

Mechanisms of pattern decorrelation by recurrent neuronal circuits

-Wiechert, et. al.

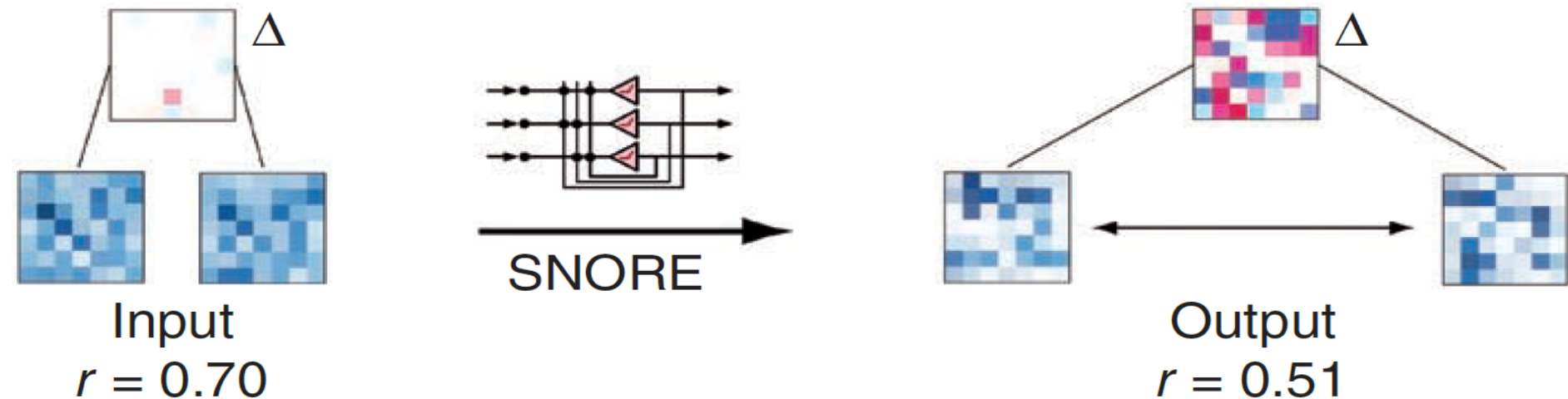
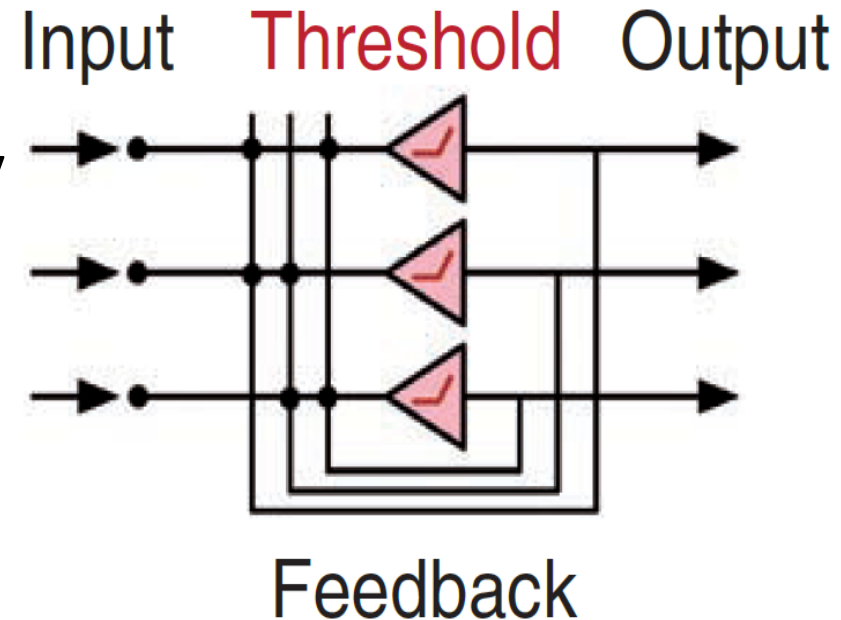
Nature Neuroscience, 2010

Presented By:

Achint

Punchline

- Theorem 1: Thresholding alone causes decorrelation
- Theorem 2: Recurrent connectivity amplifies decorrelation (reTIDe)
- Theorem 3: Recurrent-enhanced decorrelation increases with:
 - a) Sparse Connectivity
 - b) High Baseline Activity



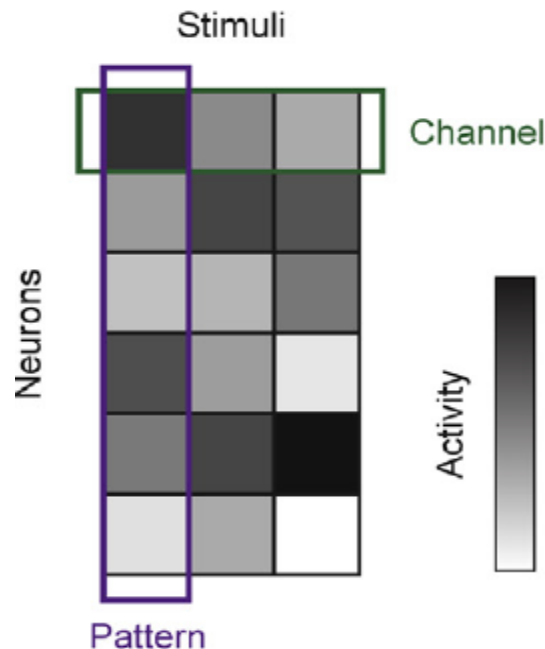
Types of Decorrelation

Pattern Decorrelation

- Reduce overlap in combinatorial pattern of activity across populations of neurons
- Eg: Olfactory Bulb, Retina, dentate gyrus
- Algo: reTIDE

