

W



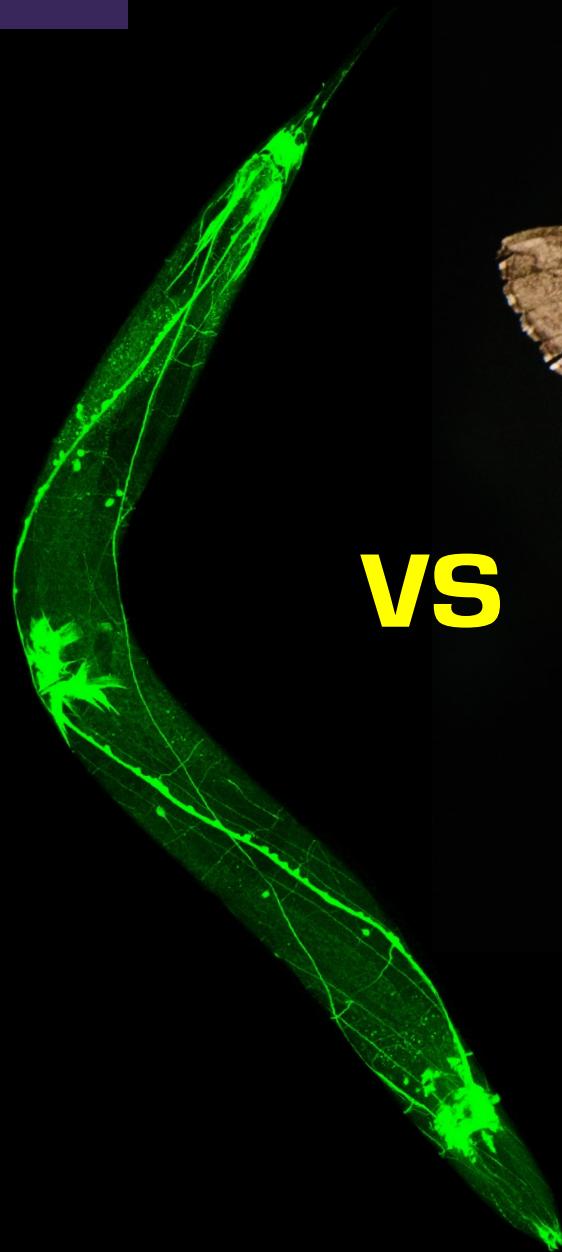
*Coarse-graining and Control of
Networked Dynamical Systems*

J. Nathan Kutz

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University of Washington
Email: kutz@uw.edu

CCS2021 - October 27, 2021

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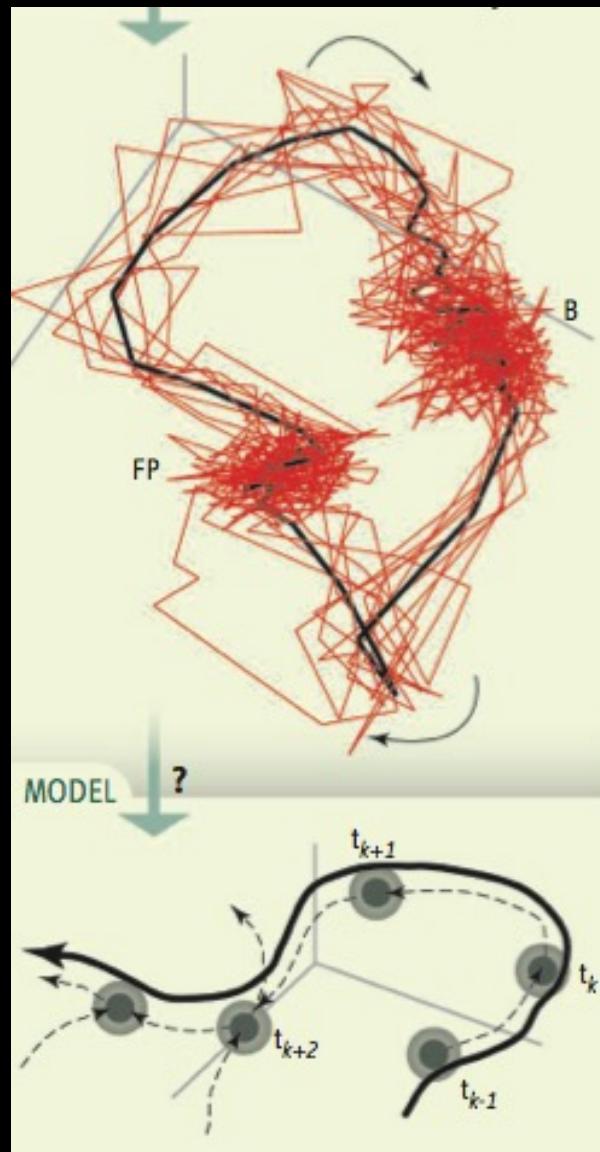
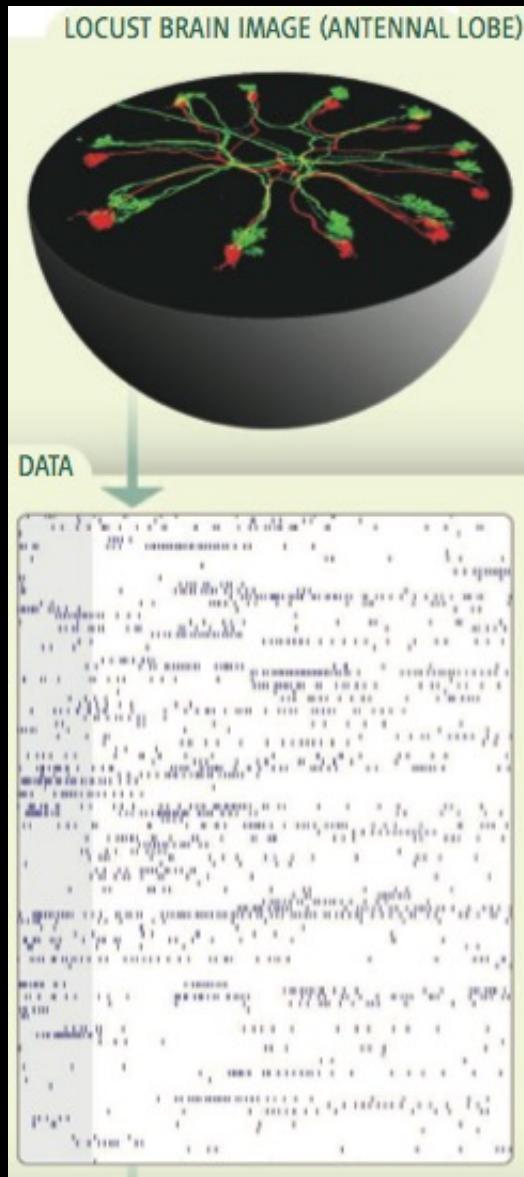


