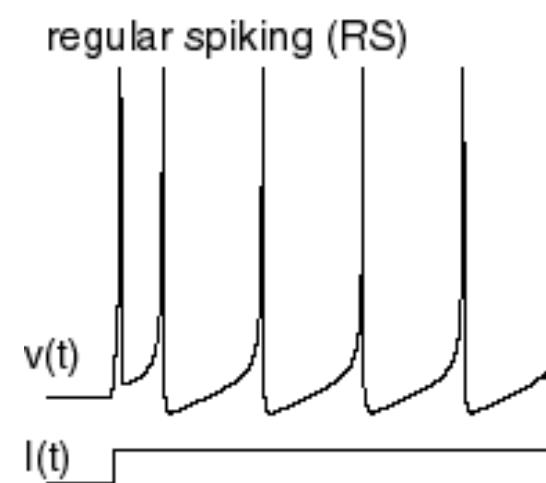
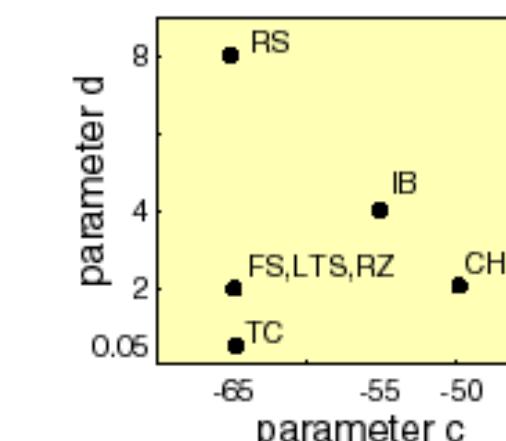
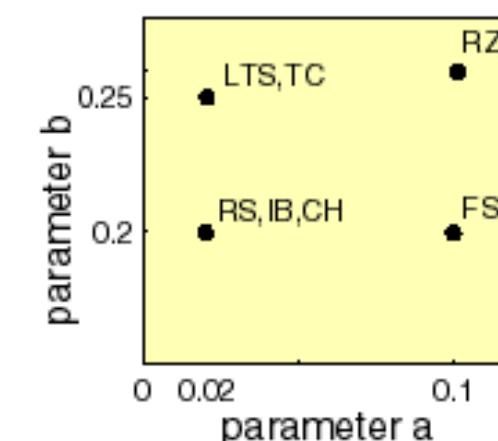
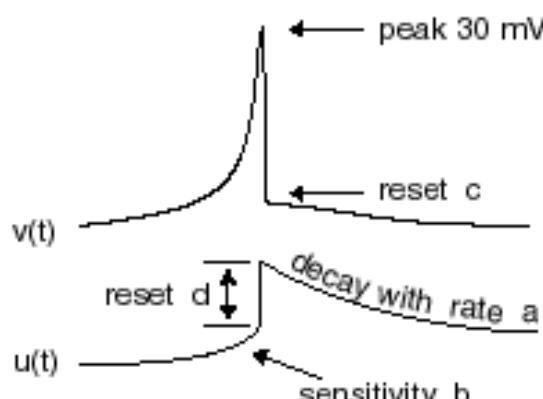
IF_cond_exp



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

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

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



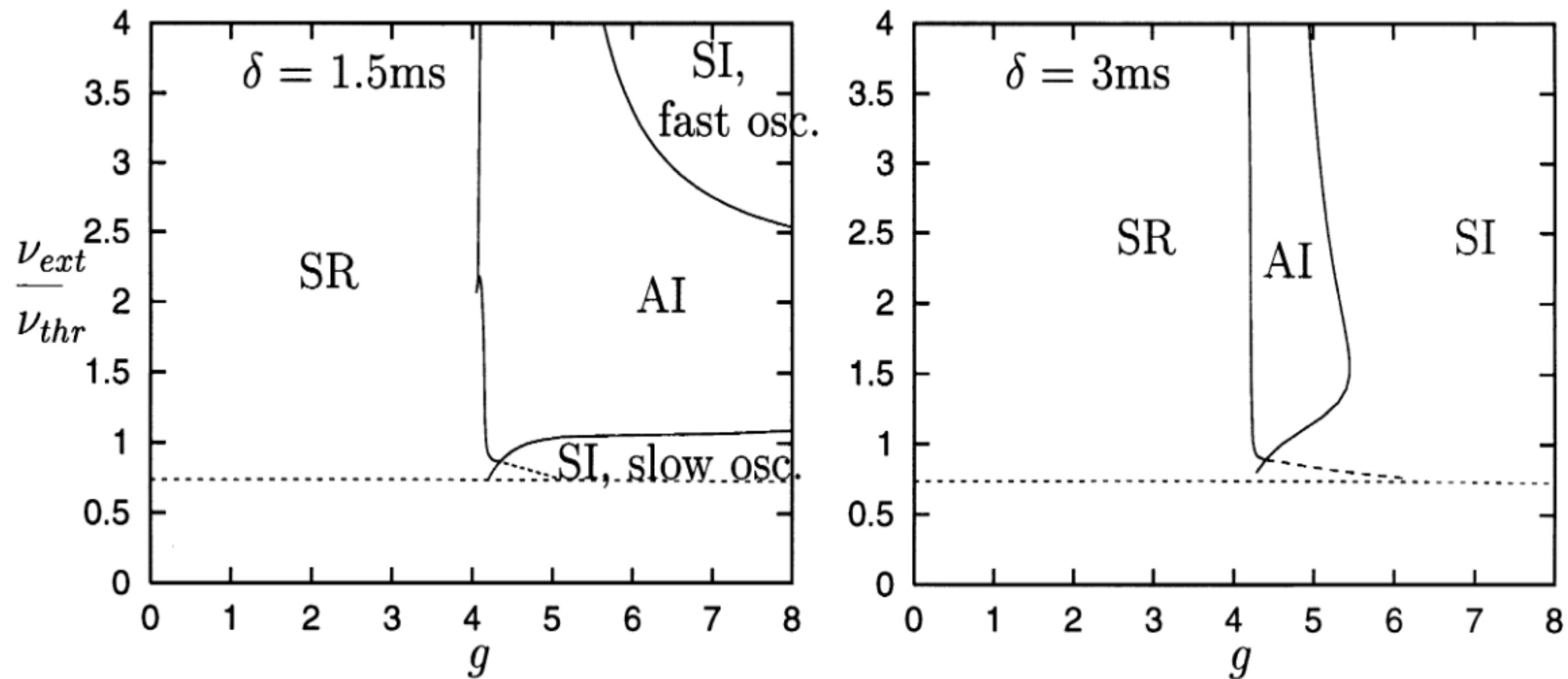


Fig. 1. ‘Phase diagrams’ of the system, for two values of the synaptic time, indicated on the corresponding picture. The remaining parameters are set to $J = 0.2$ mV; $C_E = 4000$; $C_I = 1000$. The asynchronous, stationary state is stable in the region AI, bounded by the Hopf bifurcation curves, indicated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