Channel Decorrelation

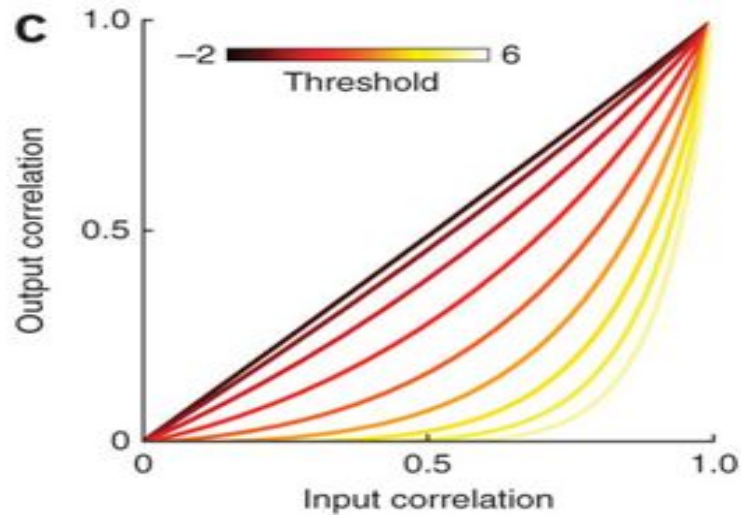
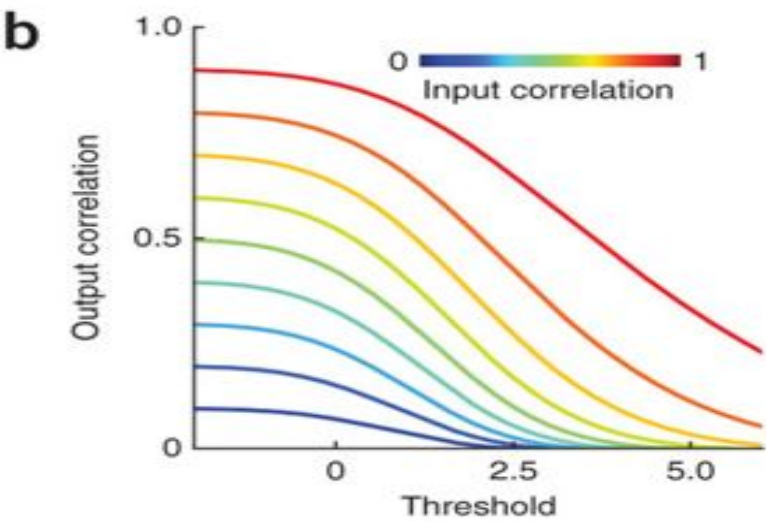
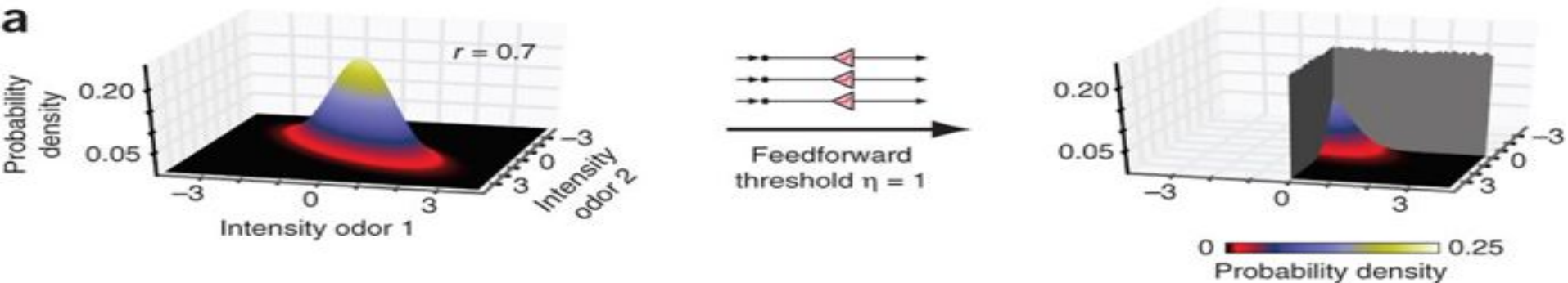
- Reduce response profile overlap of individual neurons in a neuronal population
- Eg: Place cells, V1 neurons
- Algo: PCA, ICA



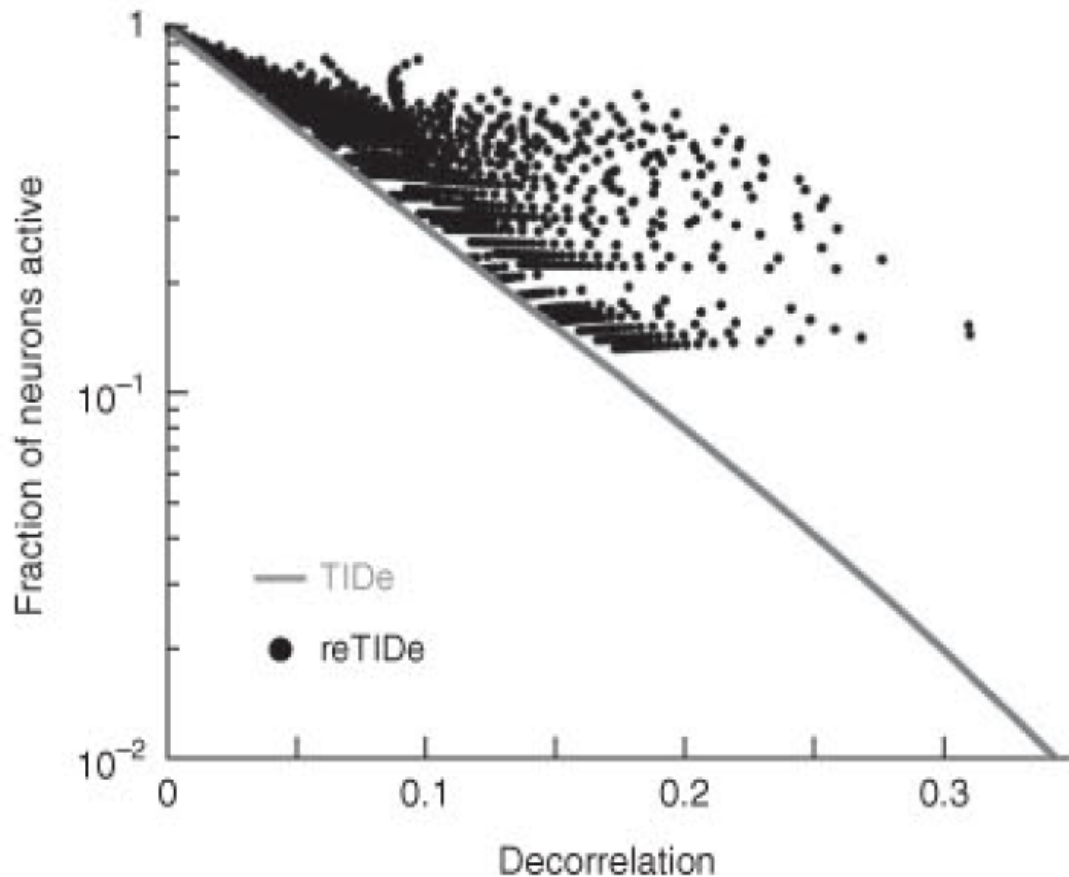
Theorem 1: Thresholding alone causes decorrelation