VS



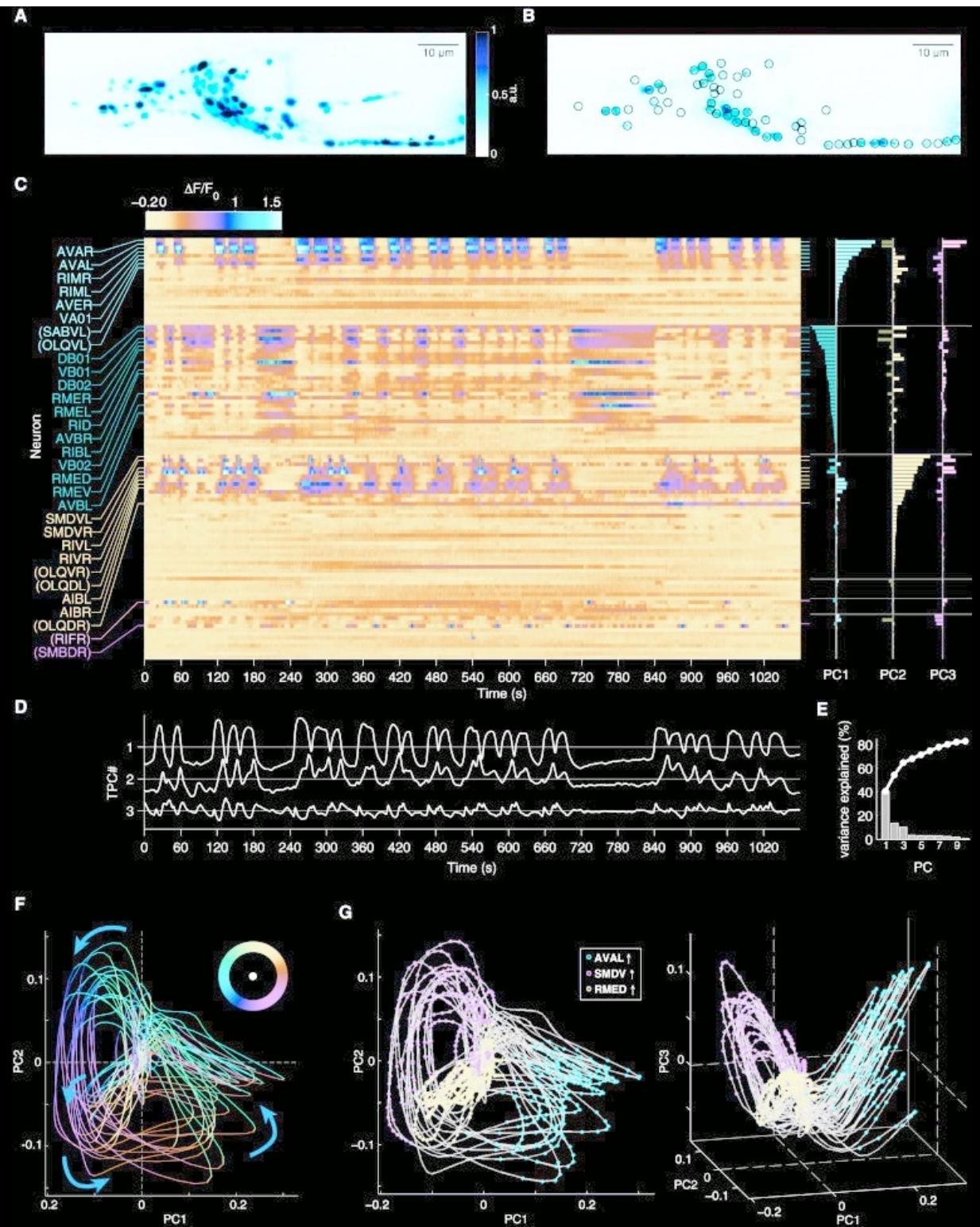
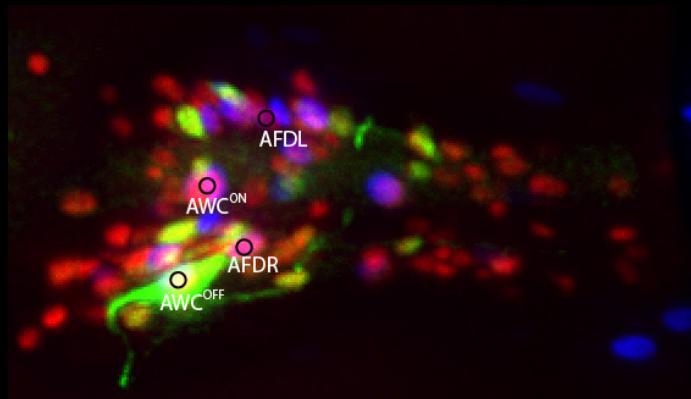
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Encoding Dynamics



Laurent & co-workers 2008

W



Manuel Zimmer
et al 2012-present

W

Manduca

Low-Dimensional Subspaces

W

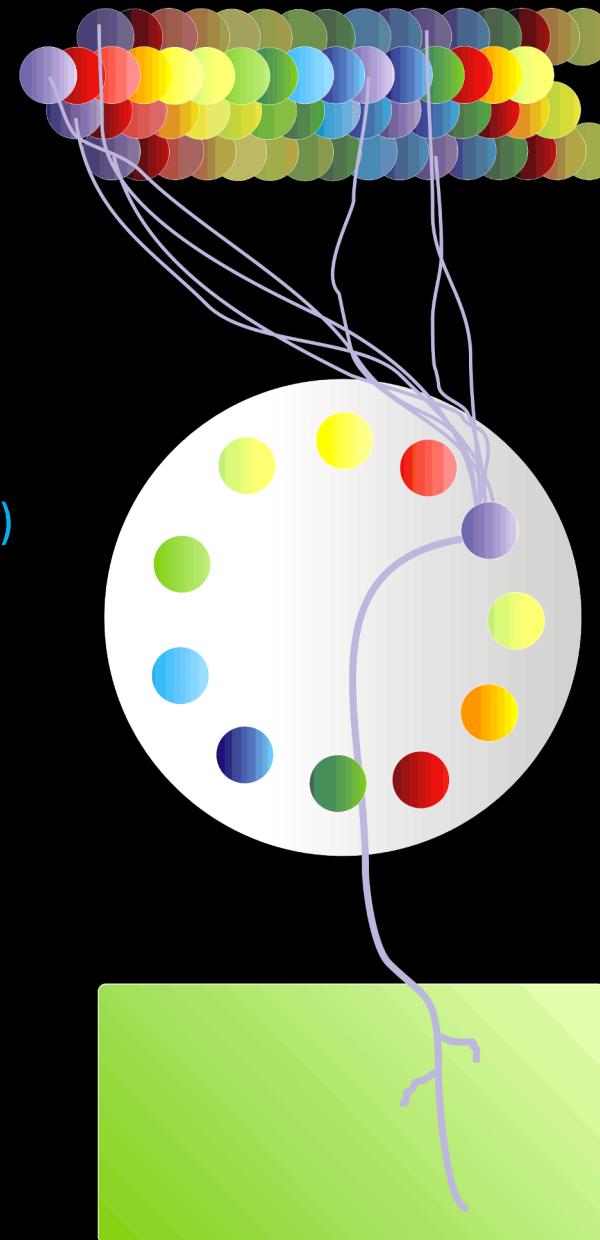
Olfactory receptor
cells

10^6 neurons

Antennal lobe (AL)