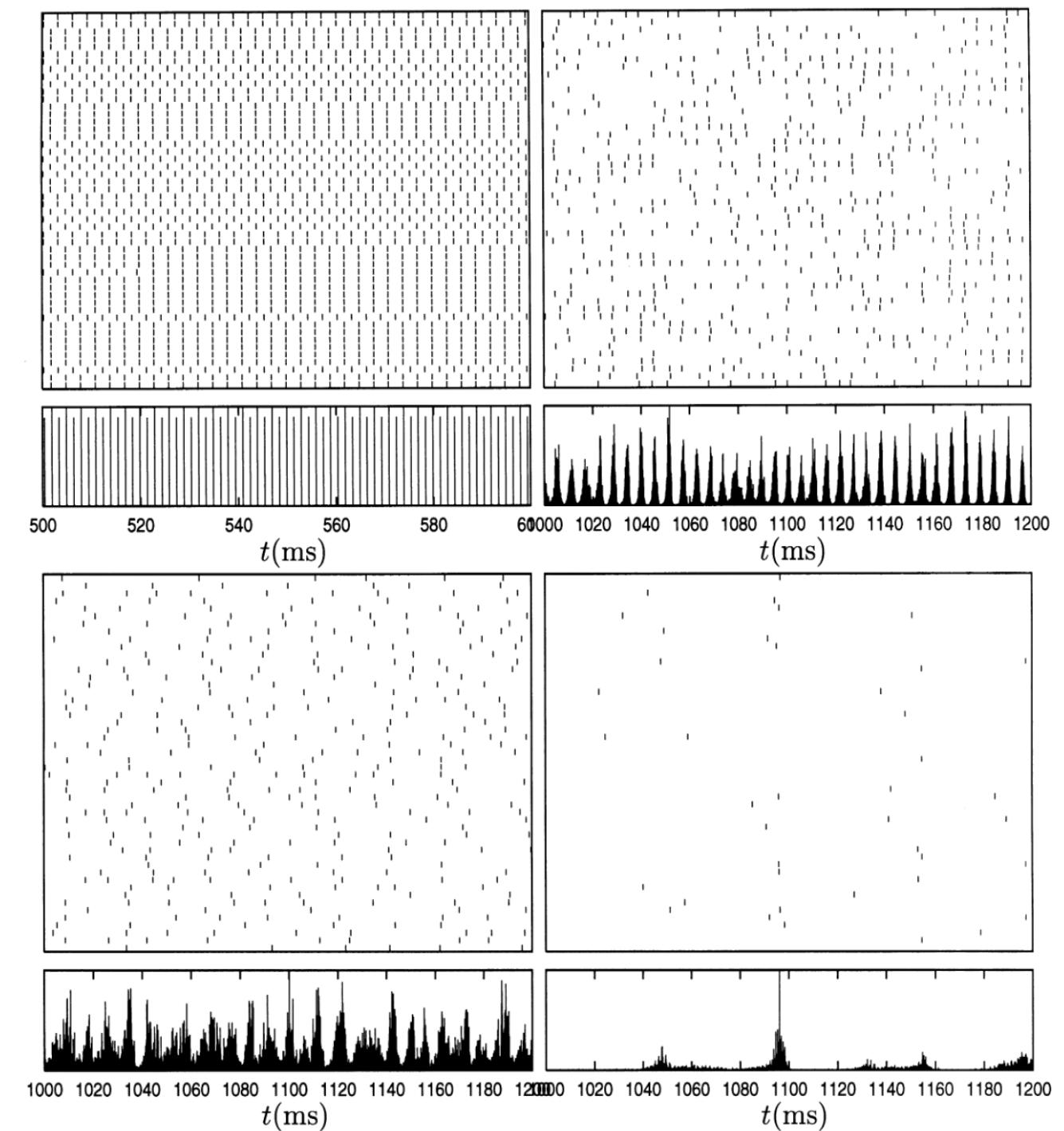
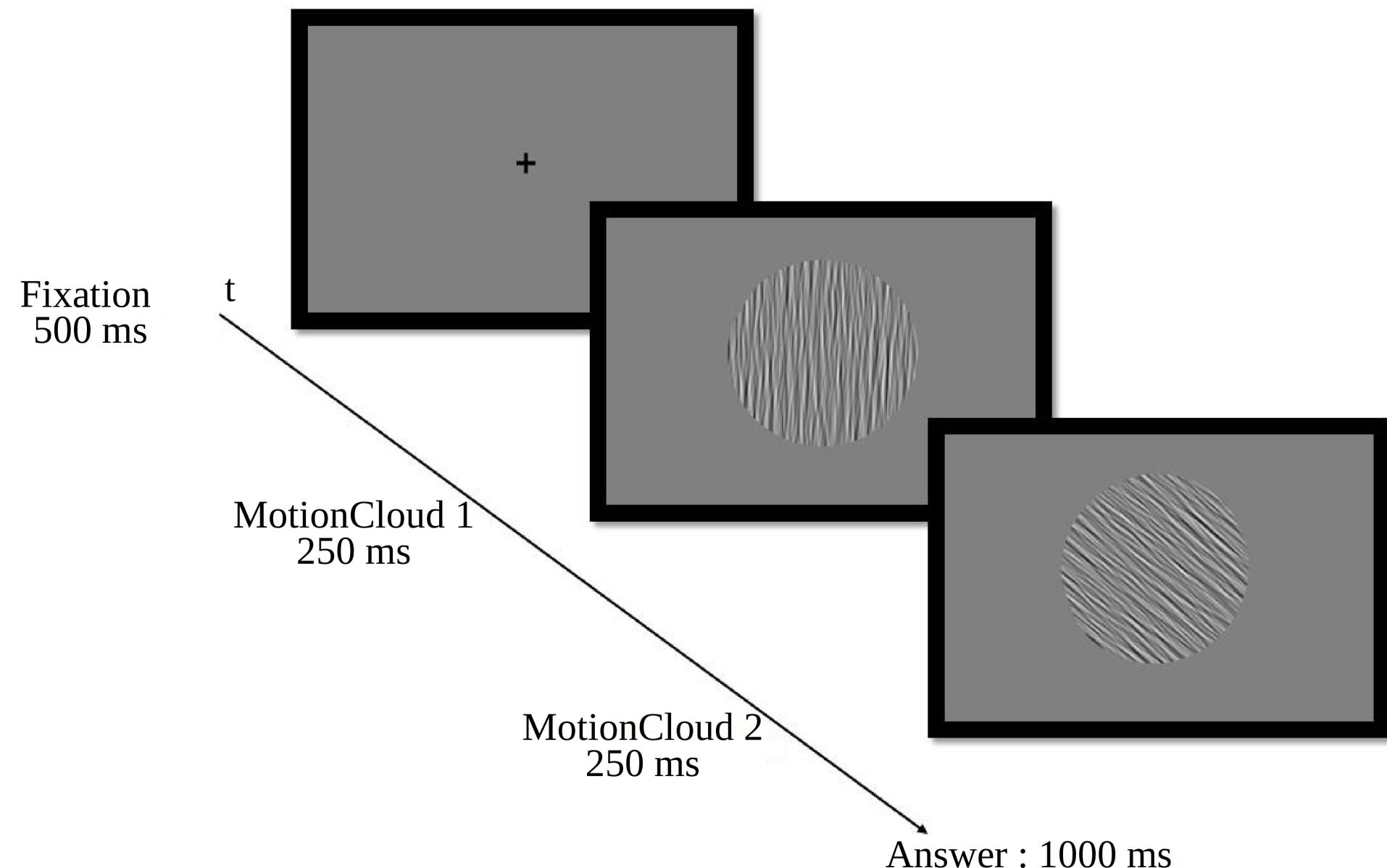
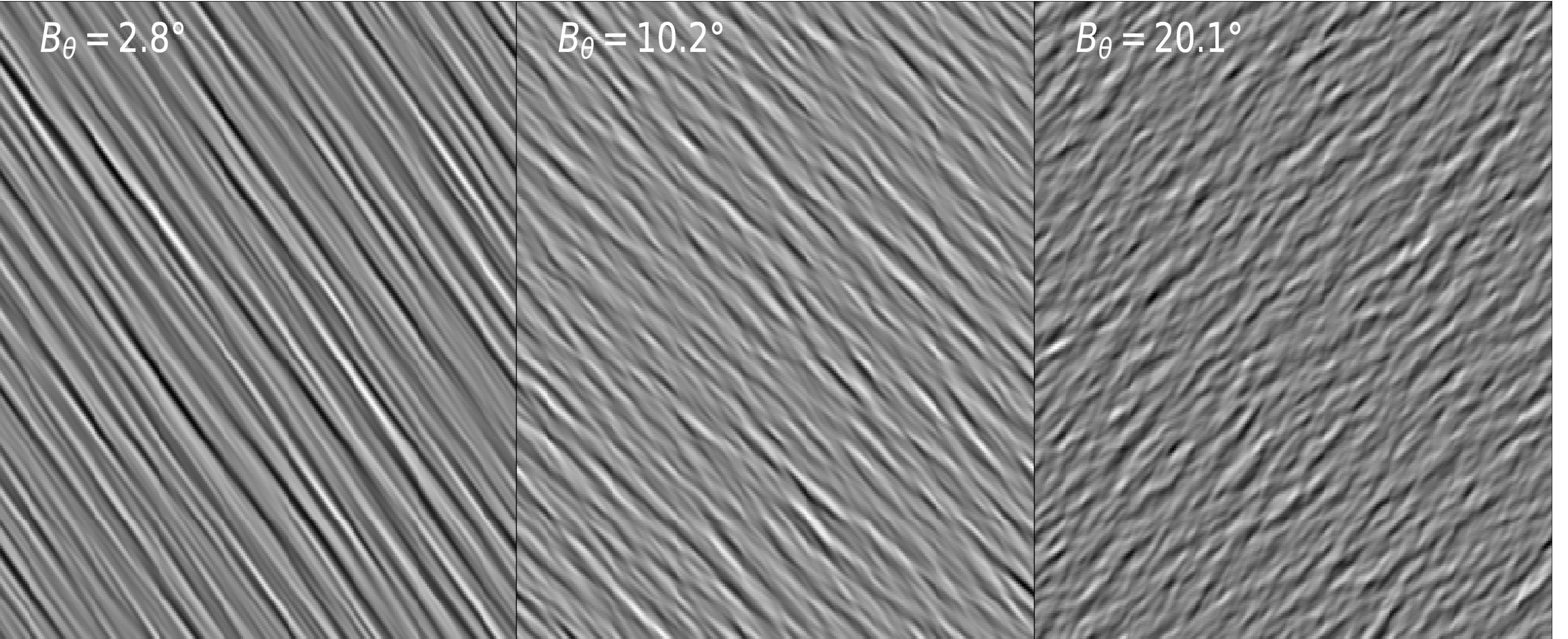
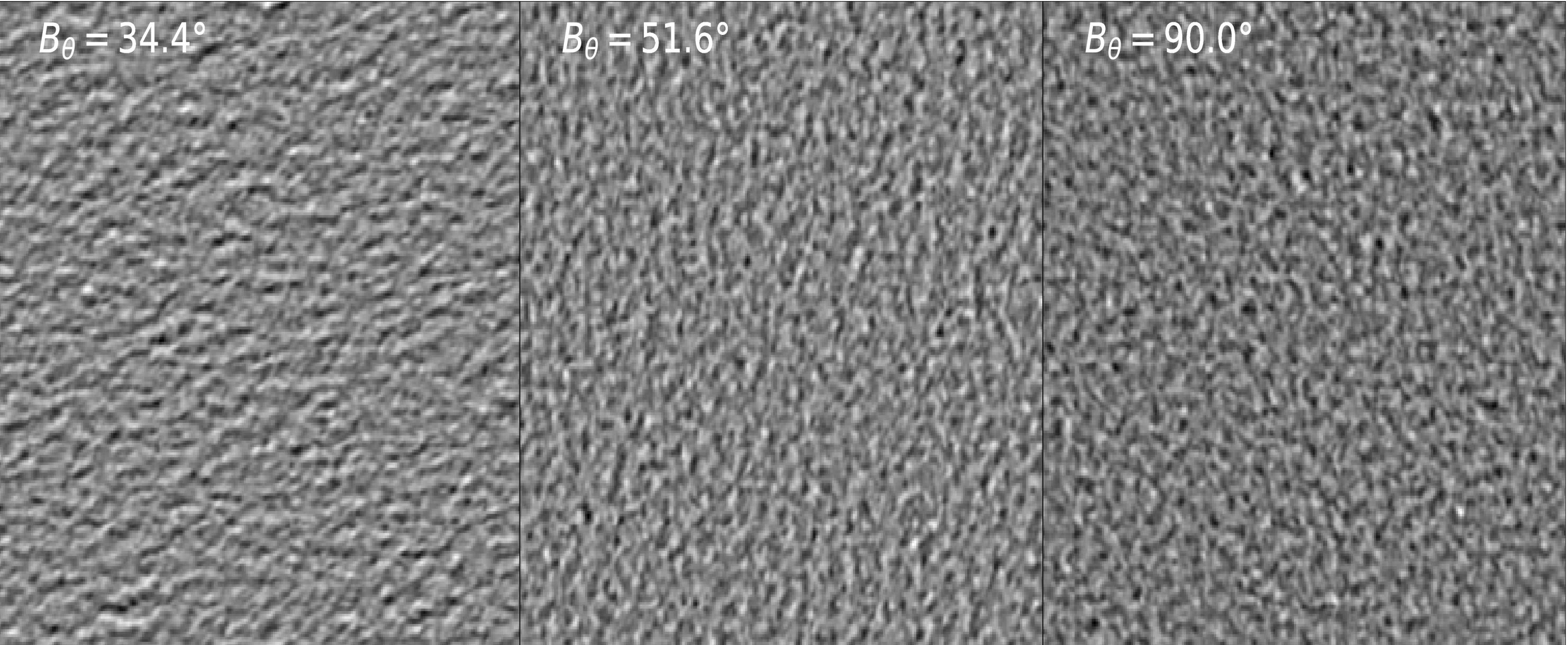
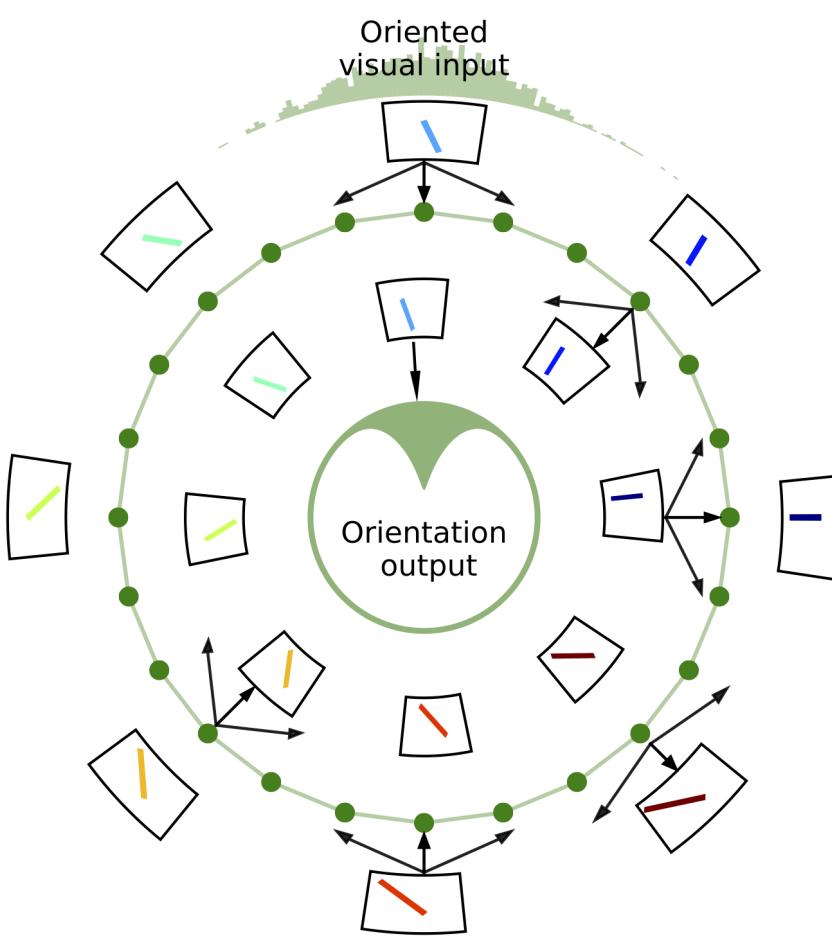