$$\tau \dot{x}_\alpha(t) = -x_\alpha(t) + a_\alpha(t) + L \left[x_\alpha(t) - \eta_0 \right]_+$$

$$x_\alpha = a_\alpha + L \left[x_\alpha - \eta_0 \right]_+$$

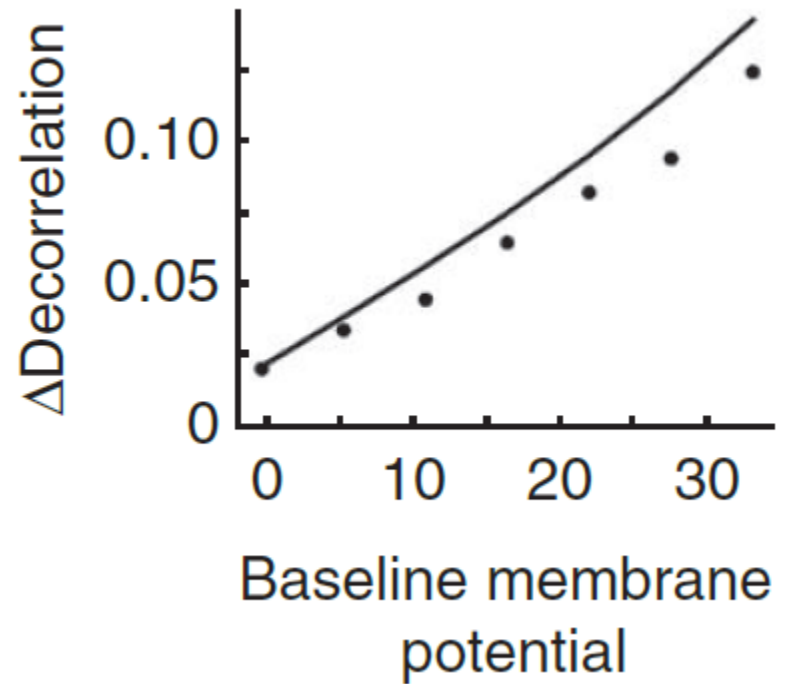
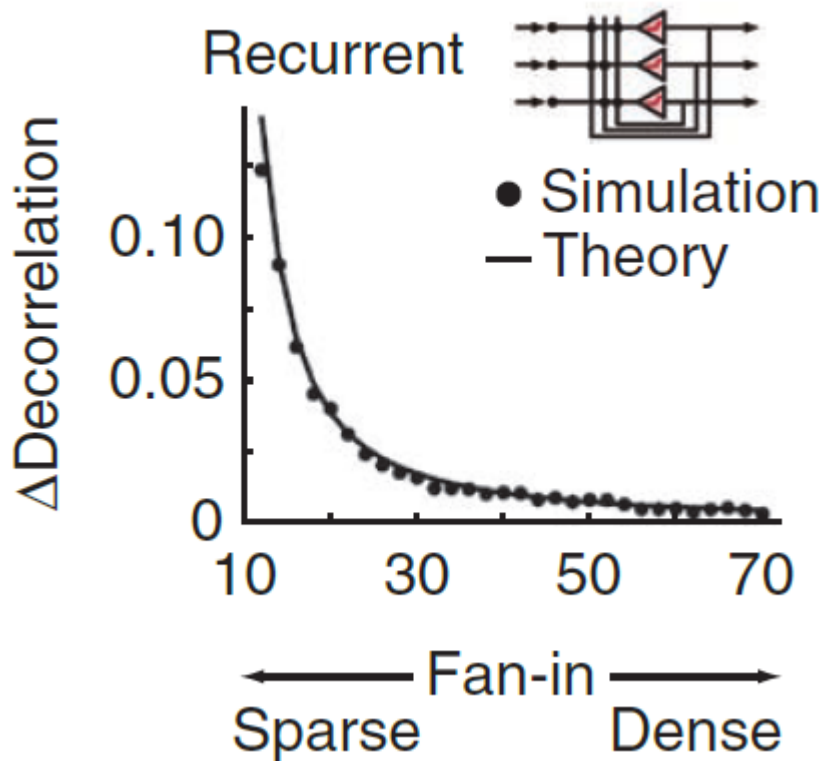


- Problem: High threshold silences most neurons
- Solution: Add recurrence (Theorem 2)