10^3 neurons

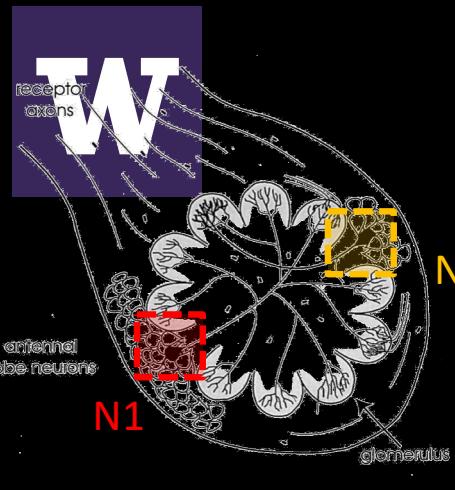
Mushroom body



Eli Shlizerman + Jeff Riffell, UW Biology

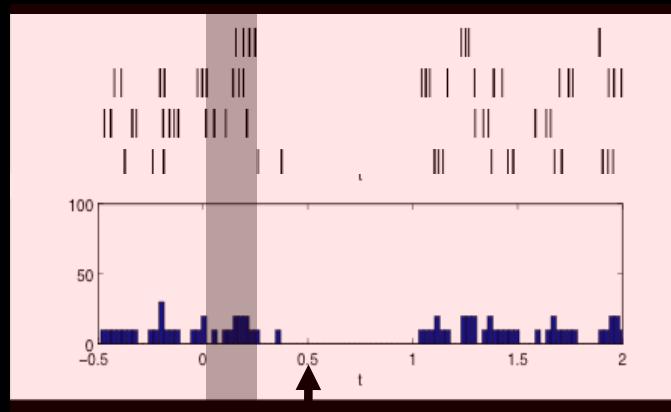


A

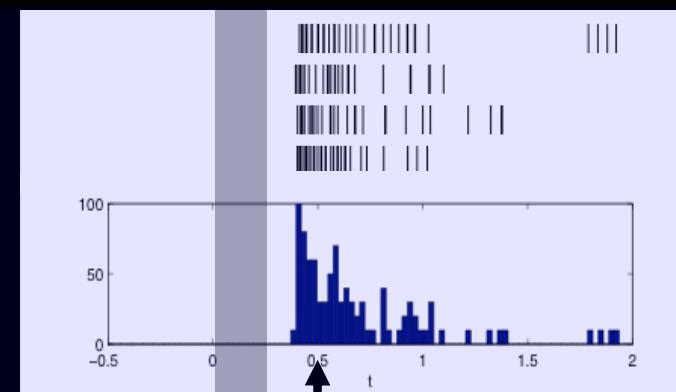


Data Driven Projections

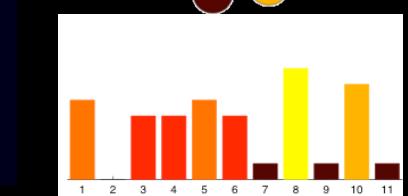
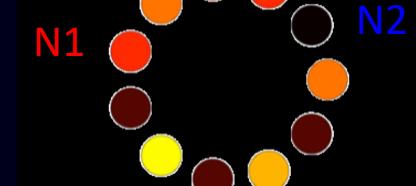
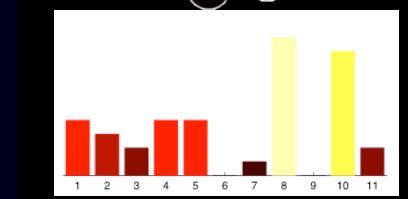
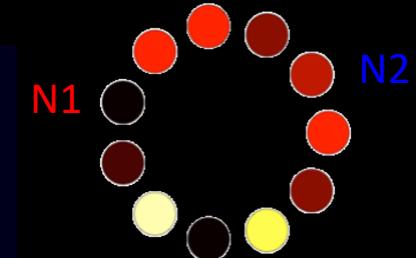
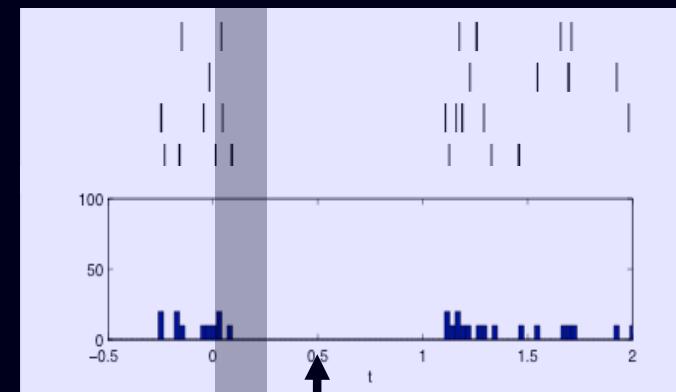
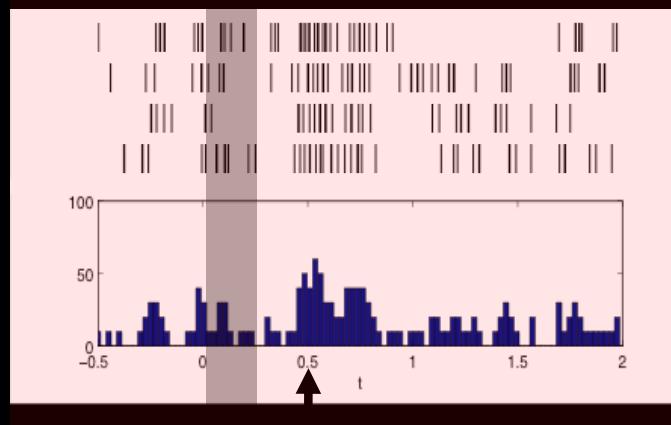
Odor A