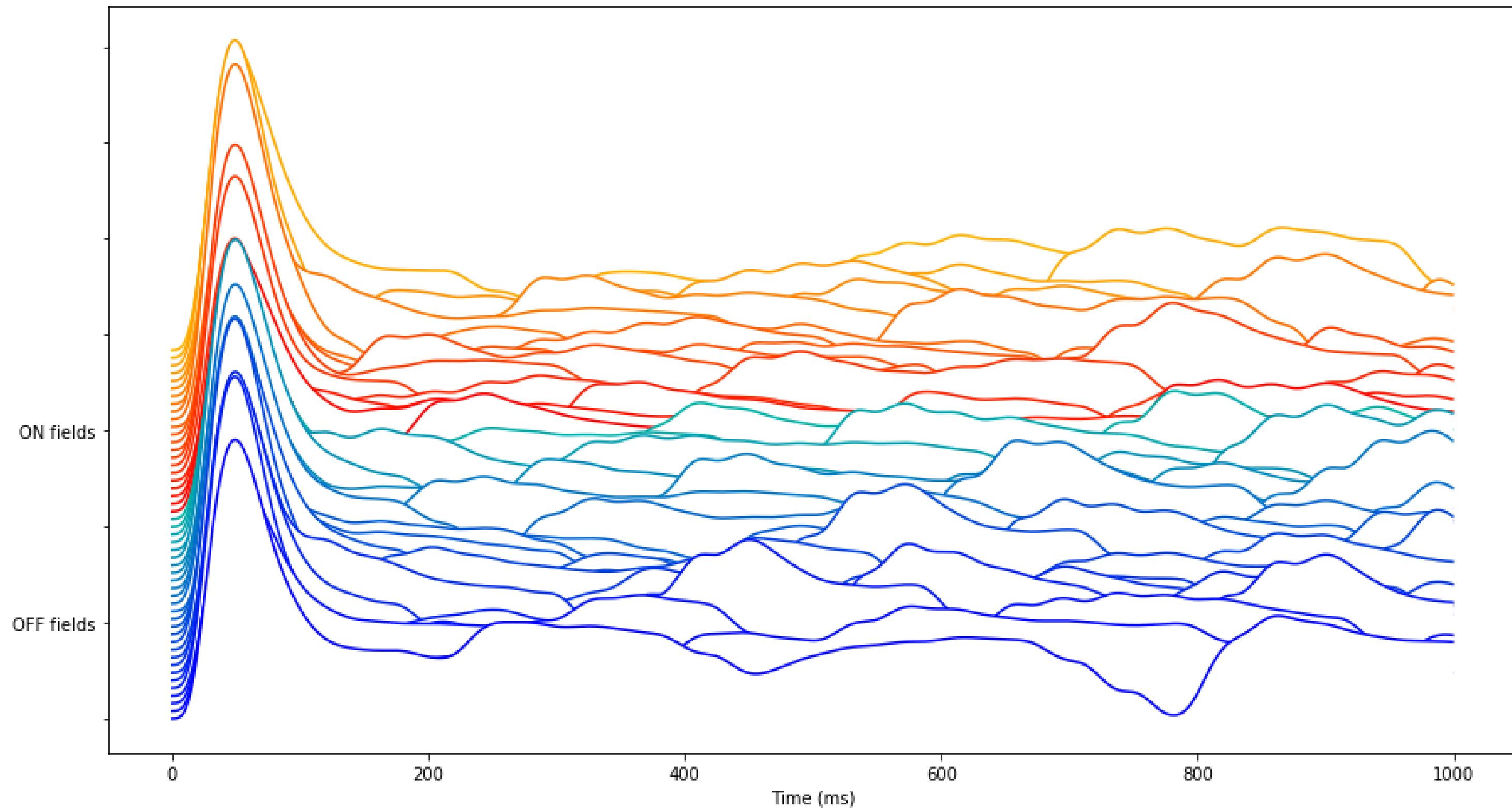
Fig. 2. The dynamics of the network depends on the balance between excitation and inhibition, and on the

