CS-E577005 - Computational Theories of the Brain

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Topic presentation (week 1)

Aalto University, April 25, 2024

Topics

- T4 - Hopfield networks
- T5 - Ring attractors
- T6 - Control loops in the brain
- T7 - Chaos

T4 - Hopfield networks

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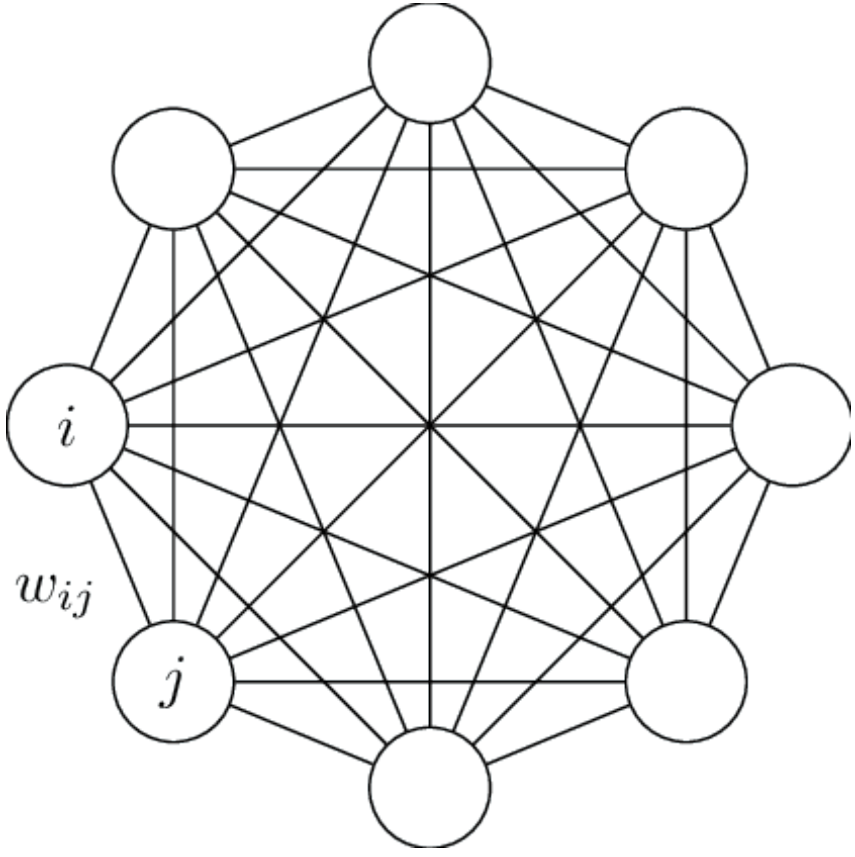
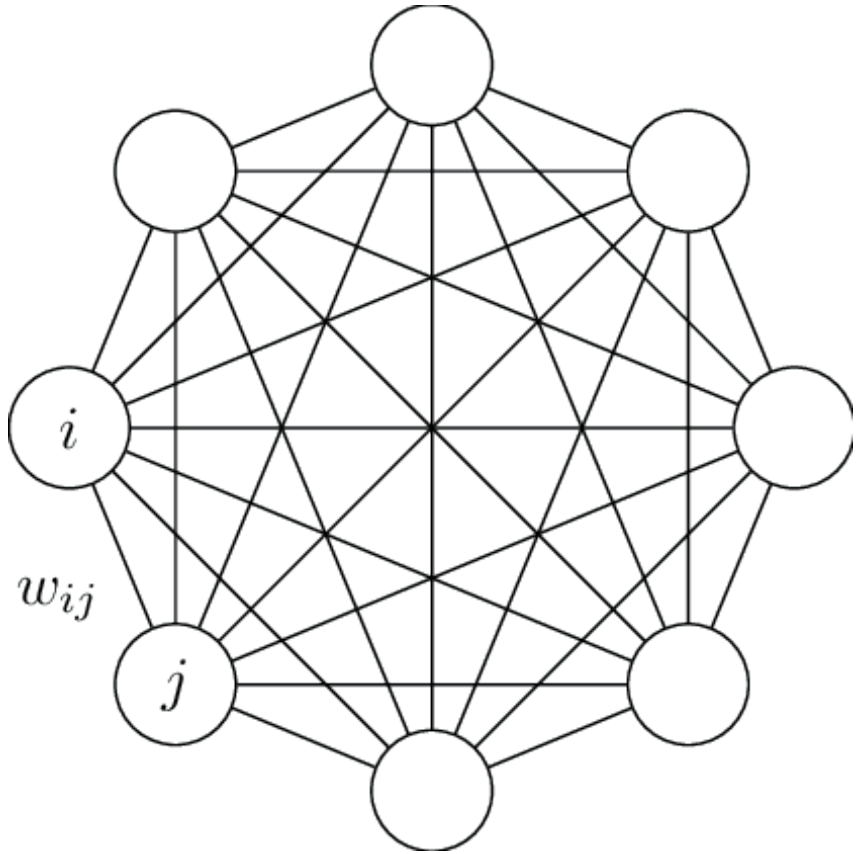
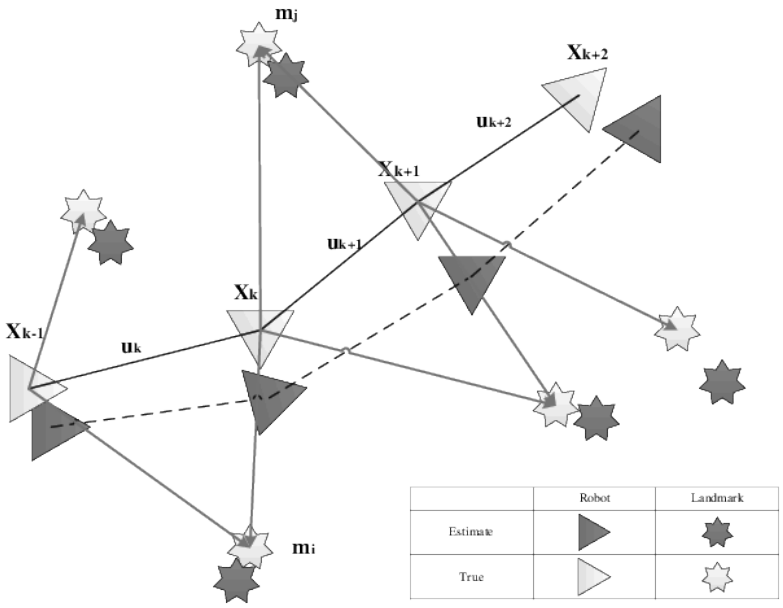