N2

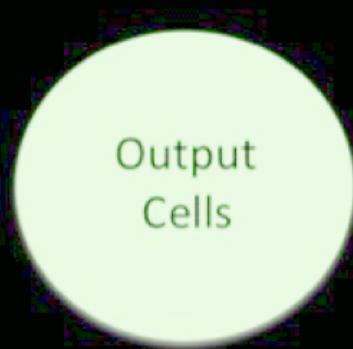


Odor B



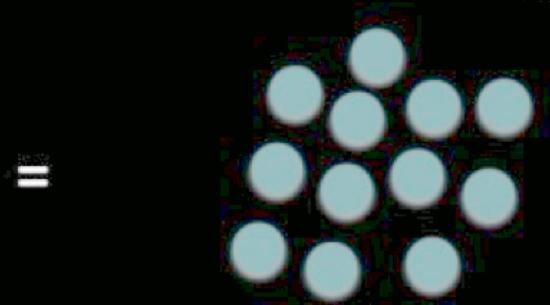
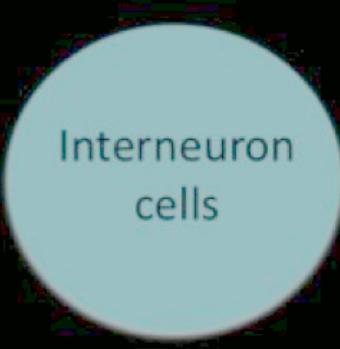
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Spatio-Temporal Coding Modes



$$= \sigma_1 + \sigma_2 + \dots$$

A circular diagram representing interneuron cells. It contains several blue circles of varying sizes, representing different firing rates or activity levels.



$$\vec{V}^{out}(t) = \sum_{m=1}^M \sigma_m a_m(t) \vec{V}^{PC}$$

$$\frac{d}{dt} a_1(t) = -a_1(t) + \langle \phi\left(-r^I(t), \vec{I}_{sen}^P(t)\right), \vec{r}_1^{PC} \rangle$$

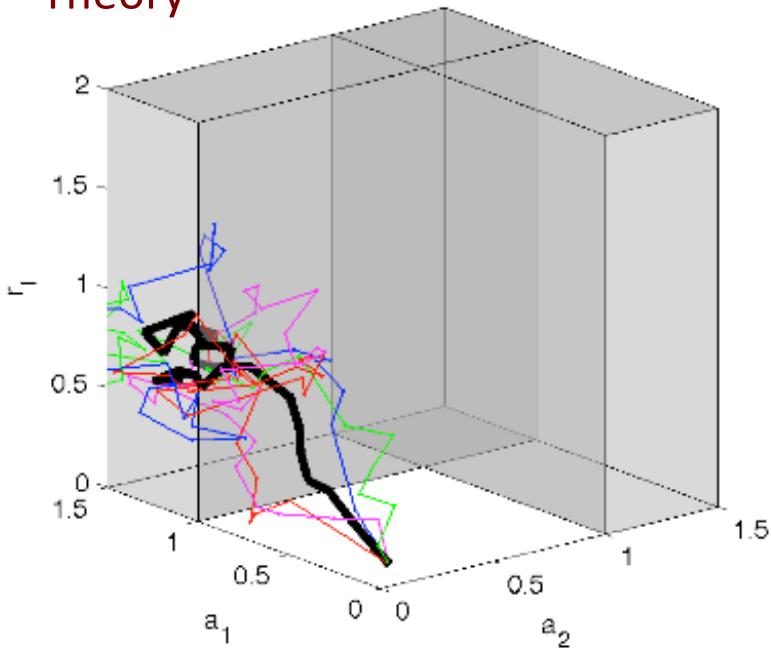
$$\frac{d}{dt} r^I(t) = -r^I(t) + \psi\left(a_1(t), \vec{r}_1^{PC}, I_{sen}^L(t), I_{sen}^G(t)\right)$$

Model of olfaction: *Spatio-temporal competing modes*

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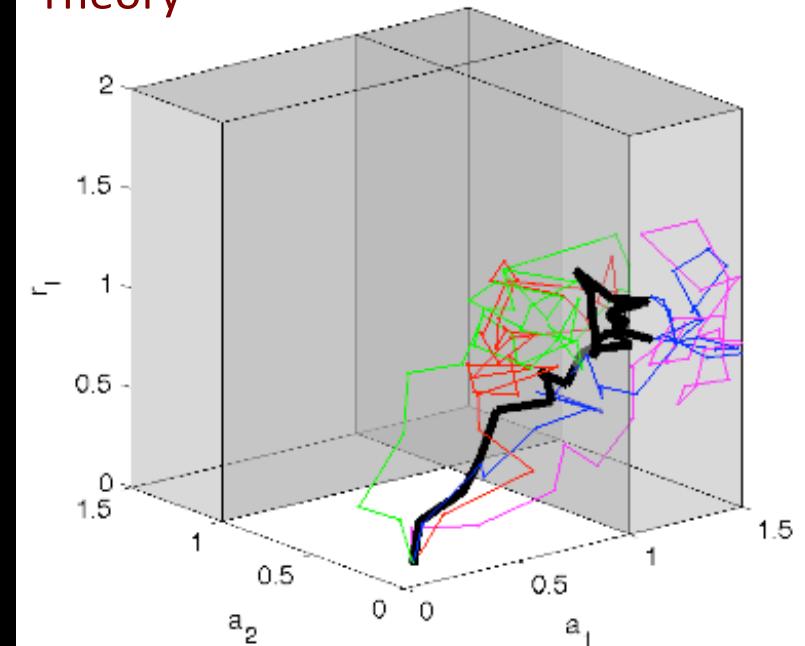
Encoding Competition Dynamics