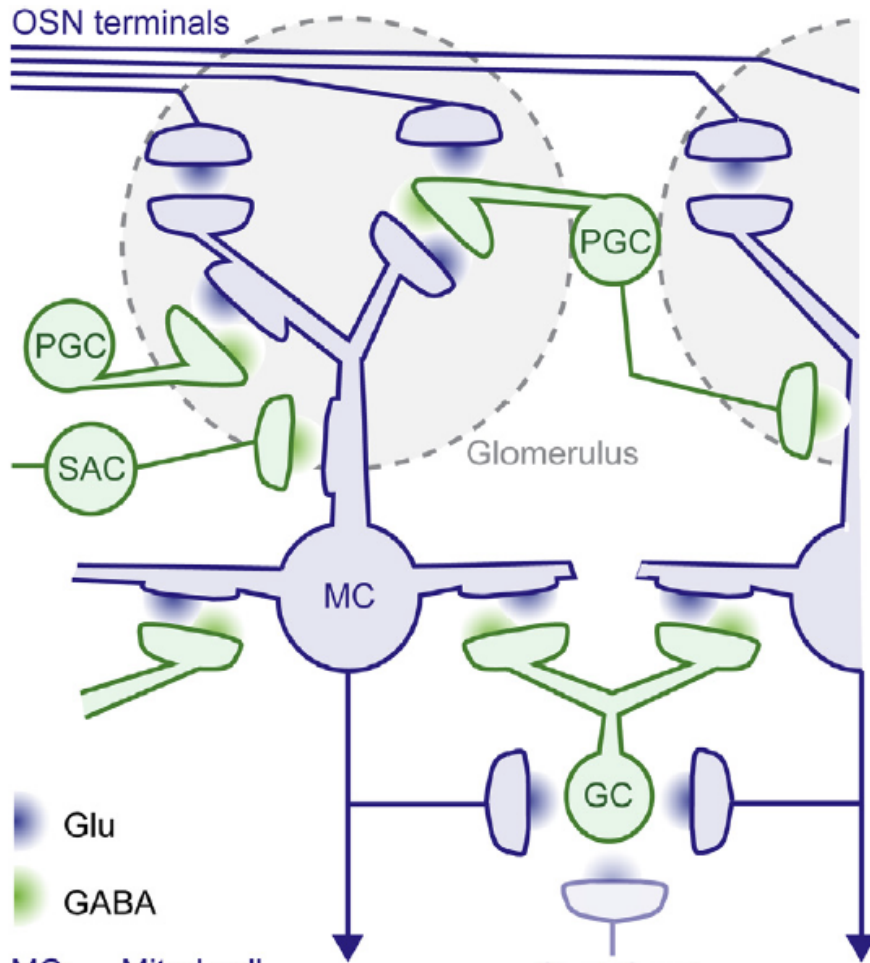


Theorem 3: Sparseness and strong coupling is good

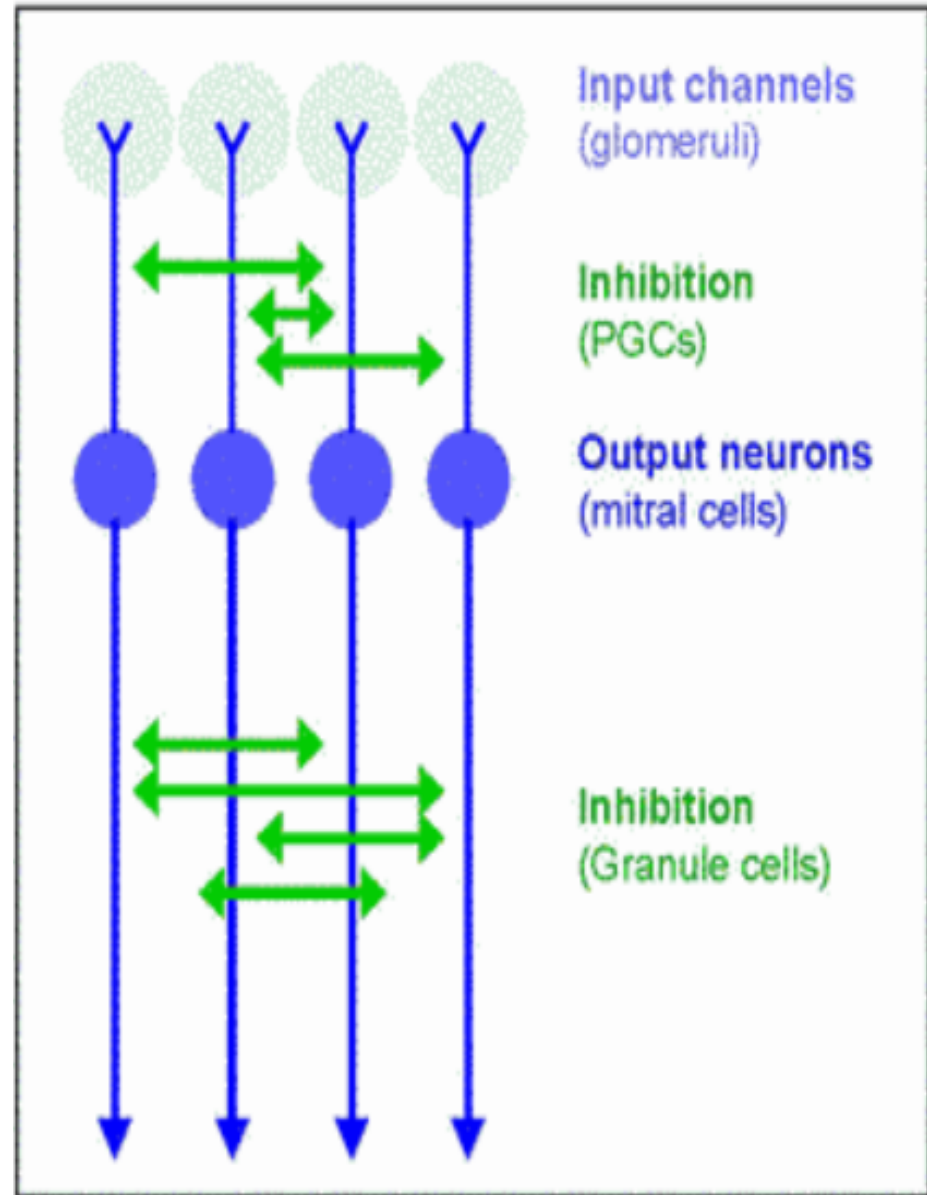
- Random recurrent connection of strength $\Lambda = (p_+ - p_-) \lambda + \gamma$



