Cortical Grid Cells

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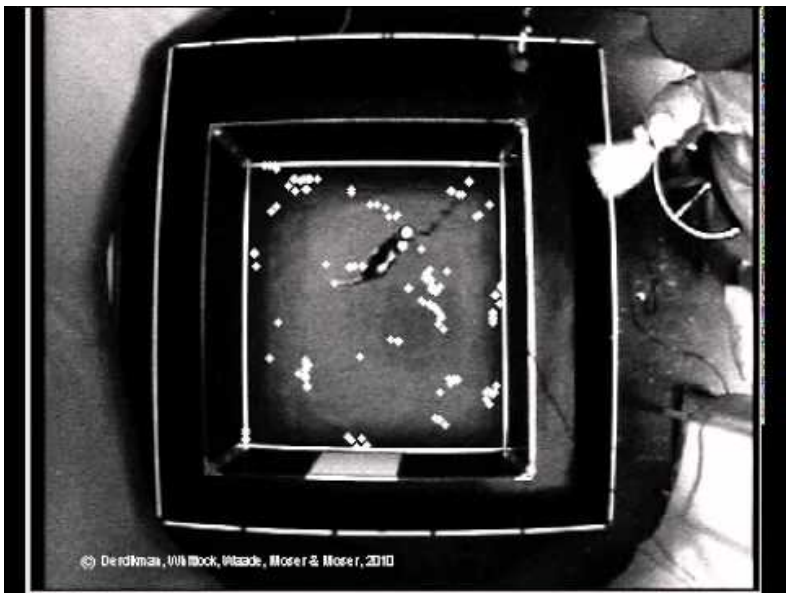
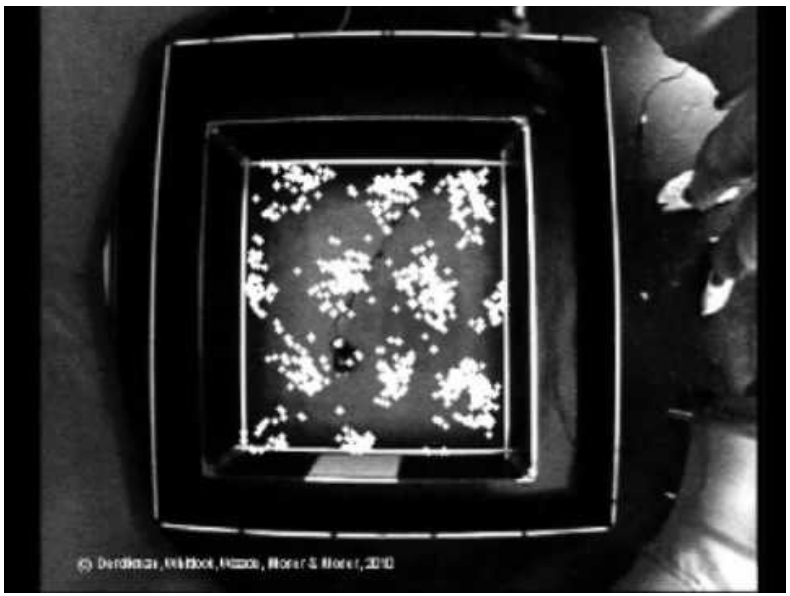
Outline