T4 - Hopfield networks



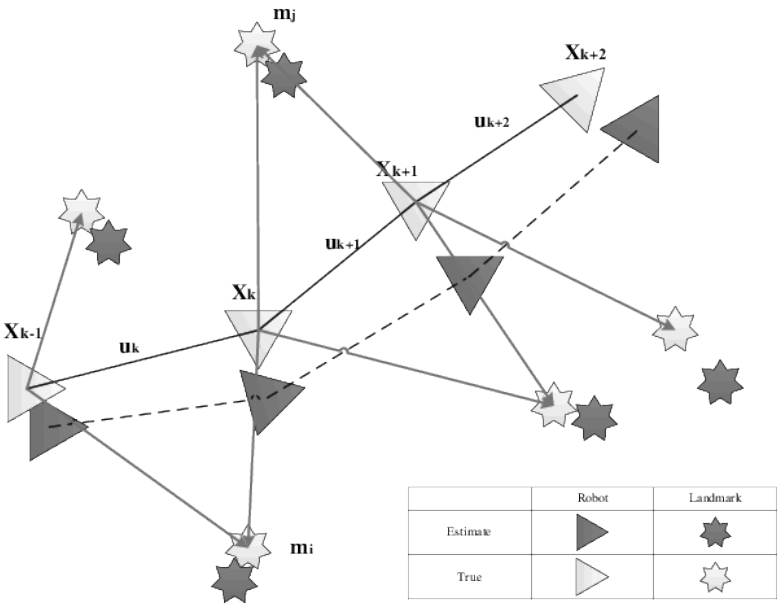
Structure of a Hopfield network (*Hopfield, 1982)*.

T5 - Attractor networks



Sketch of the SLAM problem.

T5 - Attractor networks



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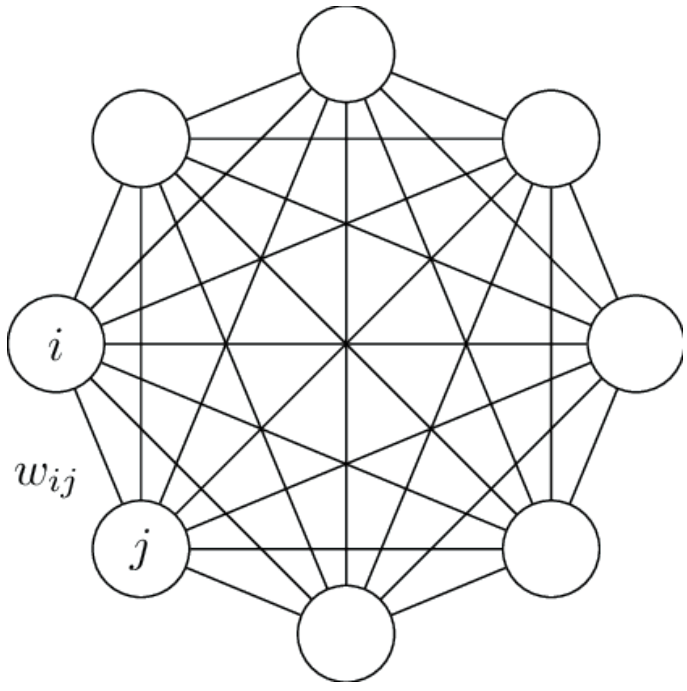

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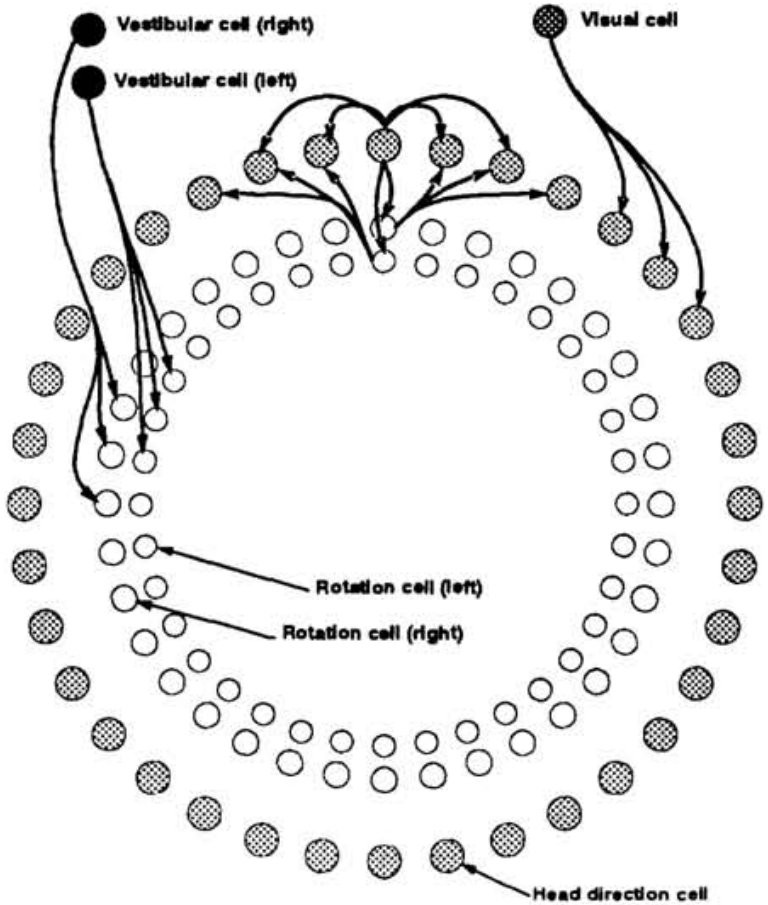

Hypothesised... (*Skaggs et al., 1994*)