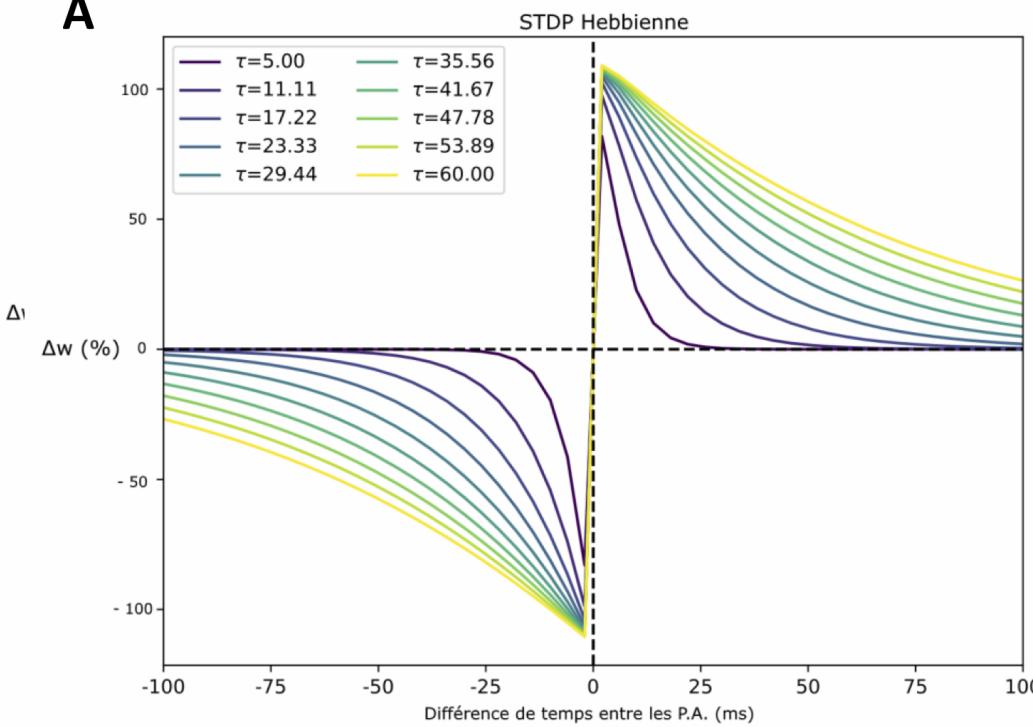
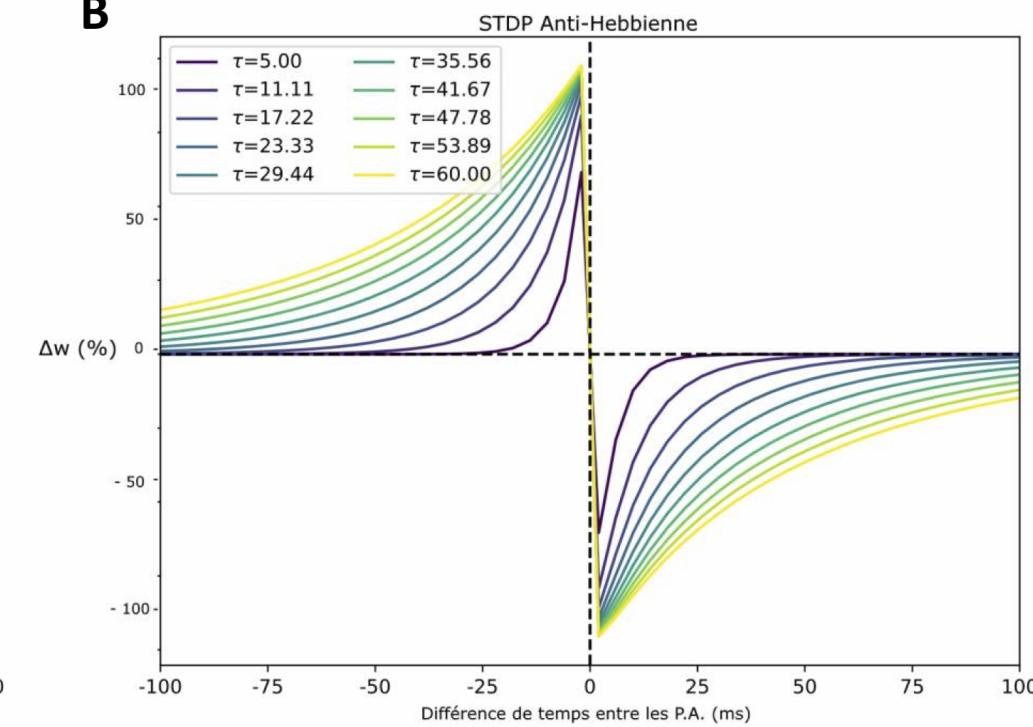
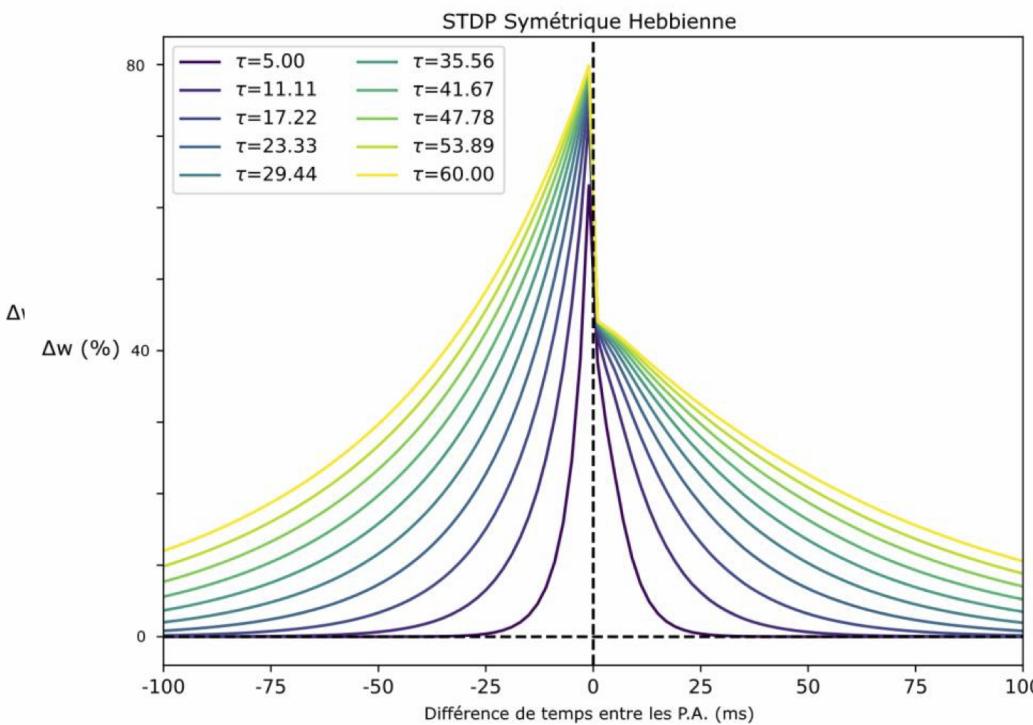
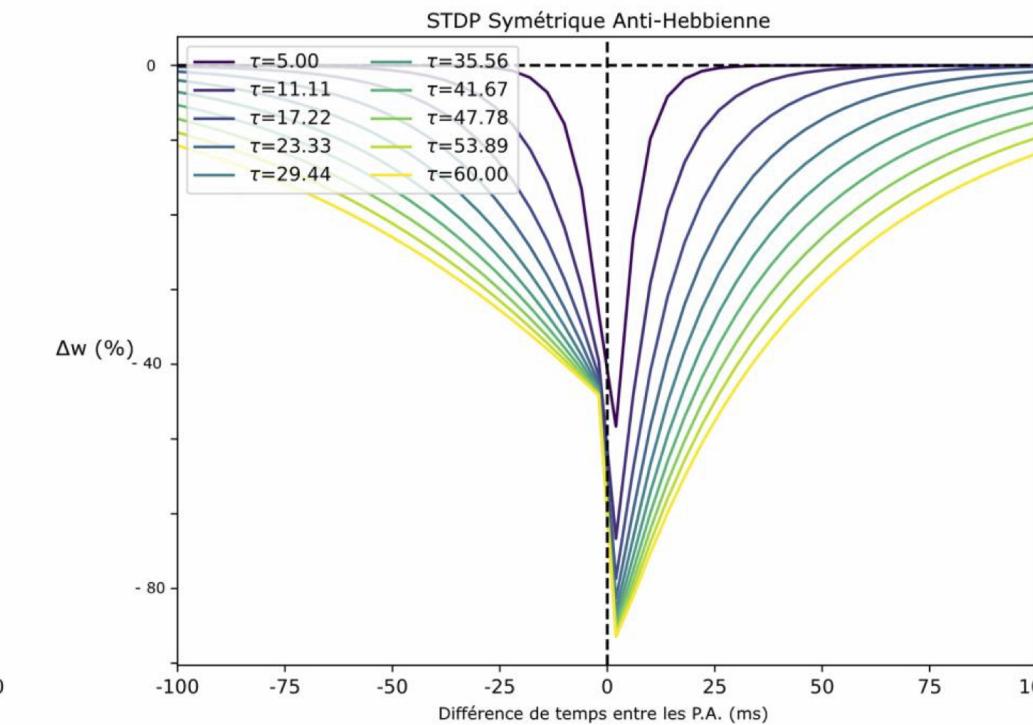