Theory

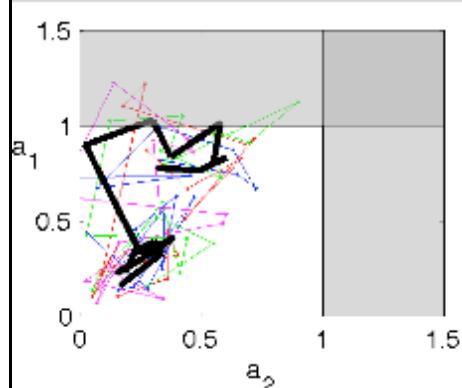


3x3
dynamical
system

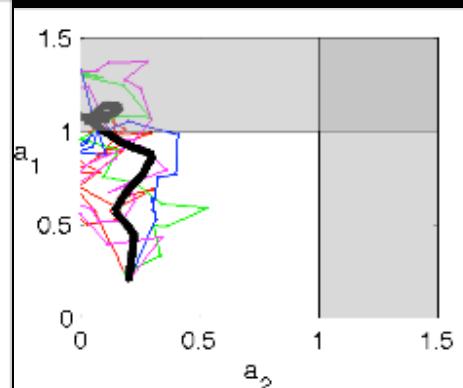
Theory



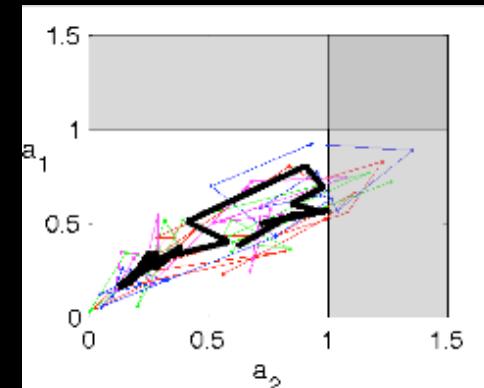
Experiment



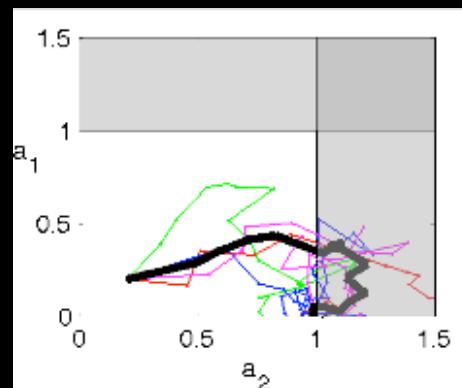
Theory



Experiment



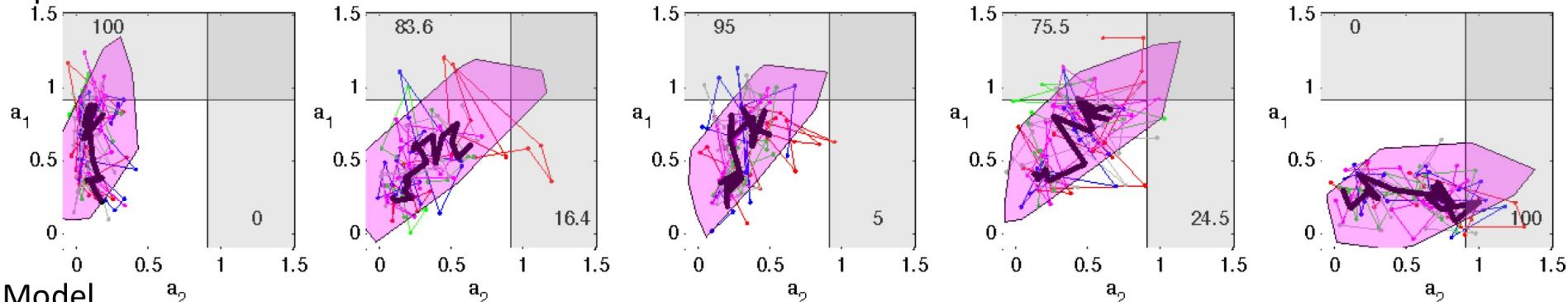
Theory



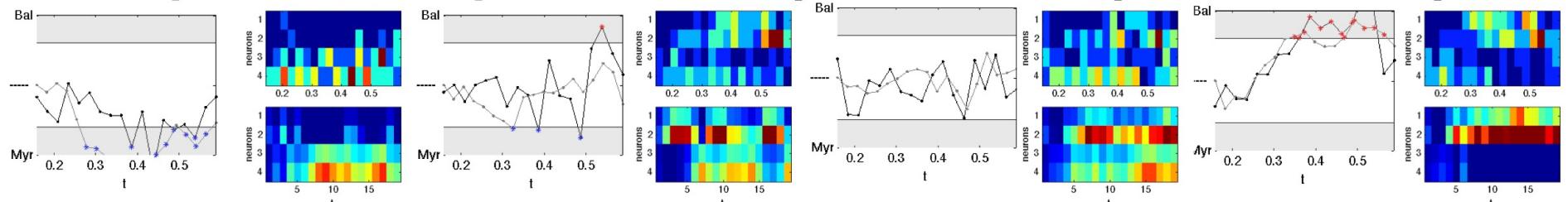
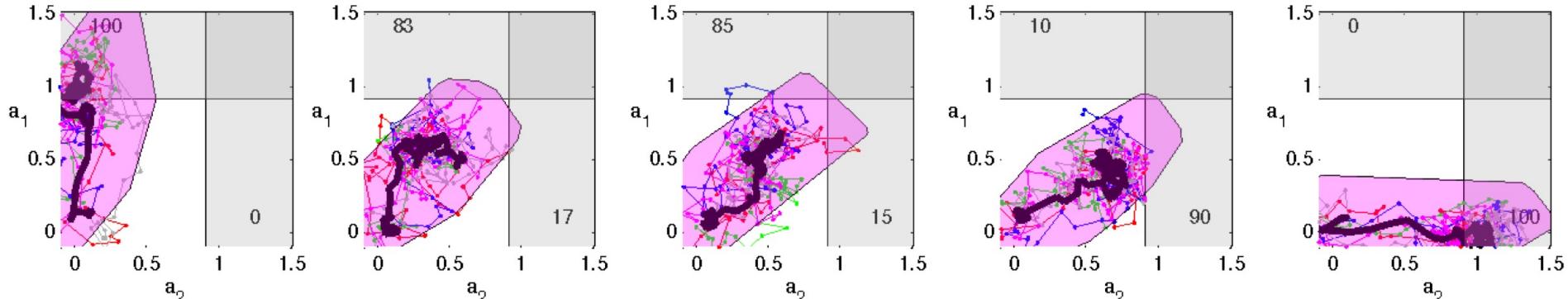
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Inhibition Mediates