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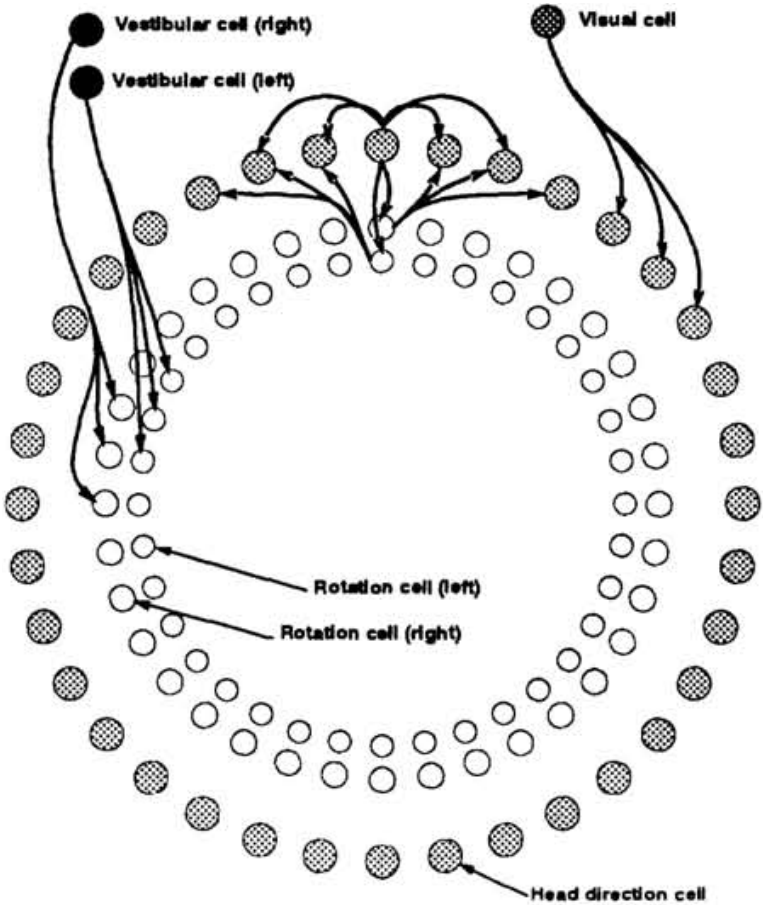

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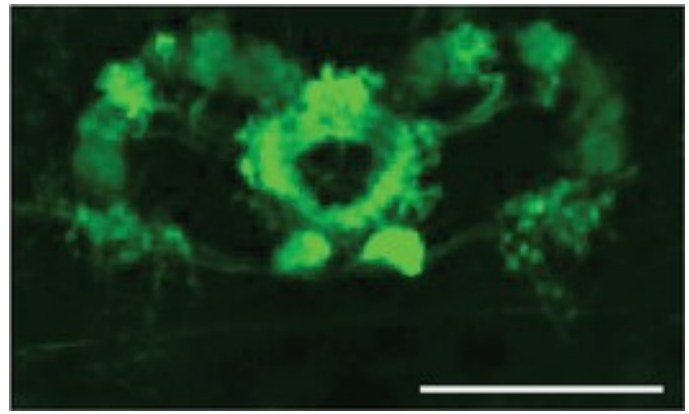

...and observed (*Jayaraman et al., 2017*).

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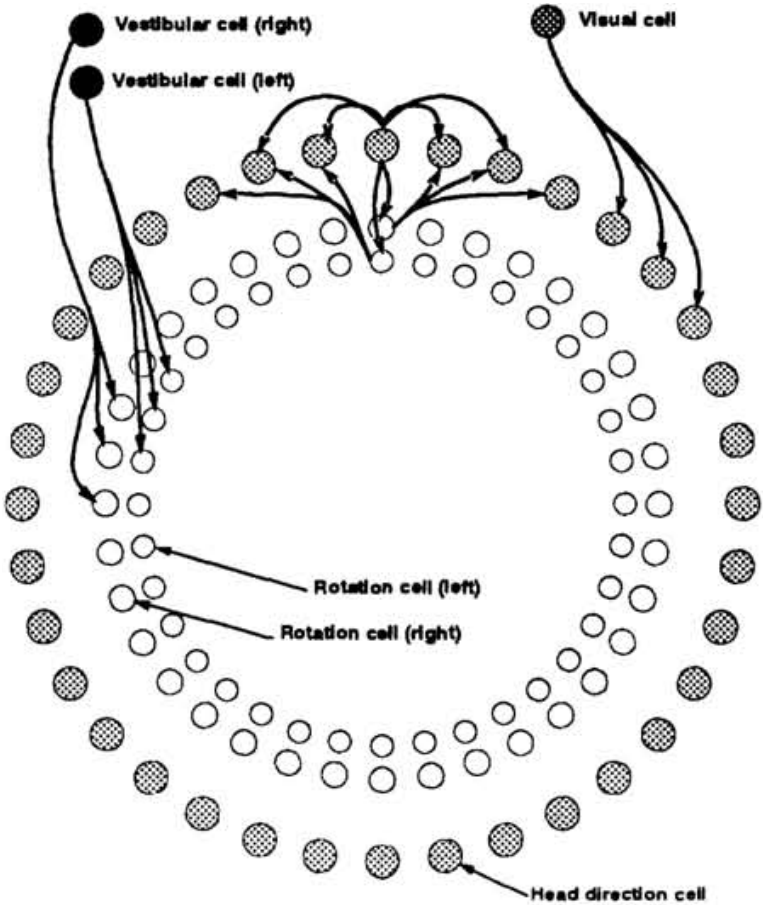

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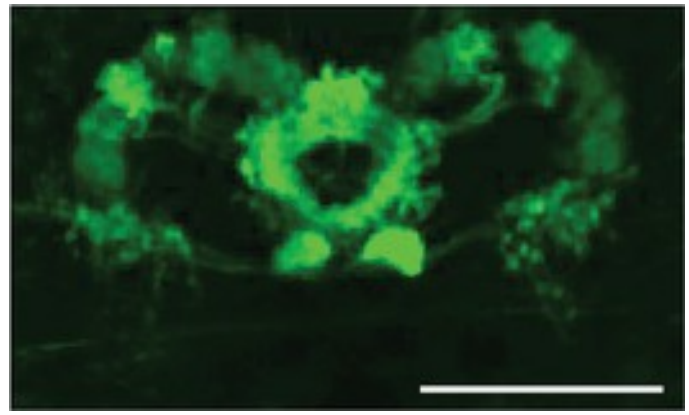