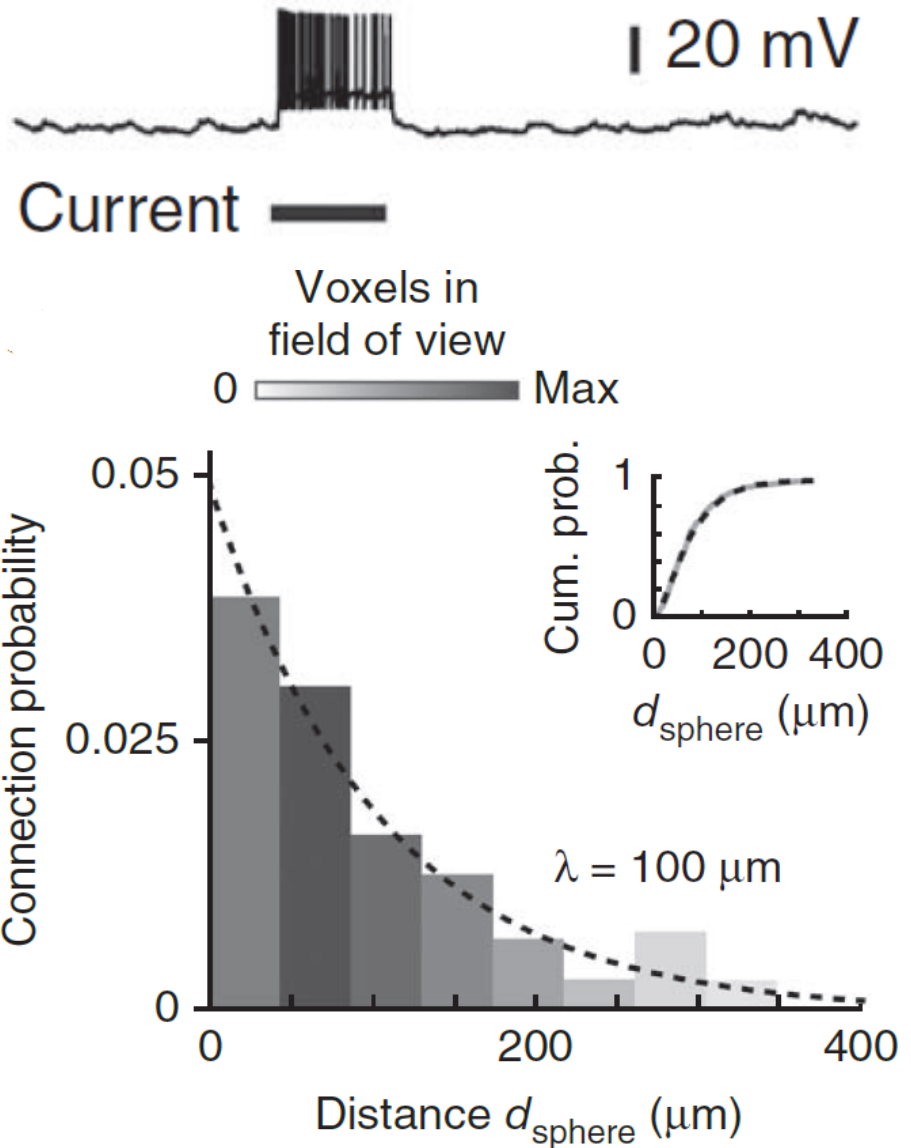
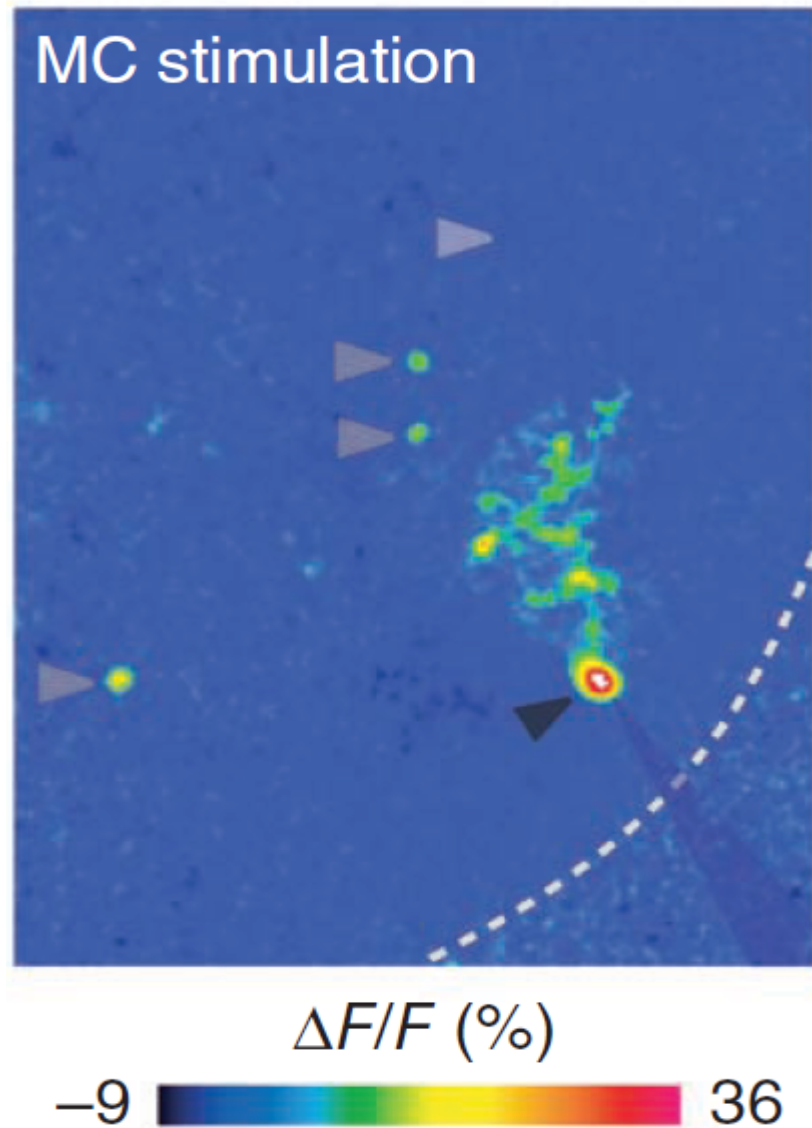
Pattern decorrelation in olfactory bulb