Rat's Grid Cell Experiment

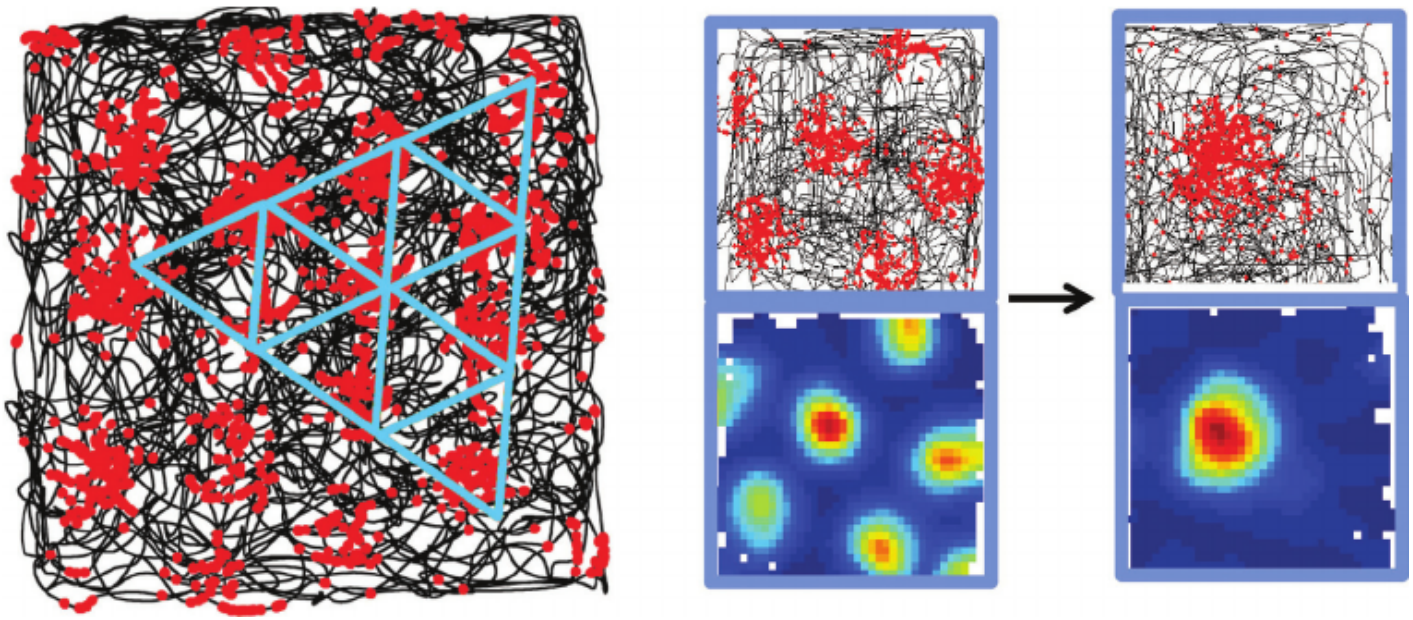
John O'Keefe, May-Britt Moser, Edvard Moser - 2014





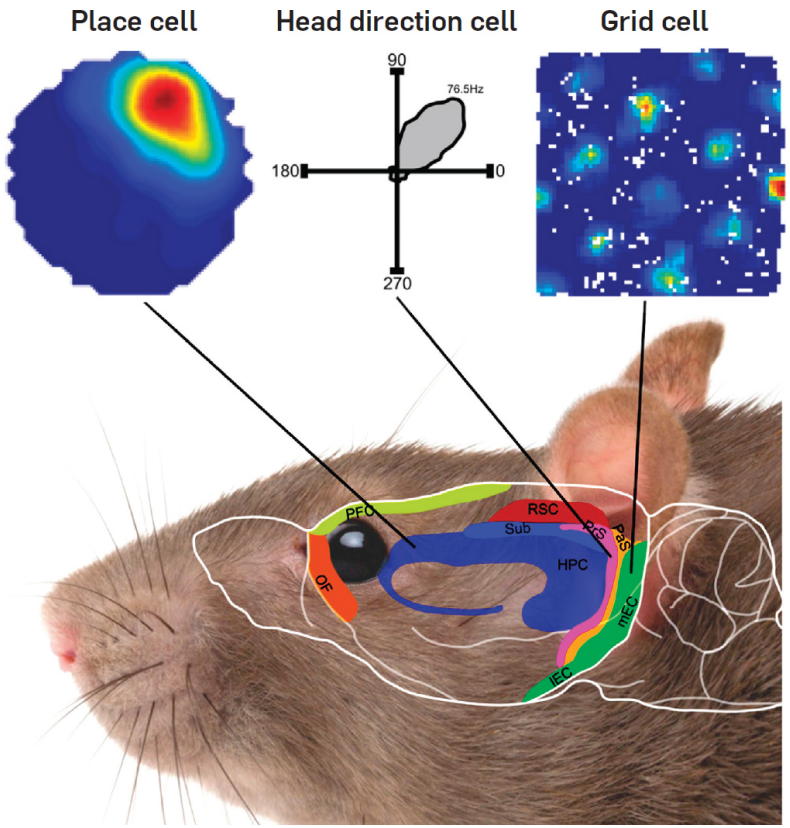
Hexagonal Pattern

Spike firing of each grid cell represents a hexagonal pattern in the 2D plane of the rat.