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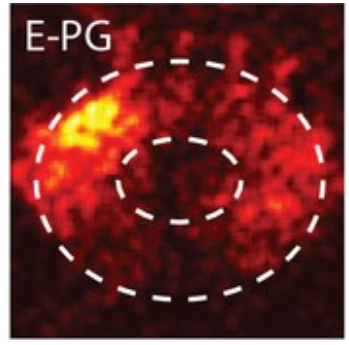
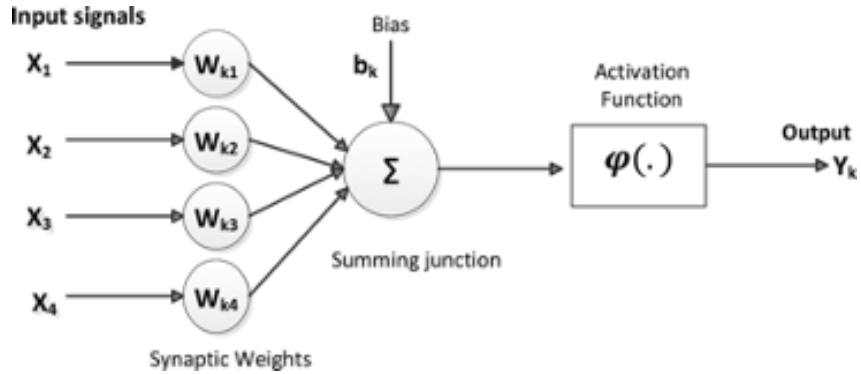


Activation bump along the ring acting as a compass (*Jayaraman et al., 2017*).

T6 - Control loops in the brain



McCulloch and Pitts model (*McCulloch and Pitts, 1943*).

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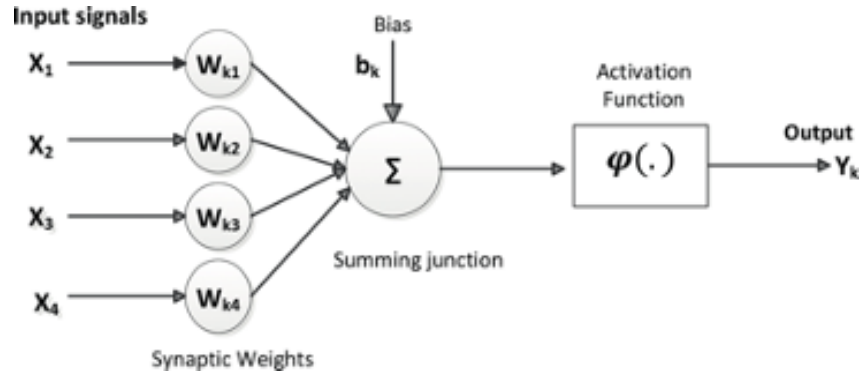

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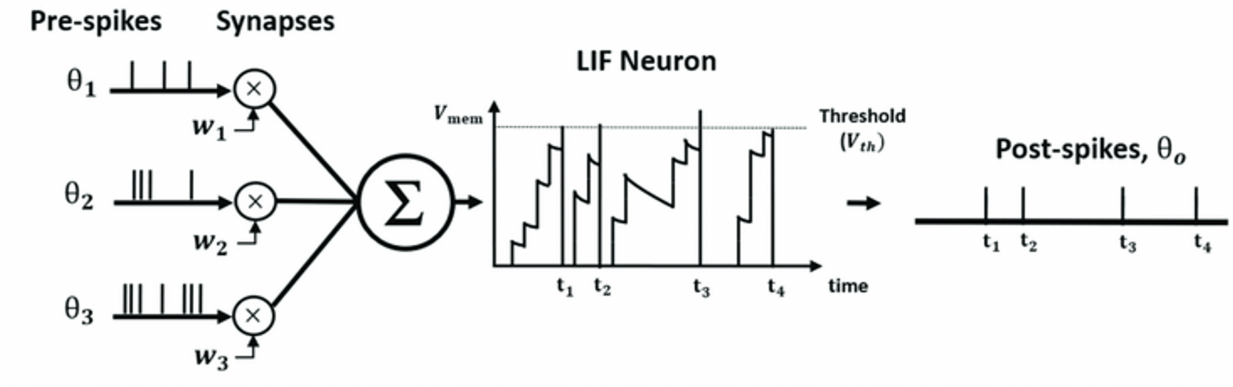

Leaky Integrate and Fire (LIF) model (*Rall et al., 1967)*.