MC: Mitral cell
 OSN: Olfactory sensory neuron
 PGC: Periglomerular cell
 GC: Granule cell
 SAC: Short axon cell



Connectivity in OB

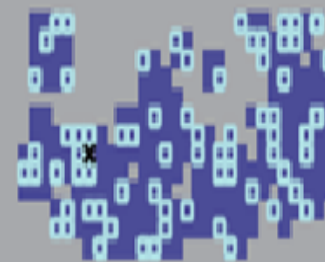
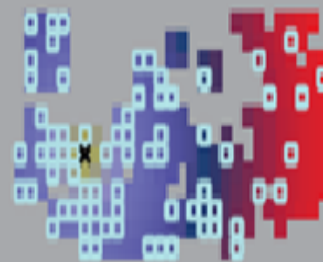
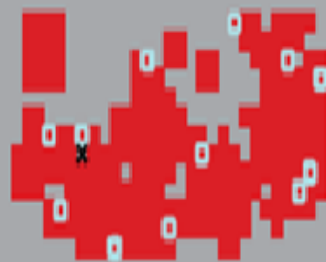
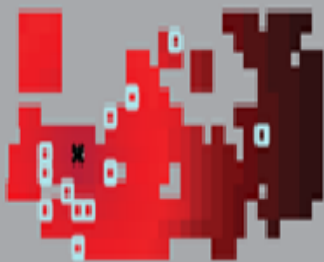
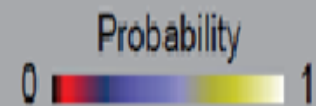


Experimental facts

- Probability of connection decreases exponentially with distance (length constant= $100\mu\text{m}$, diameter of glomerulus= $20\mu\text{m}$)
- Strength of connections constant with distance
- Connection is bidirectional

Computational Model

- Reference: Follow experimental facts
- Non-topographic
- Dense
- Dense, non-topographic



100 μm



A solid black horizontal bar representing a scale of 100 micrometers.