A**B****C****D**

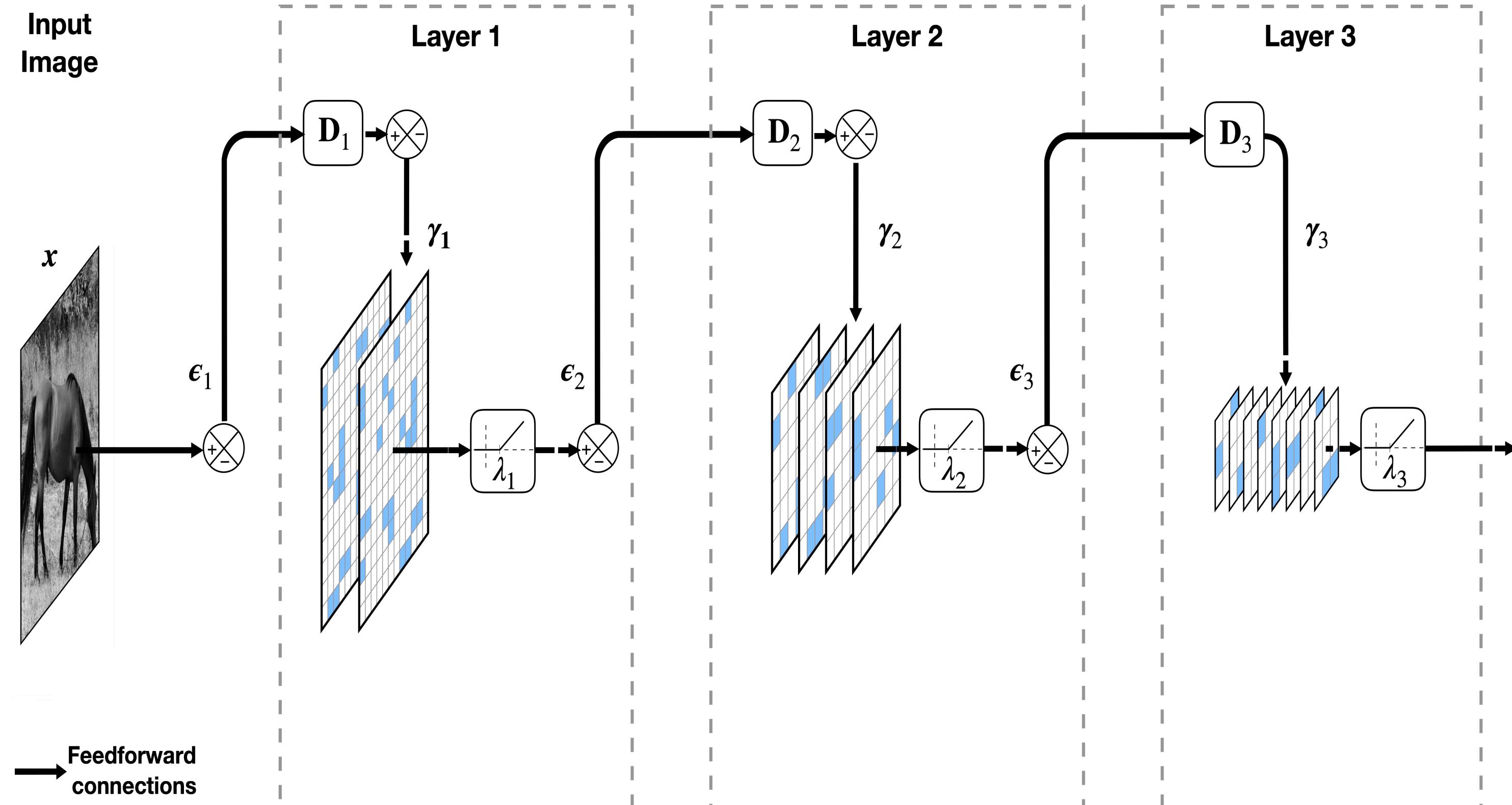


Outline

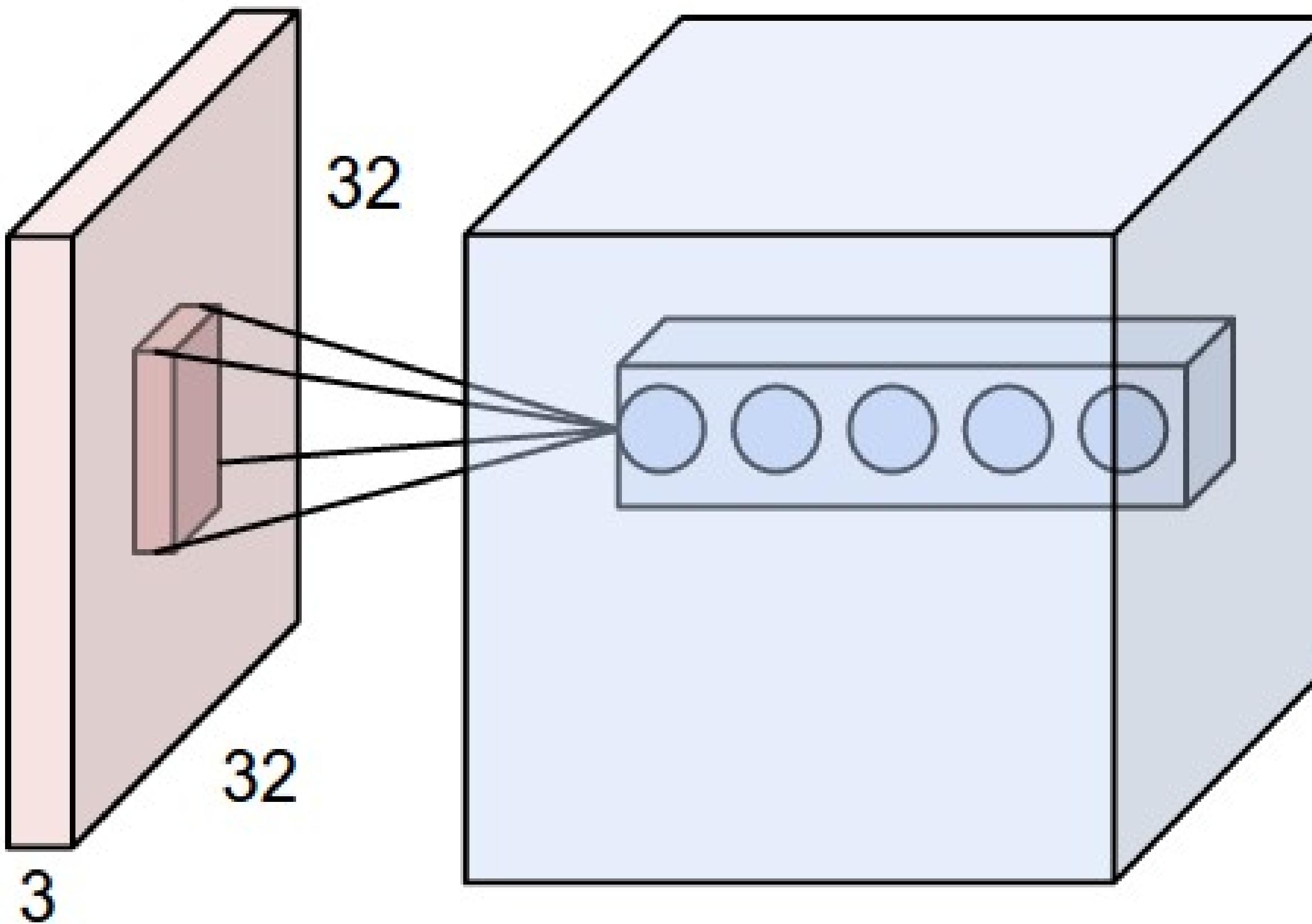
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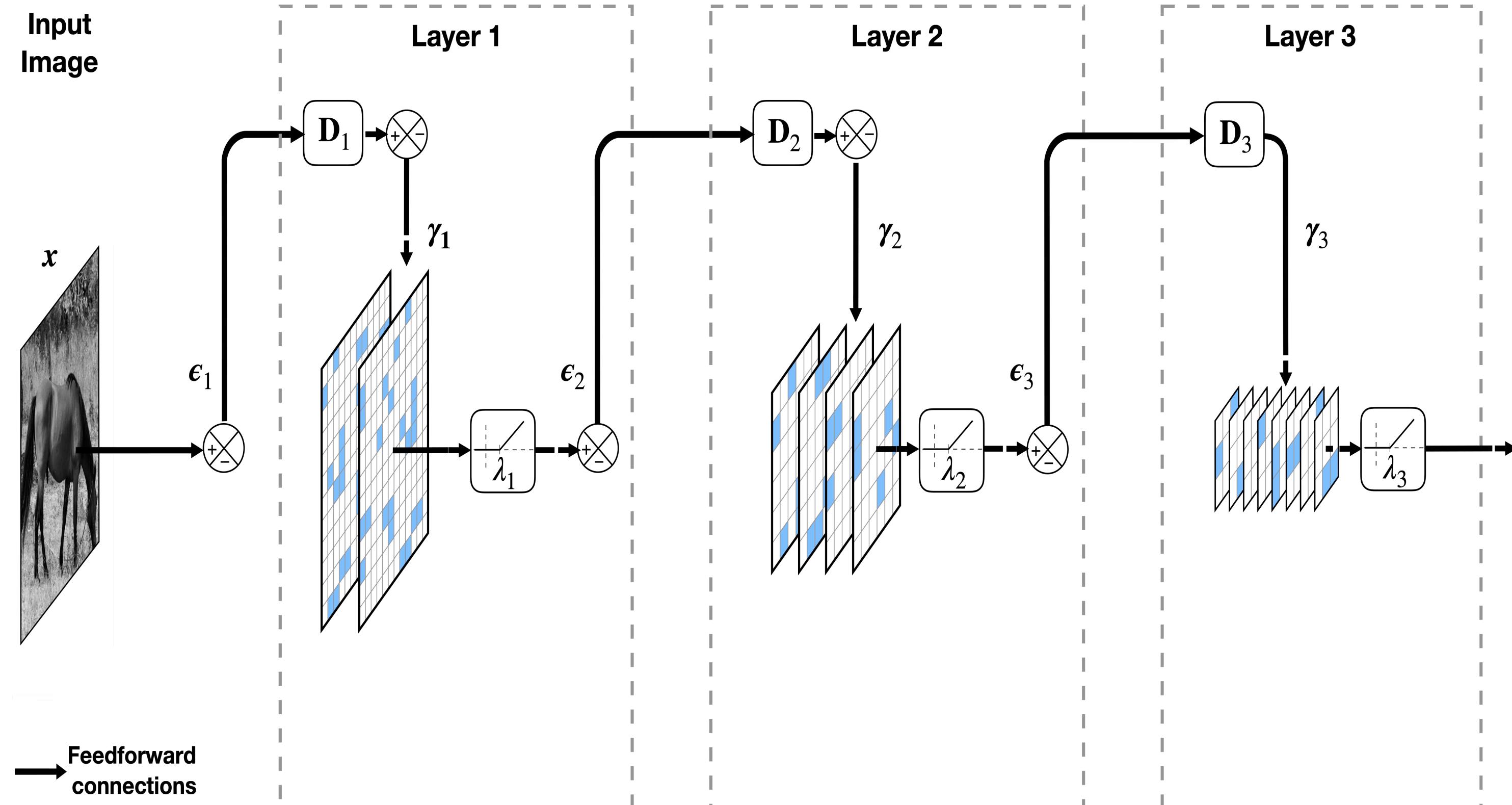
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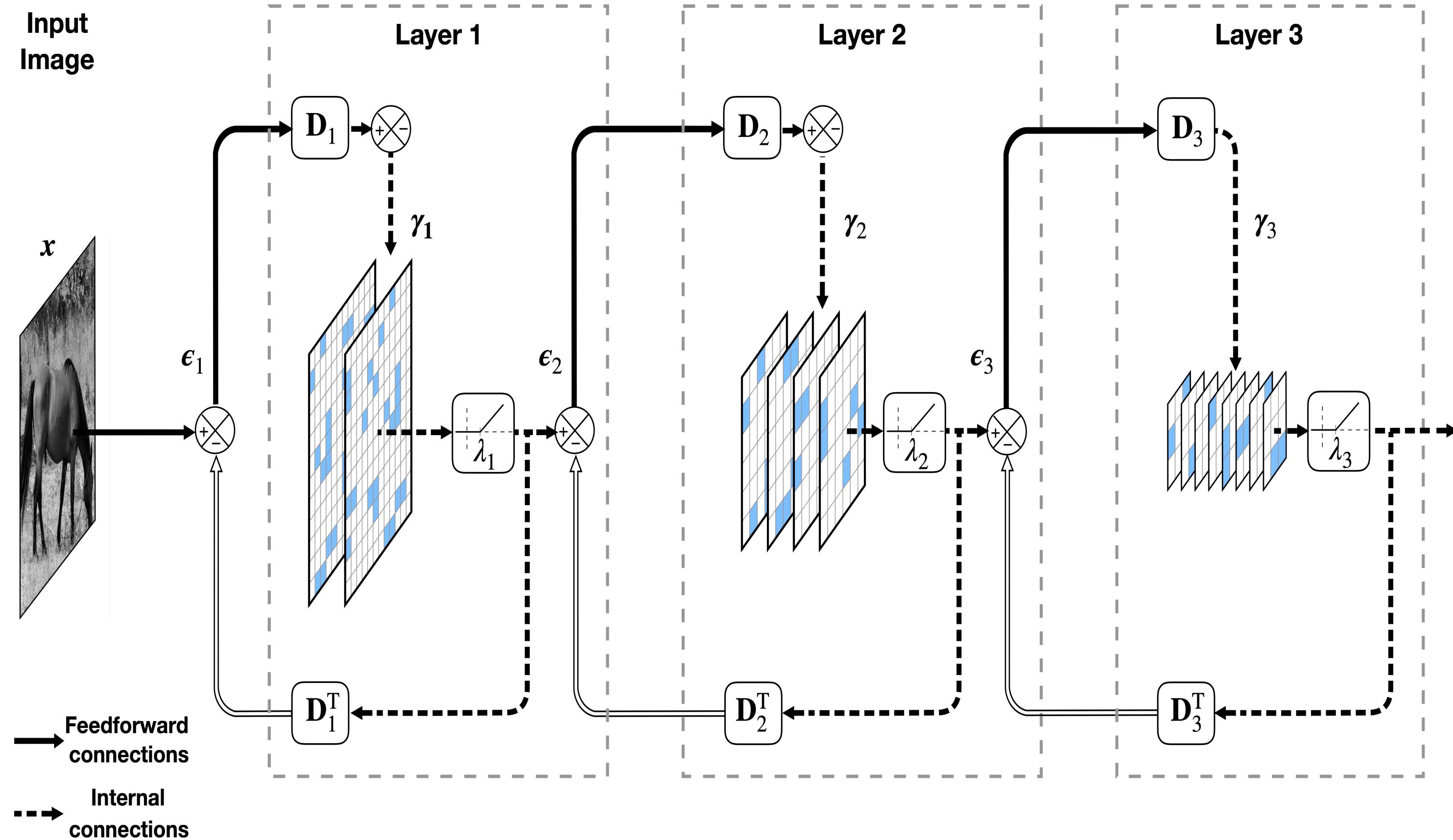
Boutin, Franciosini, Ruffier, LP (2019) *submitted*