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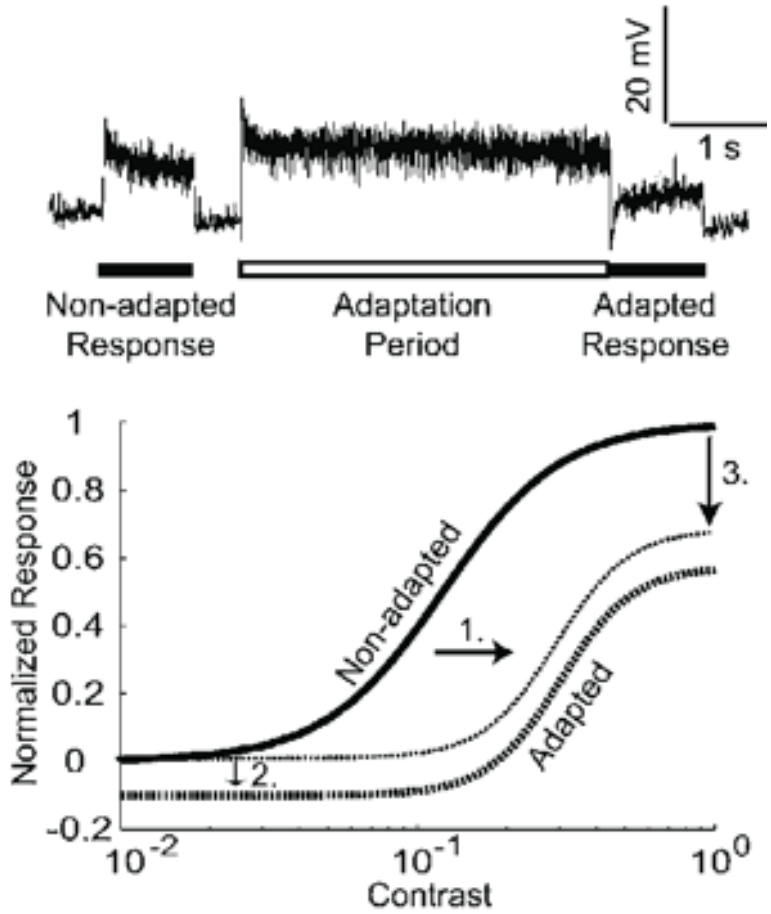
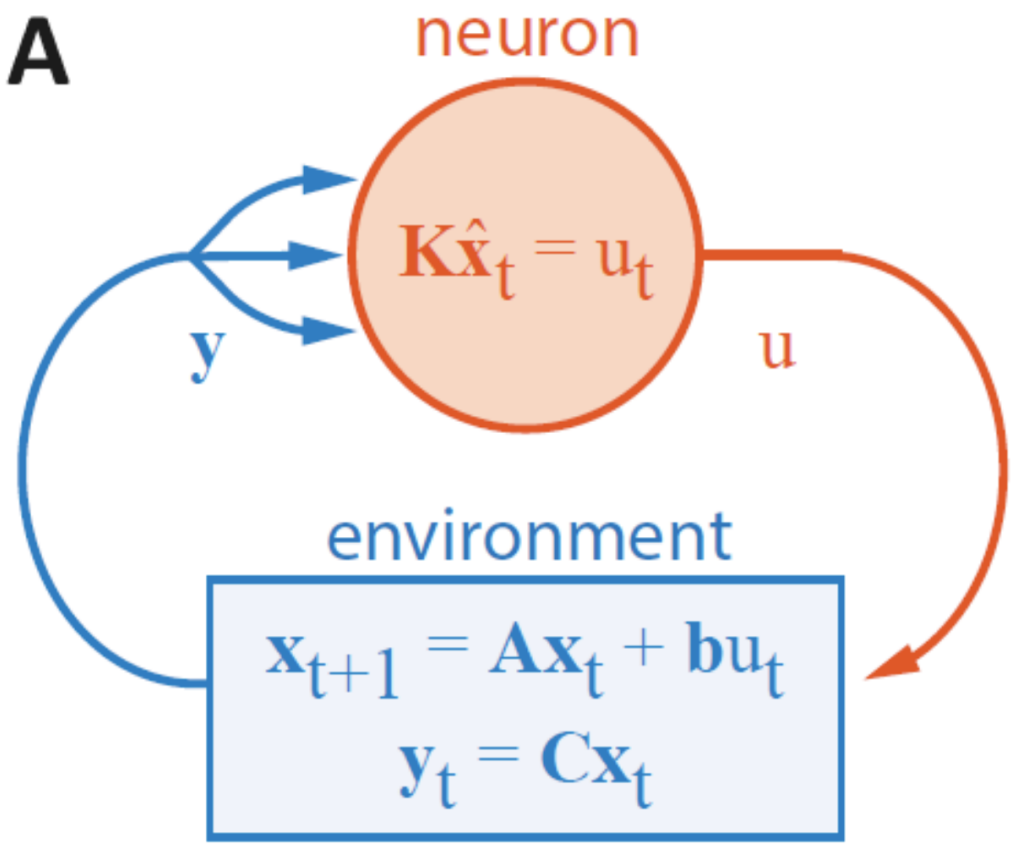


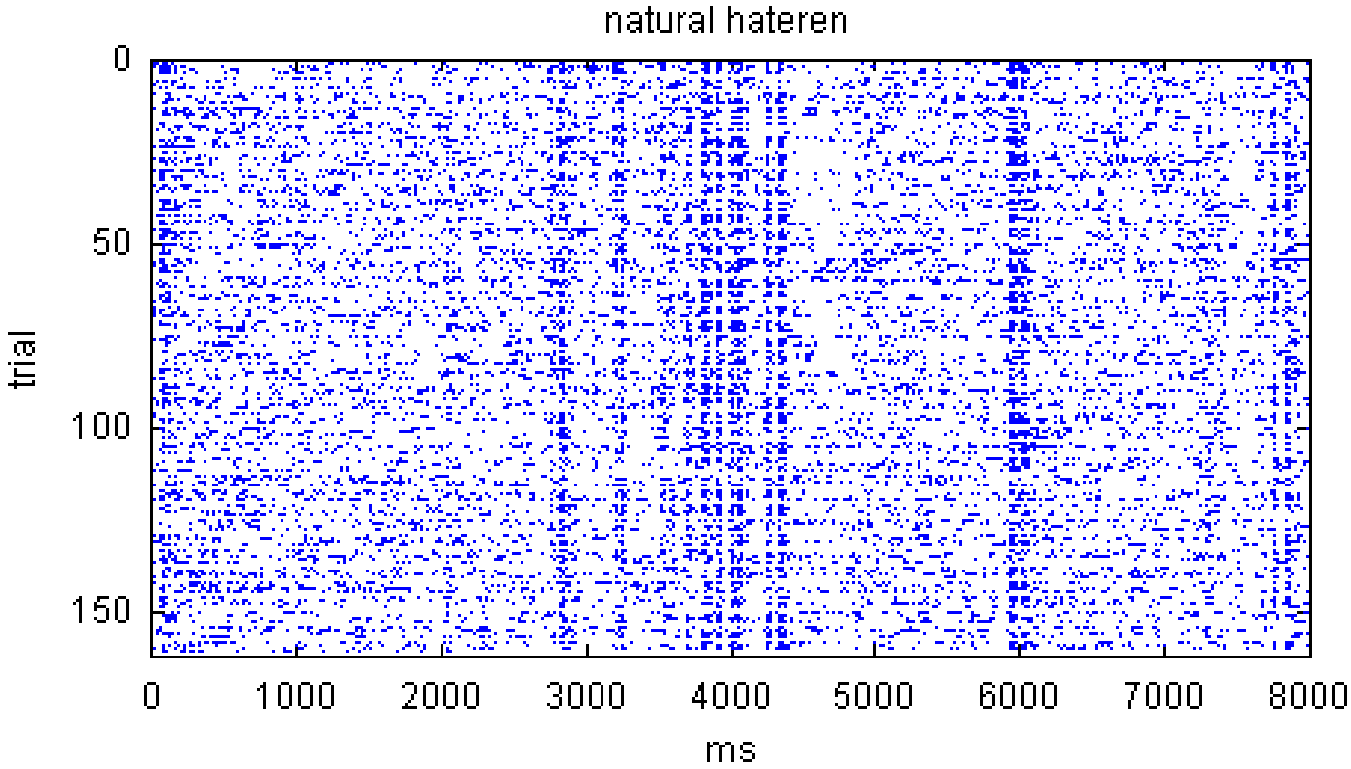
Adaptation in the neural response (*Harris et al, 2000*).