Experiment



Model



Myr

Bal

W

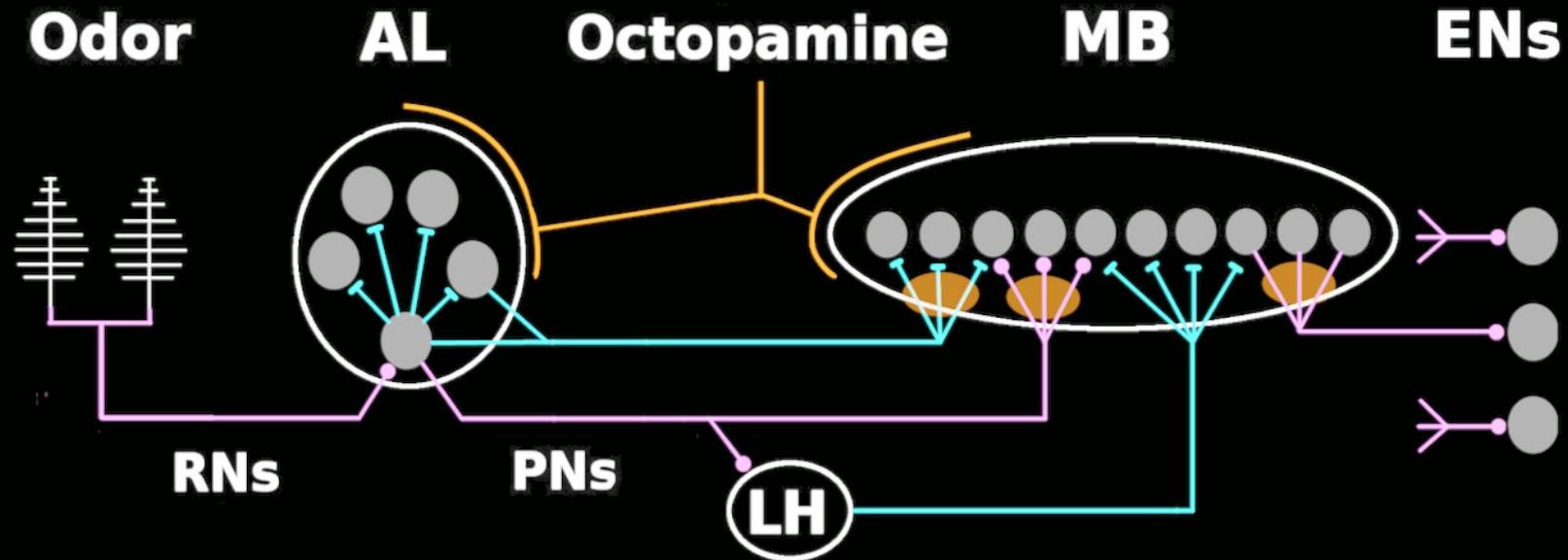
Manduca

Randomness and sparsity



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Moth Olfactory System



Riffell et al. *Science* 2013

Campbell et al. *J Neuro* 2013

Olson et al. *Neuron* 2010

Turner et al. *J NeuroPhysiol* 2008 Hong,
Wilson. *Neuron* 2015

Gupta, Stopfer. *J NeuroSci* 2012

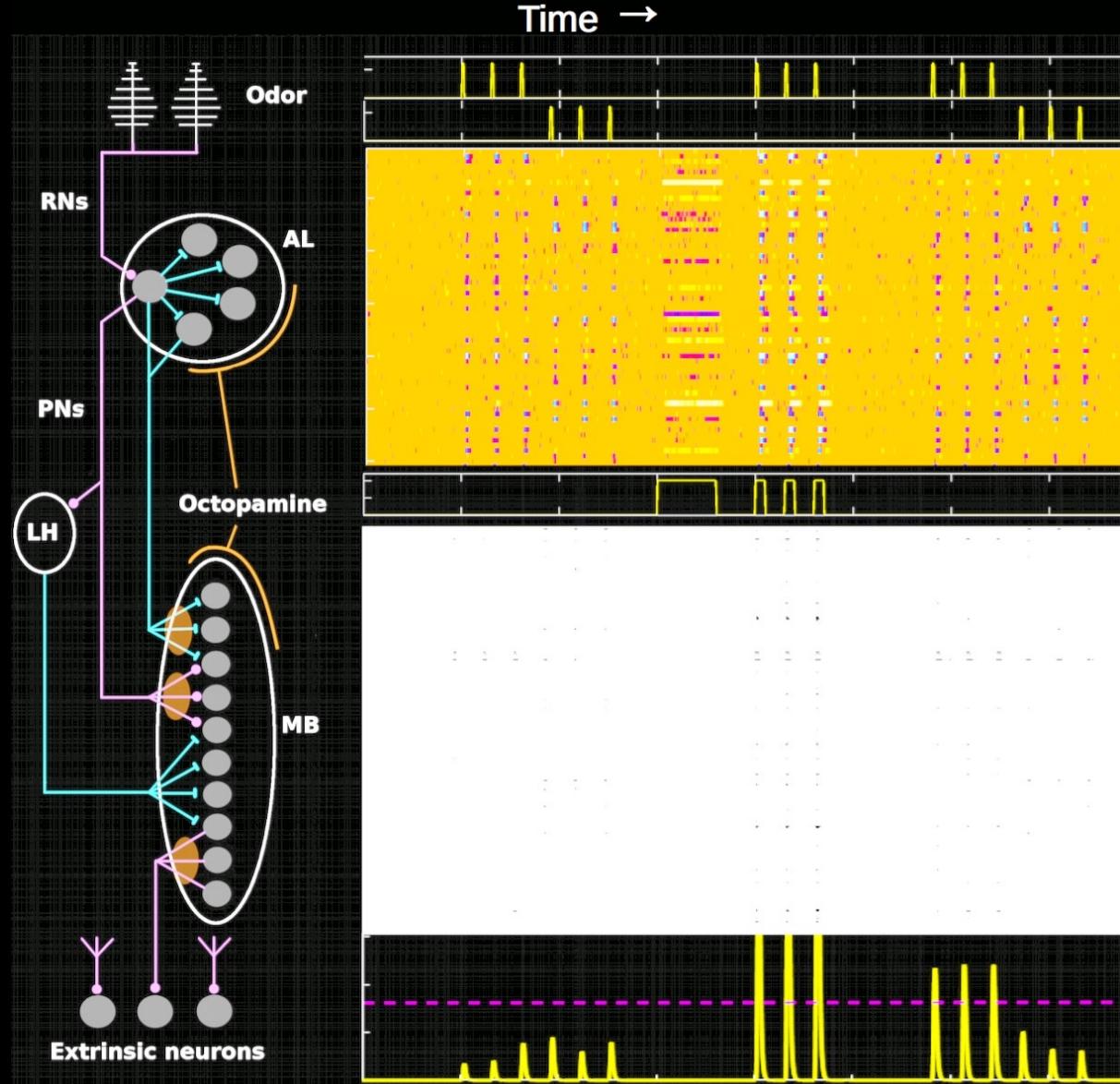
Silbering et al. *J NeuroSci* 2003

Galizia. *Eur J NeuroSci* 2014

Caron et al. *Nature* 2013