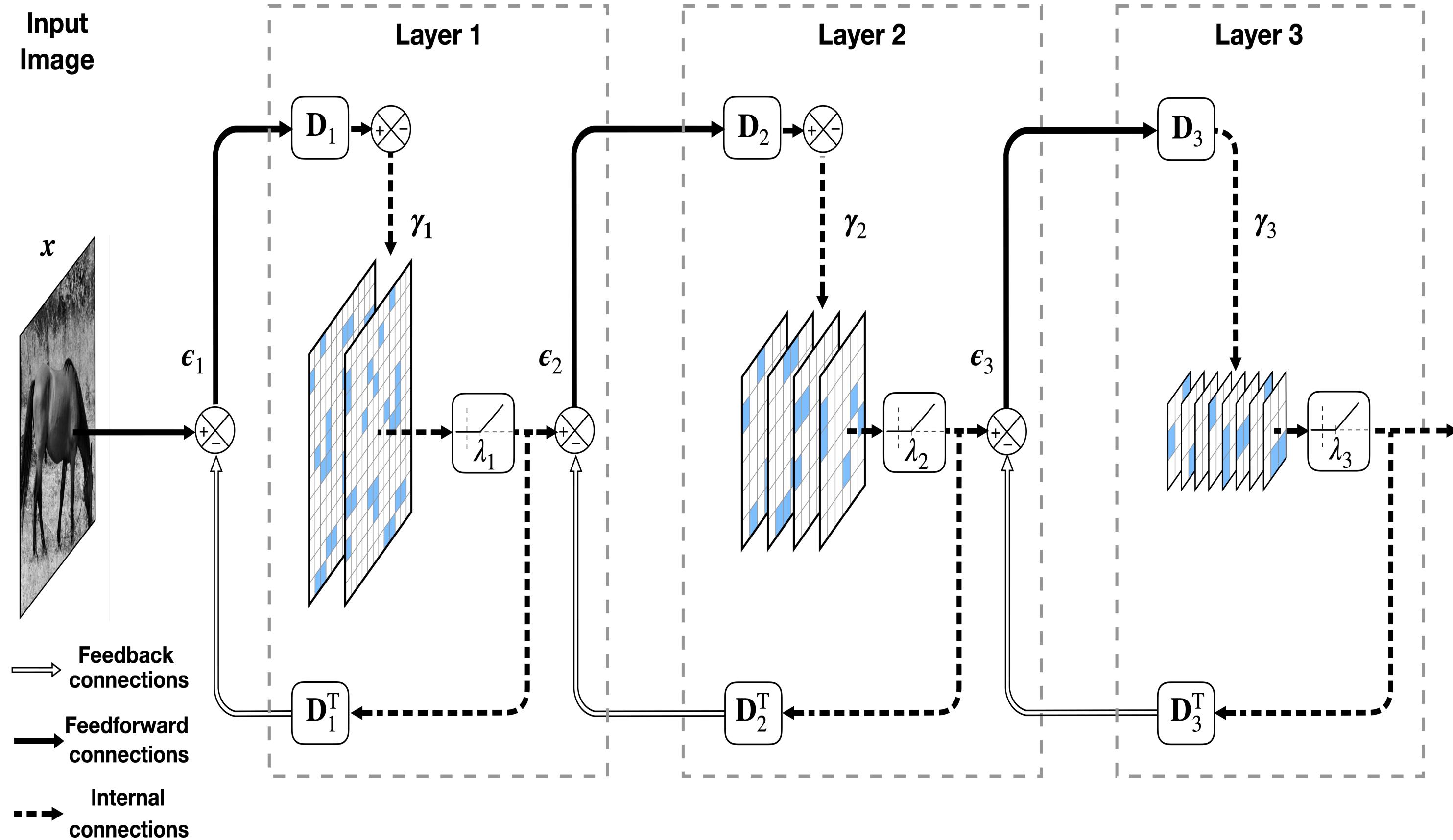
(from <http://cs231n.github.io/convolutional-networks/>)