T6 - Control loops in the brain



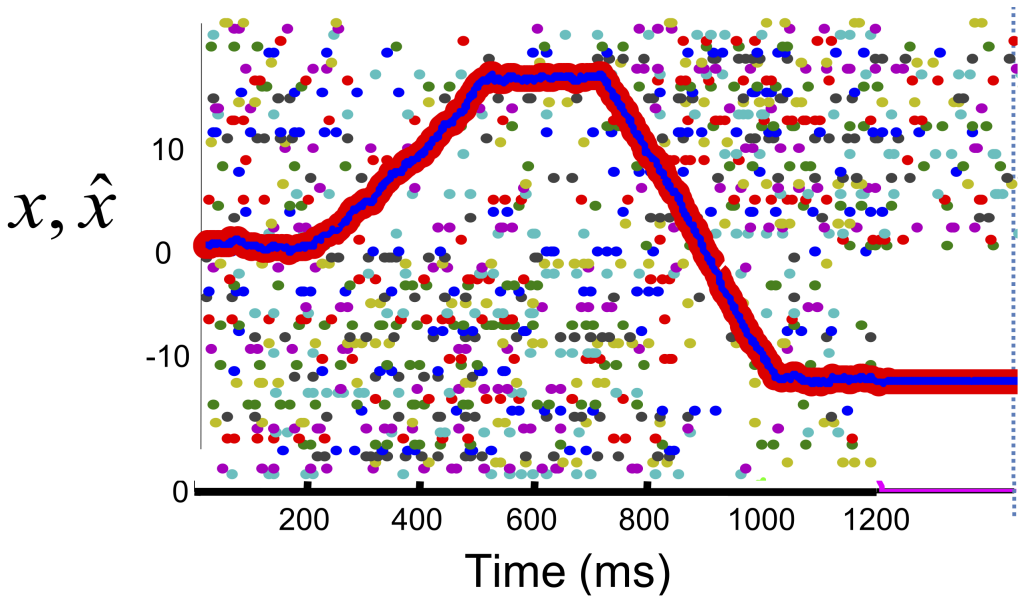
Neurons as adaptive controllers, *Chklovskii et al., 2024.*

T6 - Control loops in the brain



Neural spike train response of an LGN neuron to a same stimulus across trials (*Anderson et al., 2006*).

T6 - Control loops in the brain



Dynamics estimation by collective neural behaviour (*Deneve et al., 2013*).

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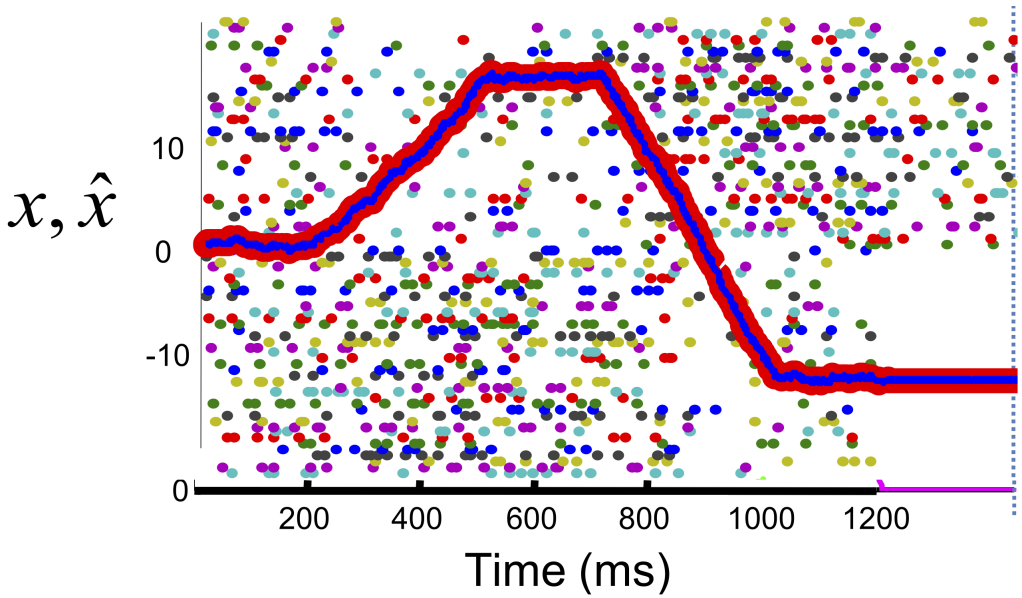

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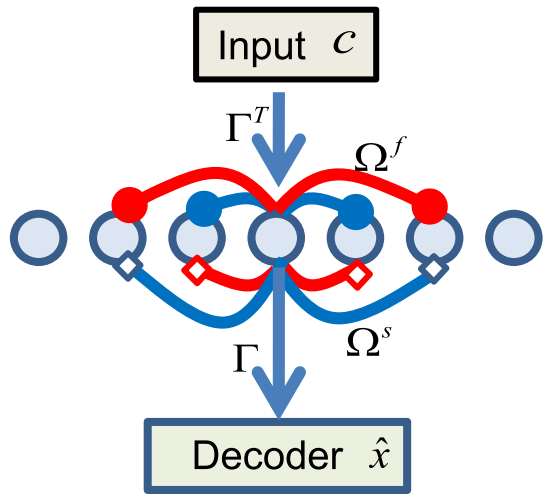
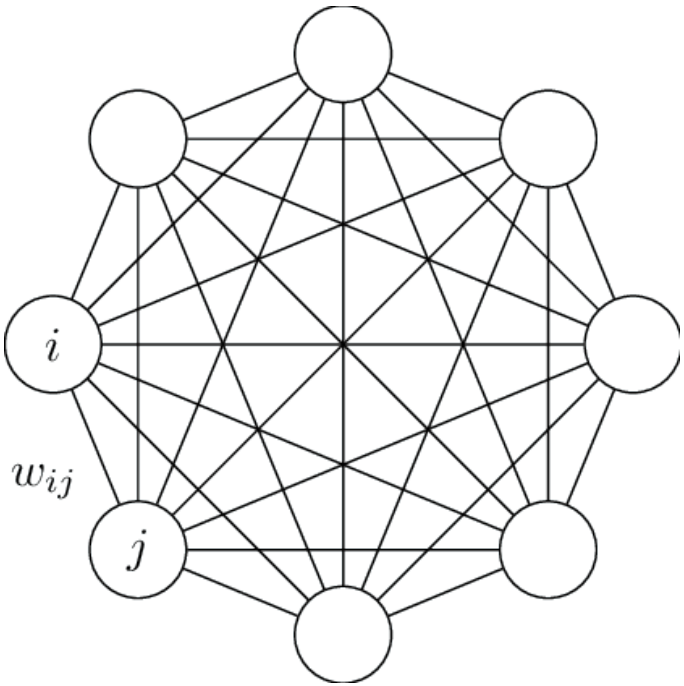


Model sketch, with excitatory and inhibitory connections (*Deneve et al., 2013*).