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Learning New Odors



Odor inputs

AL response

Octopamine

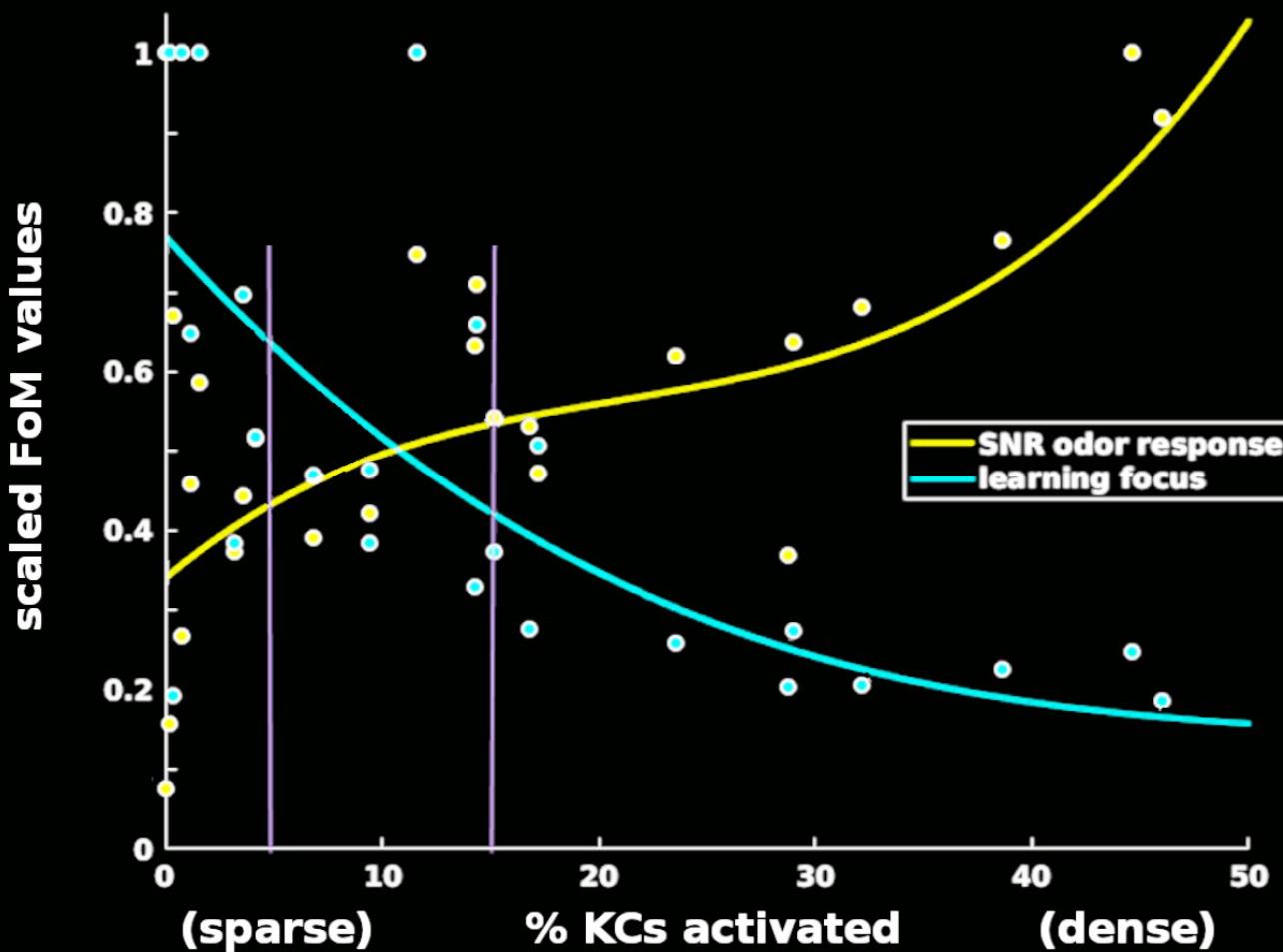
MB response

Readout neuron

Delahunt, Riffell & Kutz (2019)

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Sparsity for Learning



Signal to Noise = μ/σ of odor response.
high → reliable response.

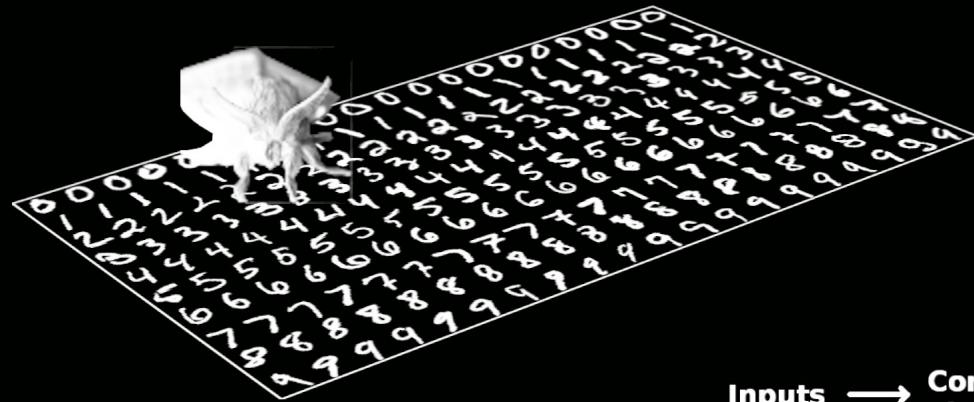
High → good.

Learning focus =
 $\Delta \text{Trained} / \Delta \text{Control}$.
high → focused learning.

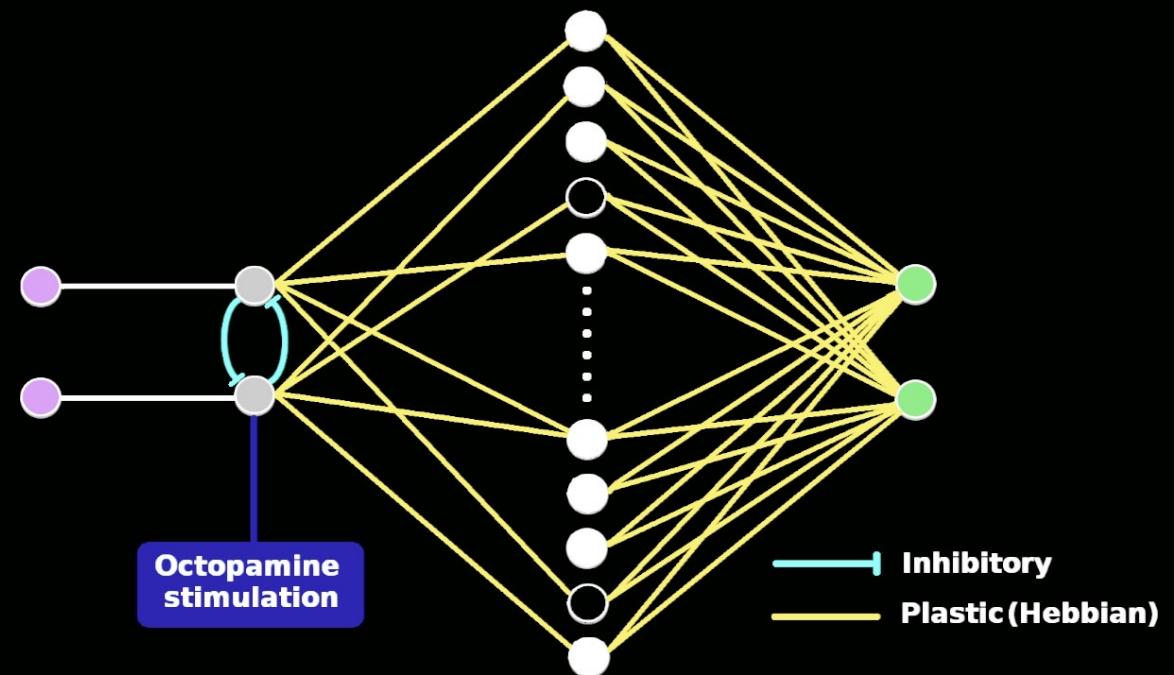
(Huerta, Nowotny;
Peng, Chittka)