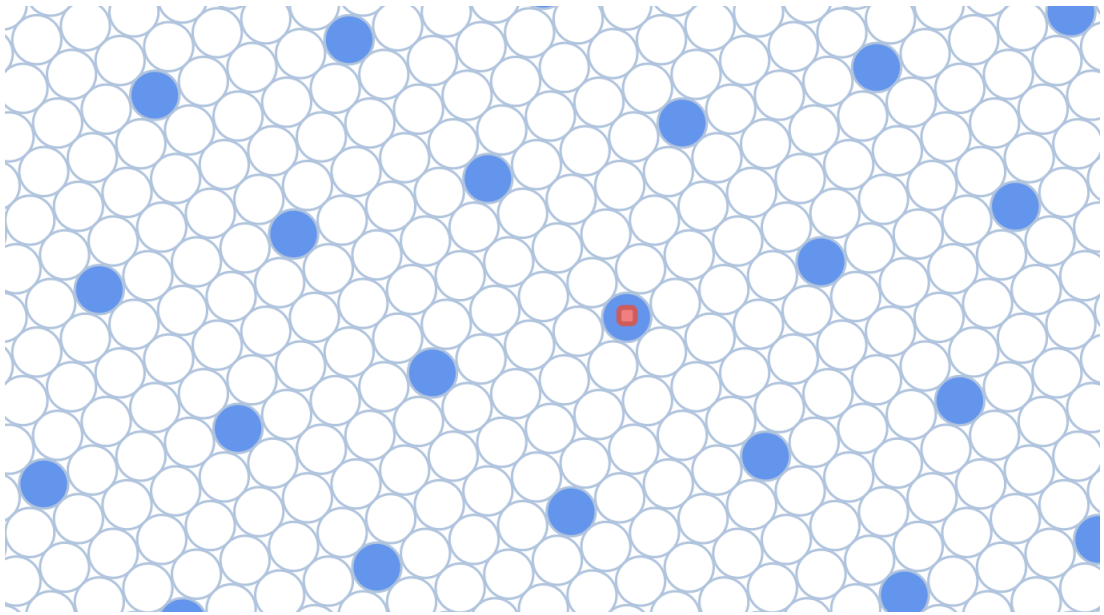
Location Related Cells

There are several cells in old brain contributing to navigation and path integration including border cells, head direction cells, speed cells, grid cells and place cells.



How Do Grid Cells Work?

A grid cell generates a hexagonal pattern of activity that maps an animal's position in space, providing a coordinate system for navigation.

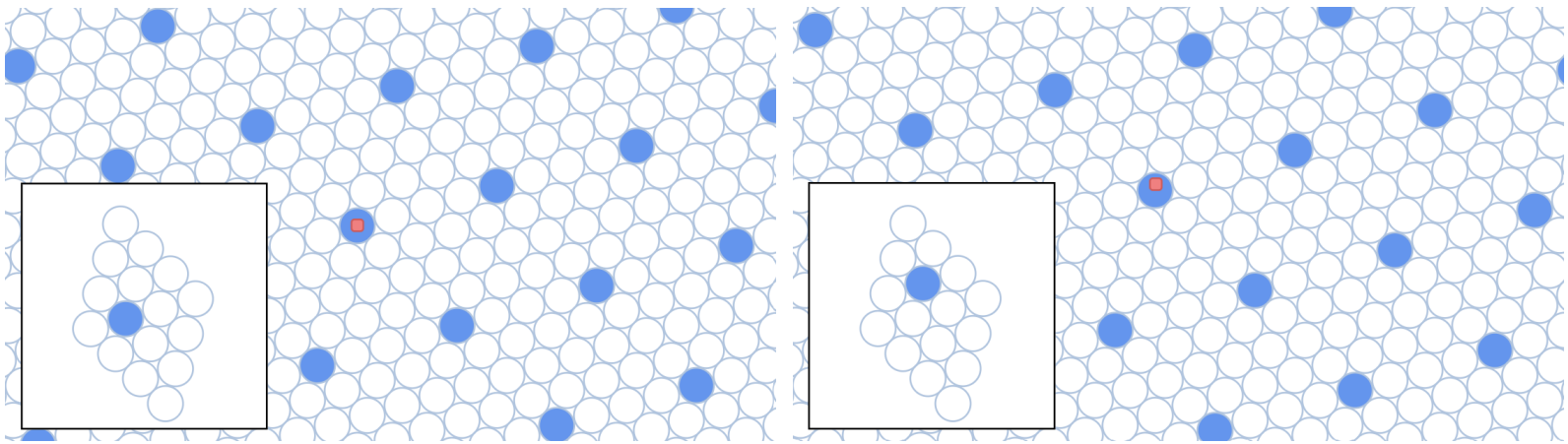


Problems with the activity of a single grid cell

- It fires action potentials only in certain location.
- The representation is ambiguous.