T7 - Chaos



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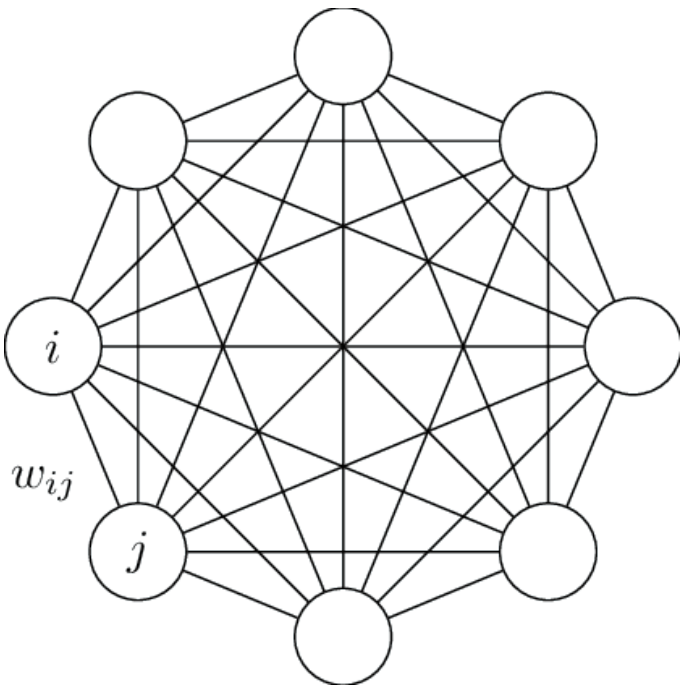