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Rapid Learning in NNs



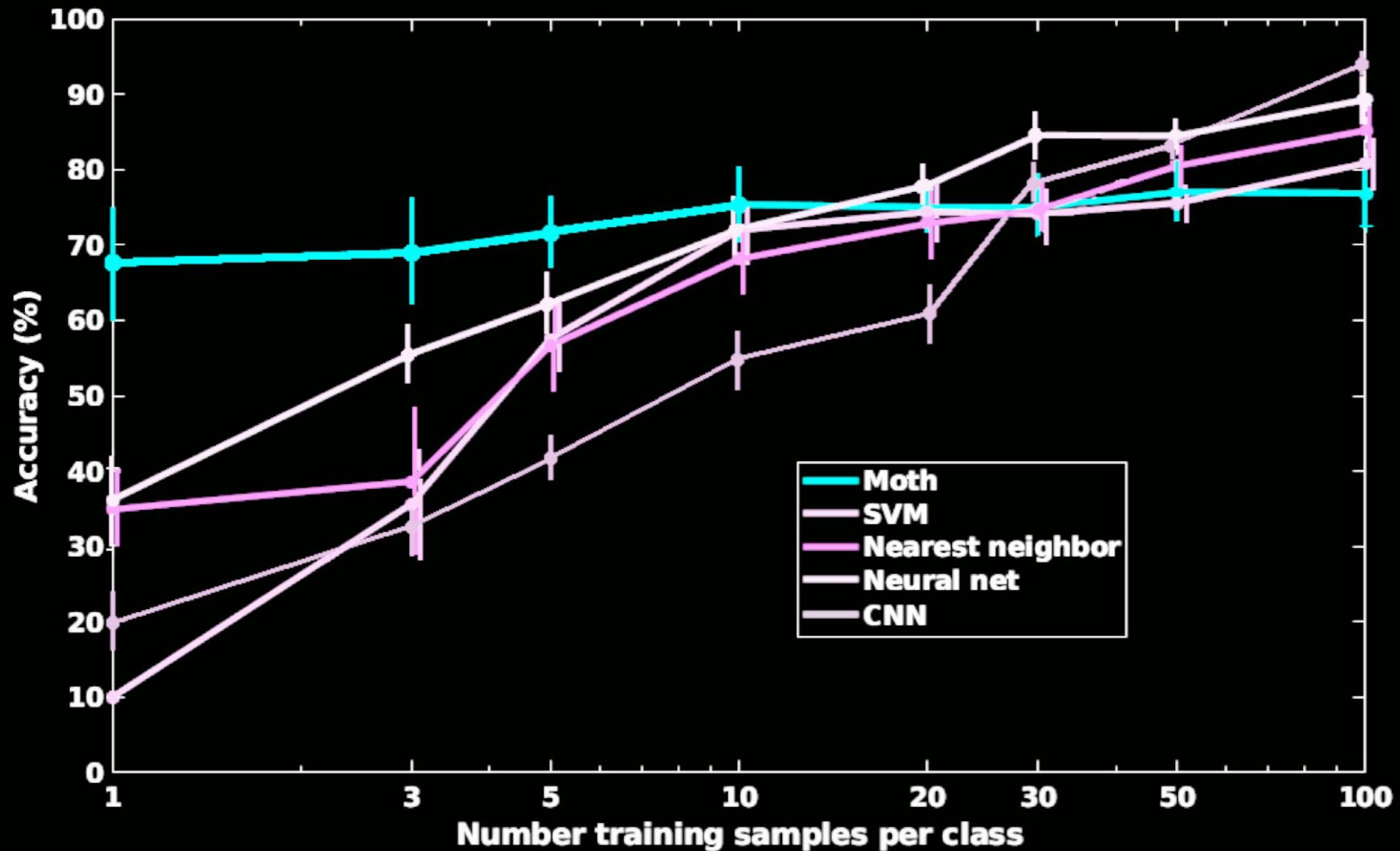
Inputs → Competitive inhibition $\xrightarrow{\approx 50x}$ Sparse (5 to 15%) $\xrightarrow{\approx \frac{1}{200}x}$ Readouts



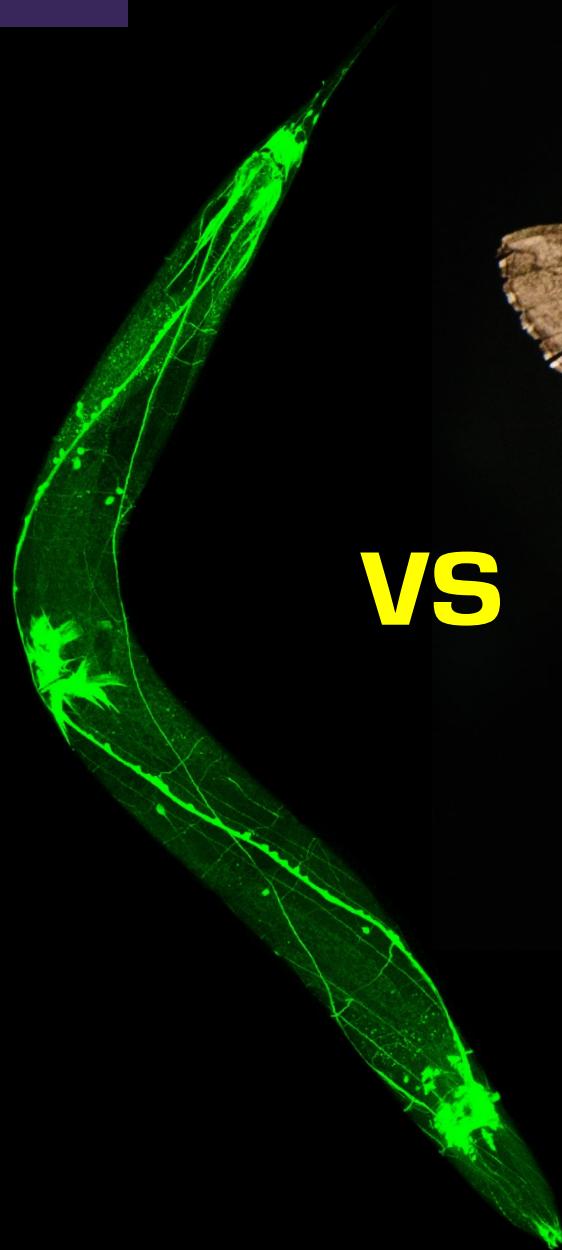
Delahunt & Kutz (2019)

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Comparisons



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VS