Reference

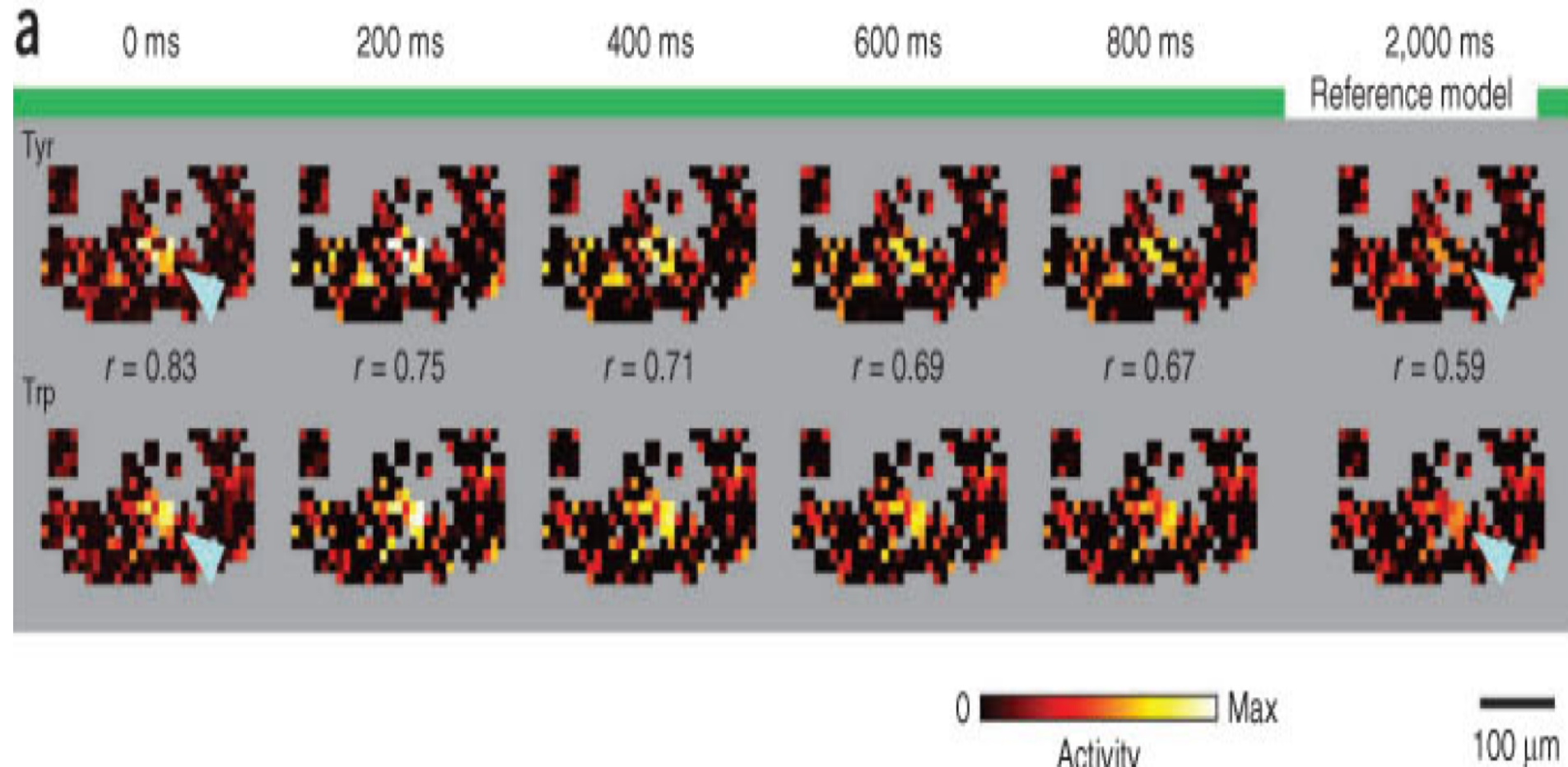
Non-topographic

Dense

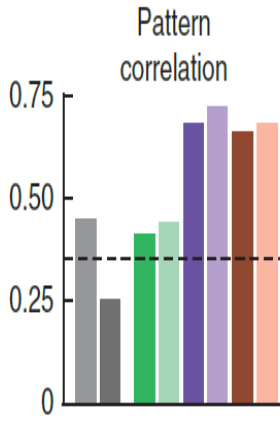
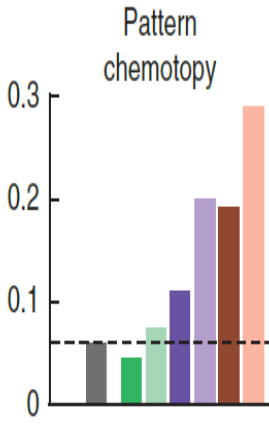
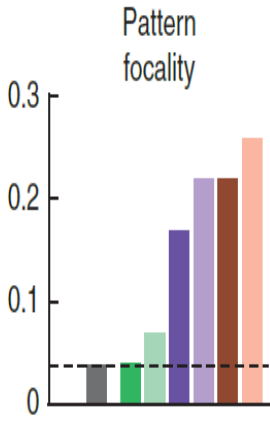
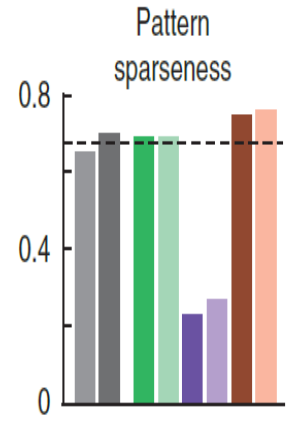
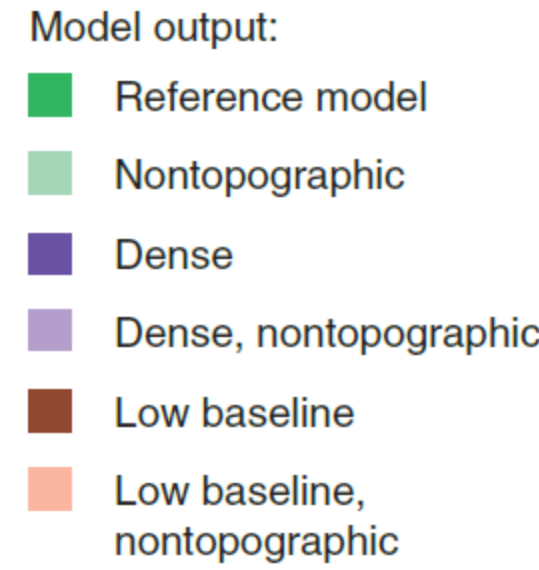
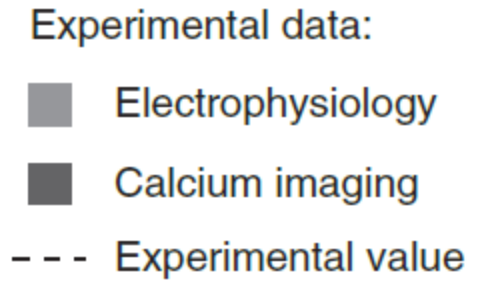
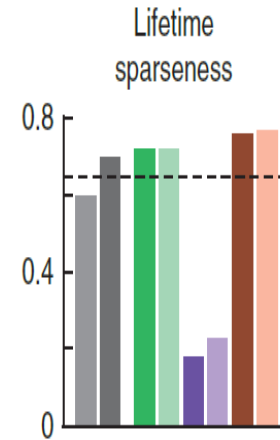
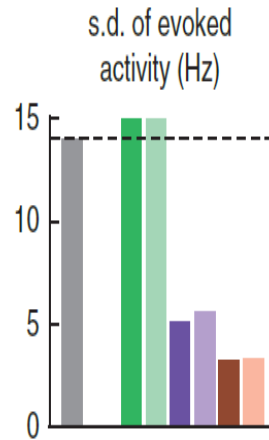
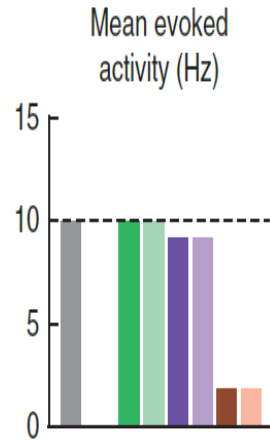
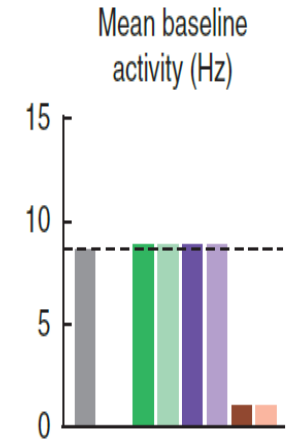
Dense, non-topographic