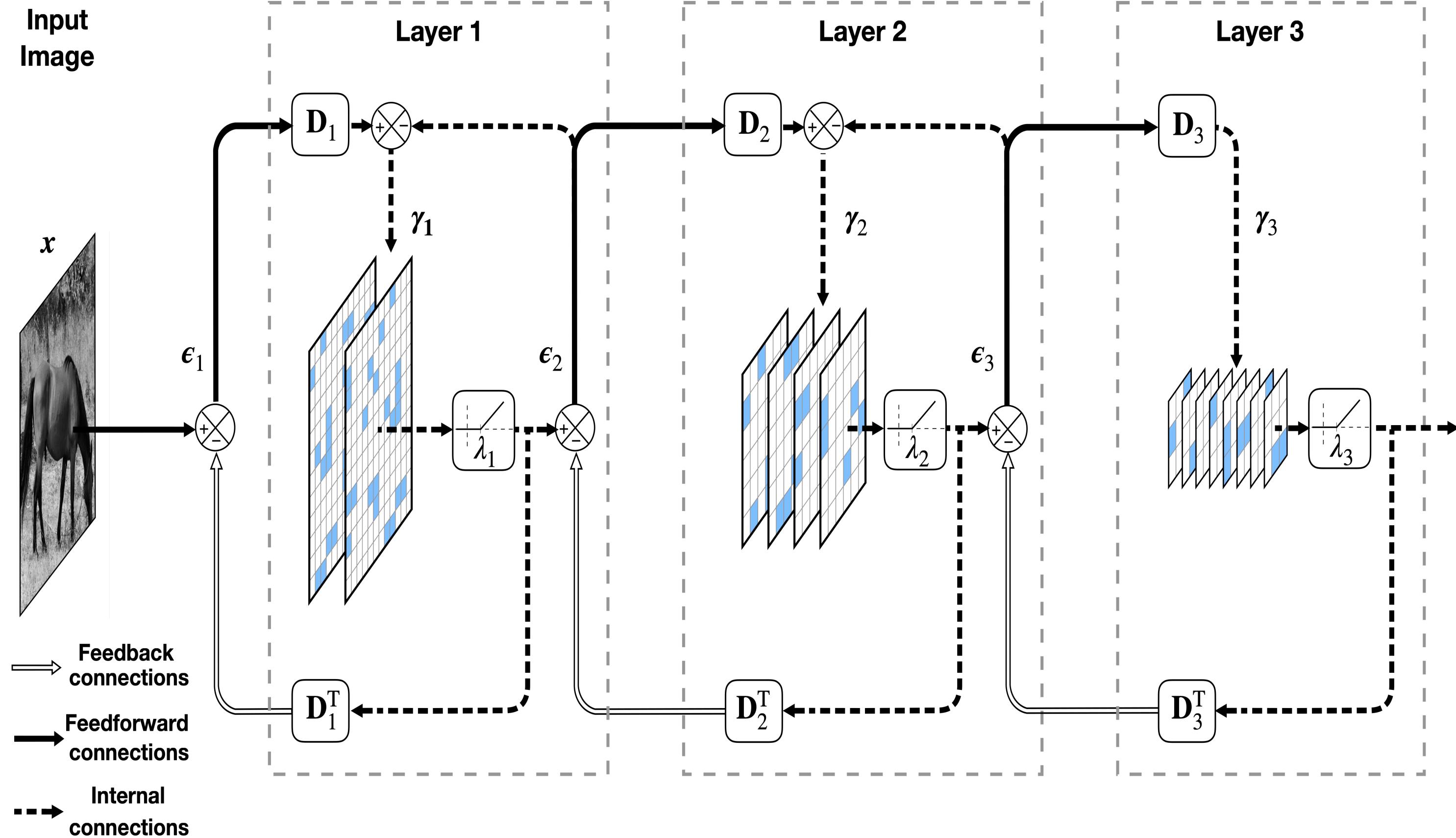
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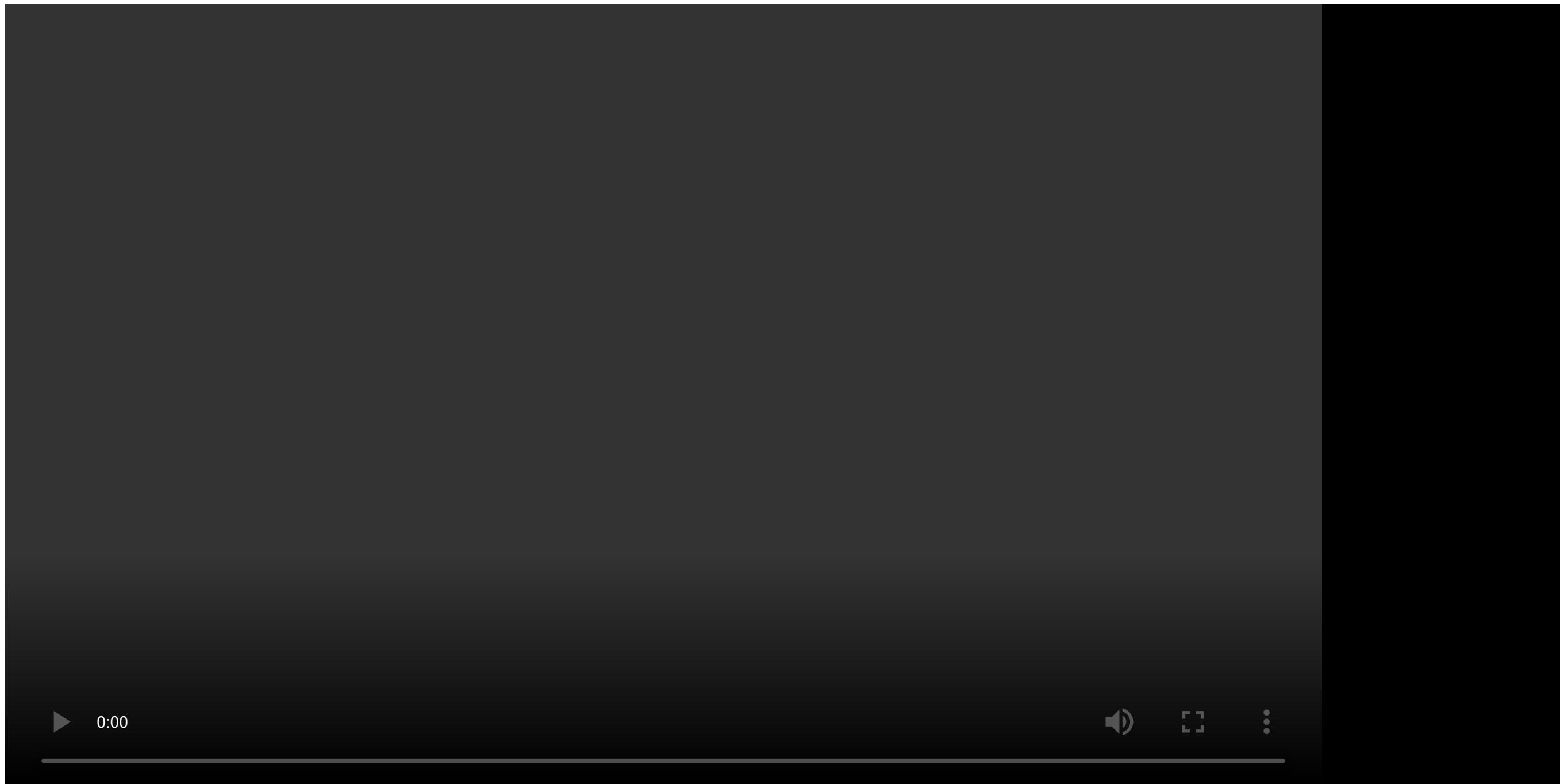
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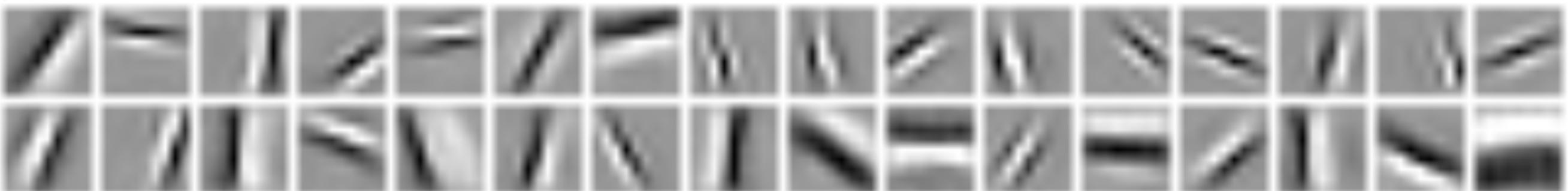
Boutin, Franciosini, Ruffier, LP (2019) submitted