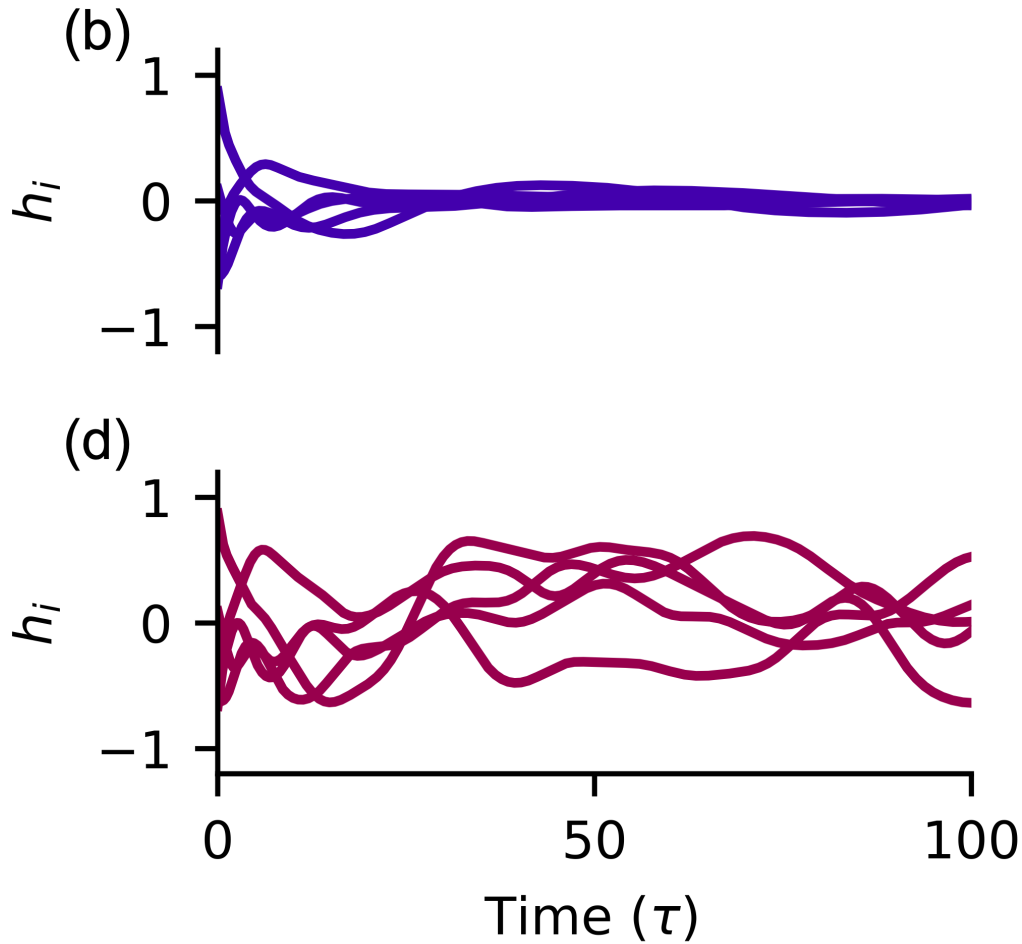

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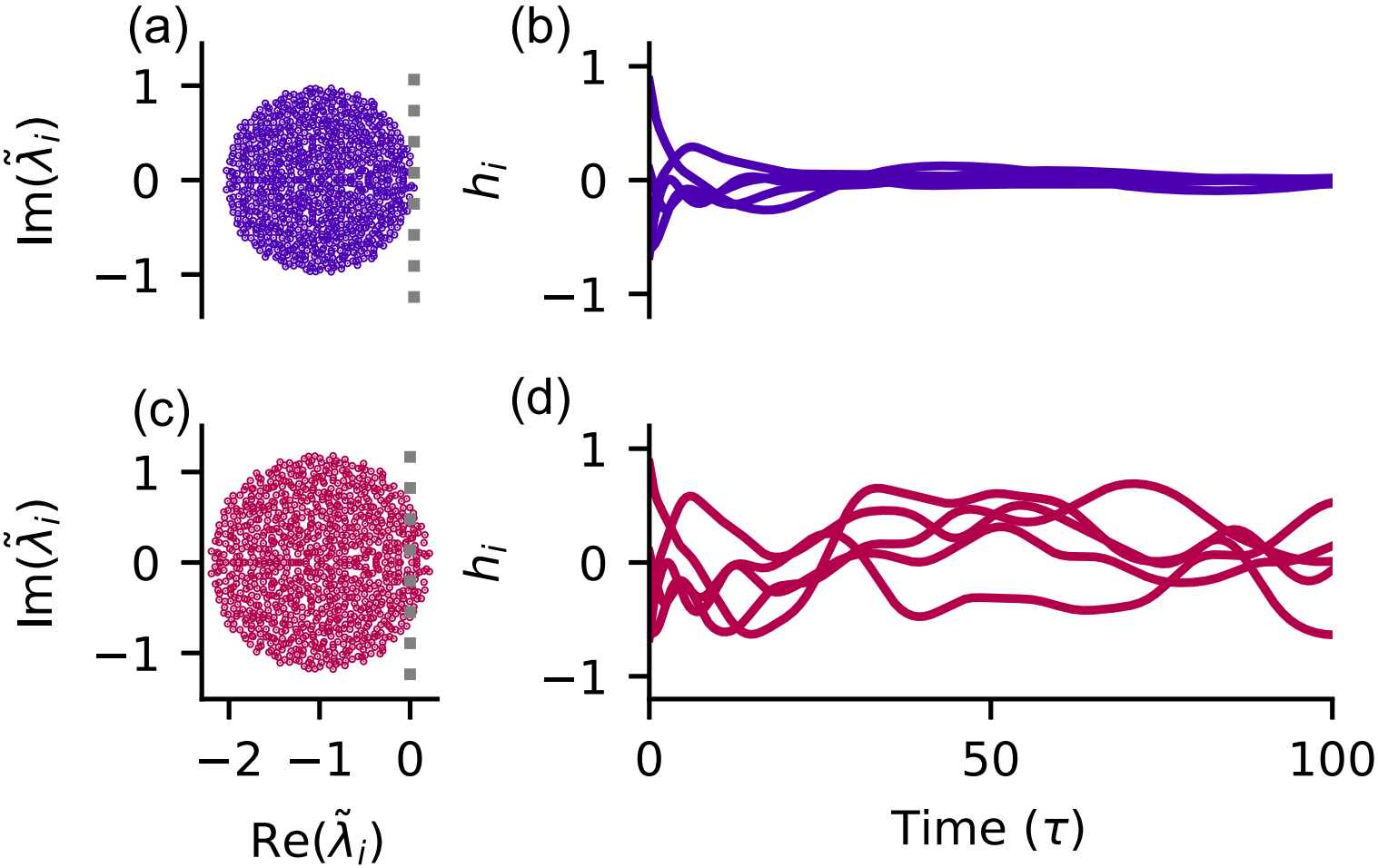
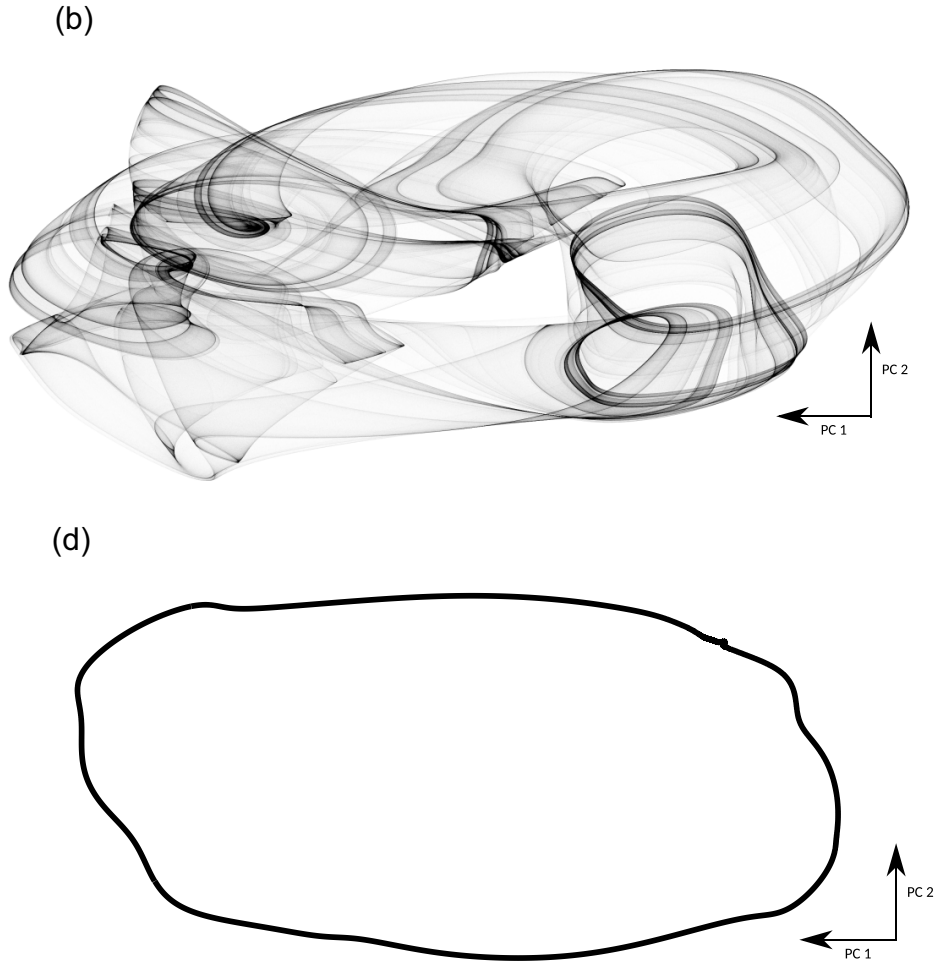


Fixed point vs. chaotic RNN behaviour (*Engelken et al, 2023*).

T7 - Chaos



Activation trajectories for untrained and trained RNNs (*Engelken et al, 2023*).