Experimental Response

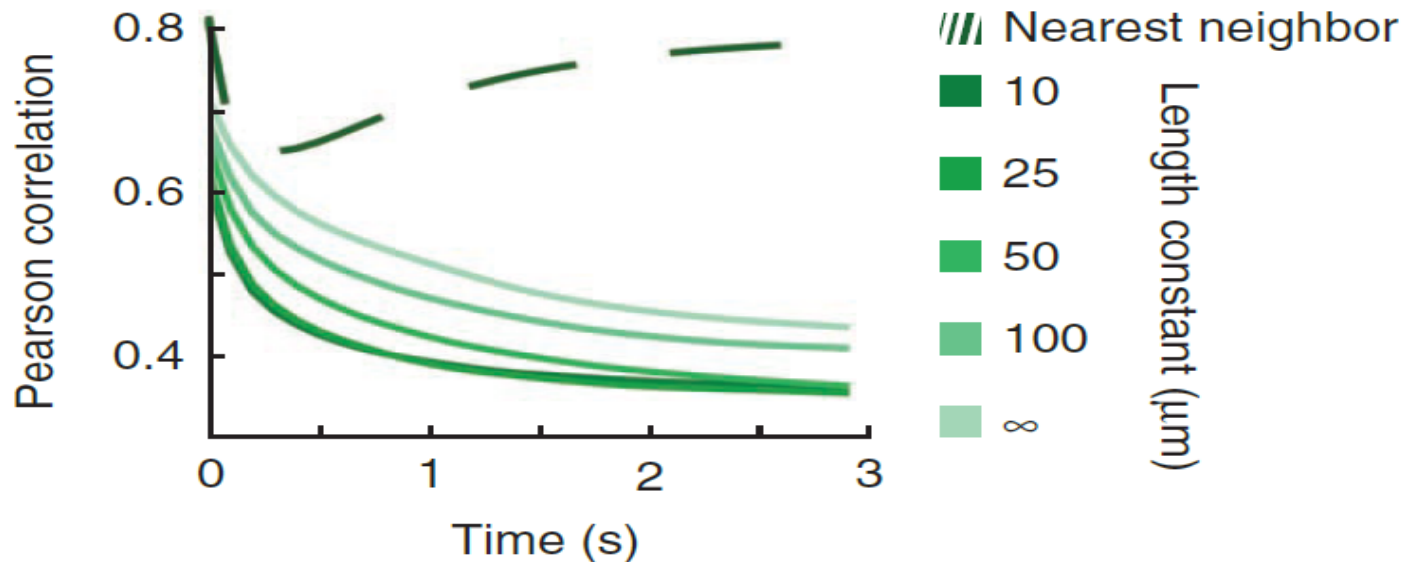
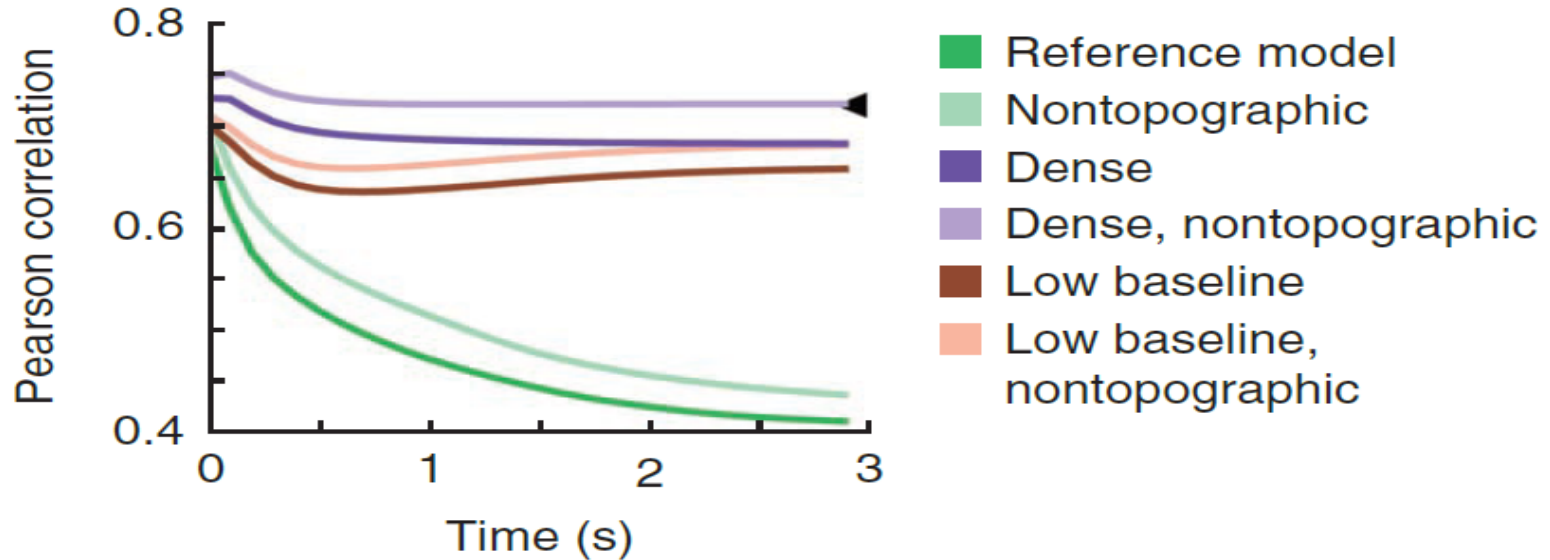
- Decorrelation over time



Results



Results



Conclusion

- reTIDE is primary mechanism behind pattern correlation in OB
- Open Question: Does the same mechanism work in Dentate Gyrus?



Thank You