(a) Examples of AT&T images after pre-processing



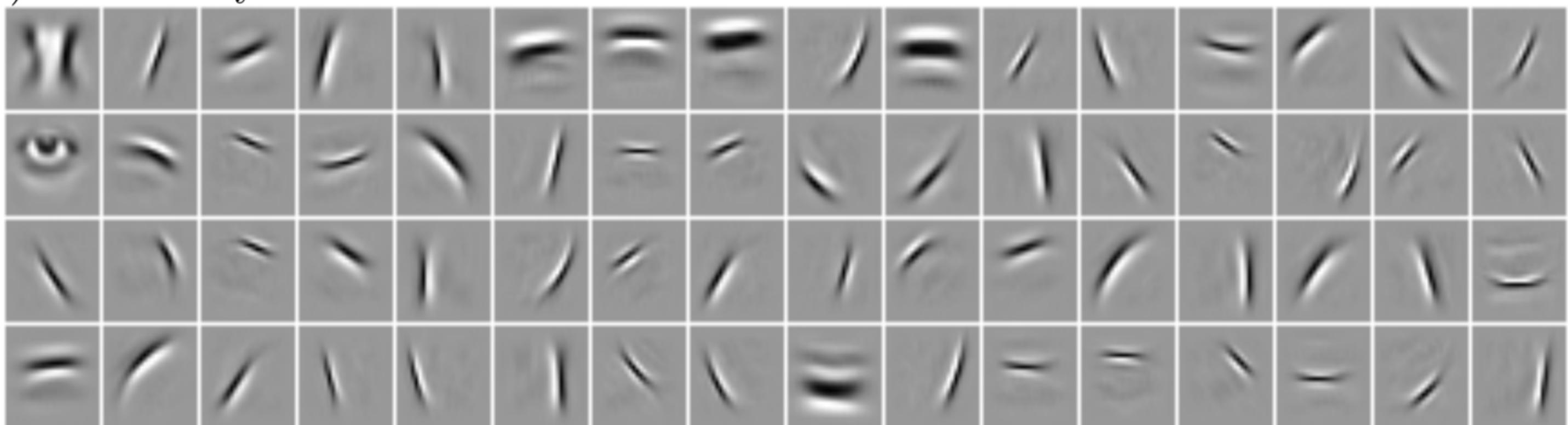
(b) First layer RFs



(c) First layer prediction

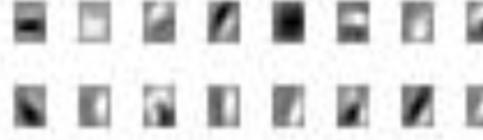
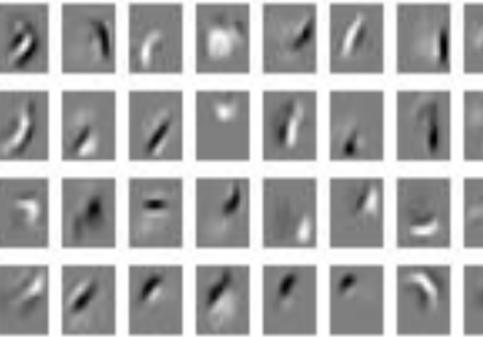
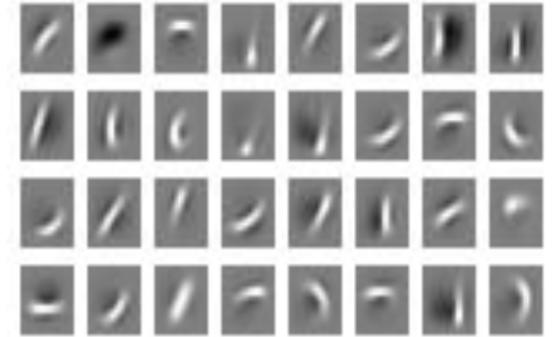
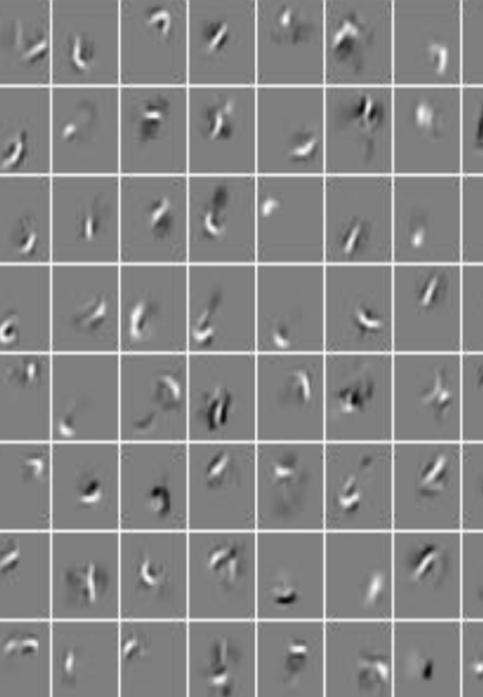
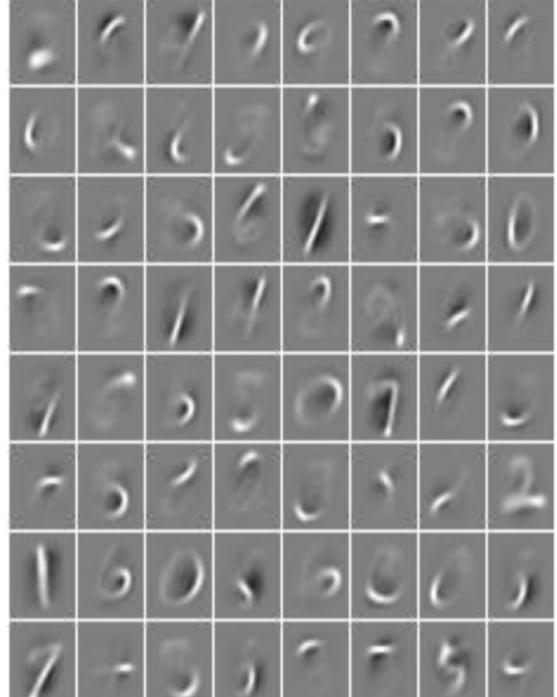


(d) Second layer RFs

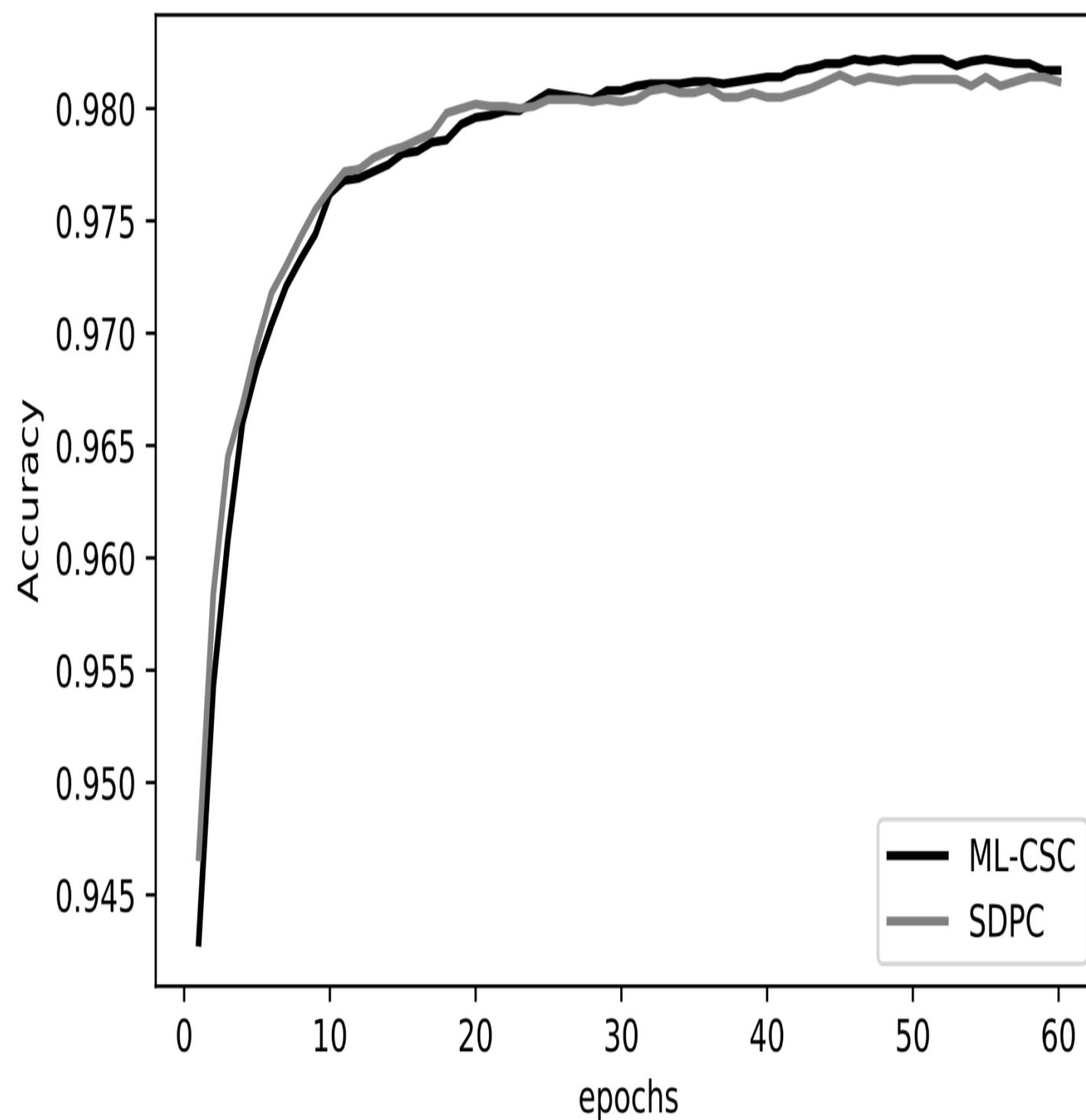


(e) Second Layer prediction



Layer	ML-CSC	SDPC
Layer 1		
Layer 2		
Layer 3		

Layer	ML-CSC	SDPC
Layer 1		
Layer 2		
Layer 3		



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