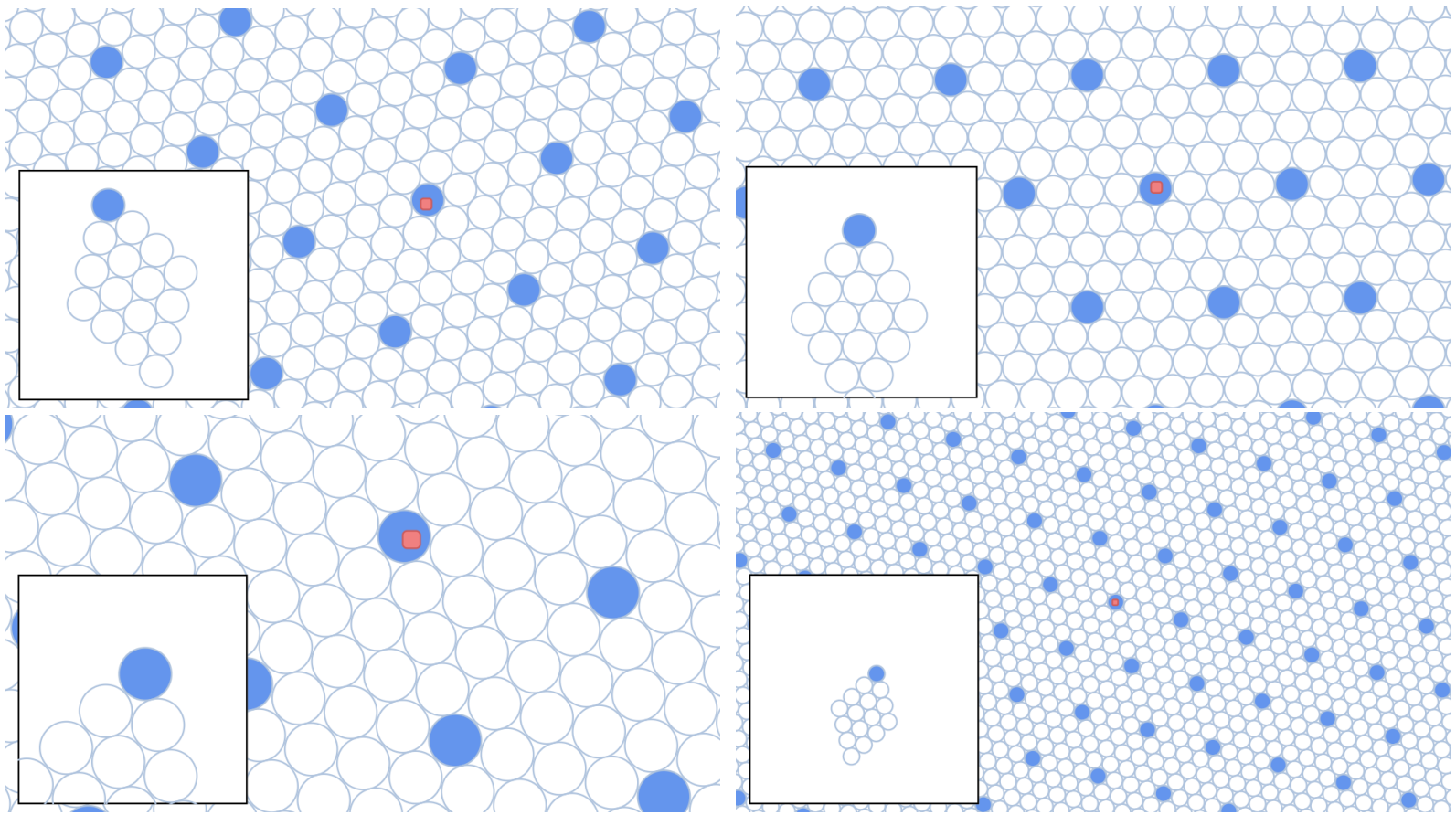
Grid Cell Modules

A grid cell module is a network of grid cells with similar spatial periodicity but different spatial phases, collectively covering all locations.



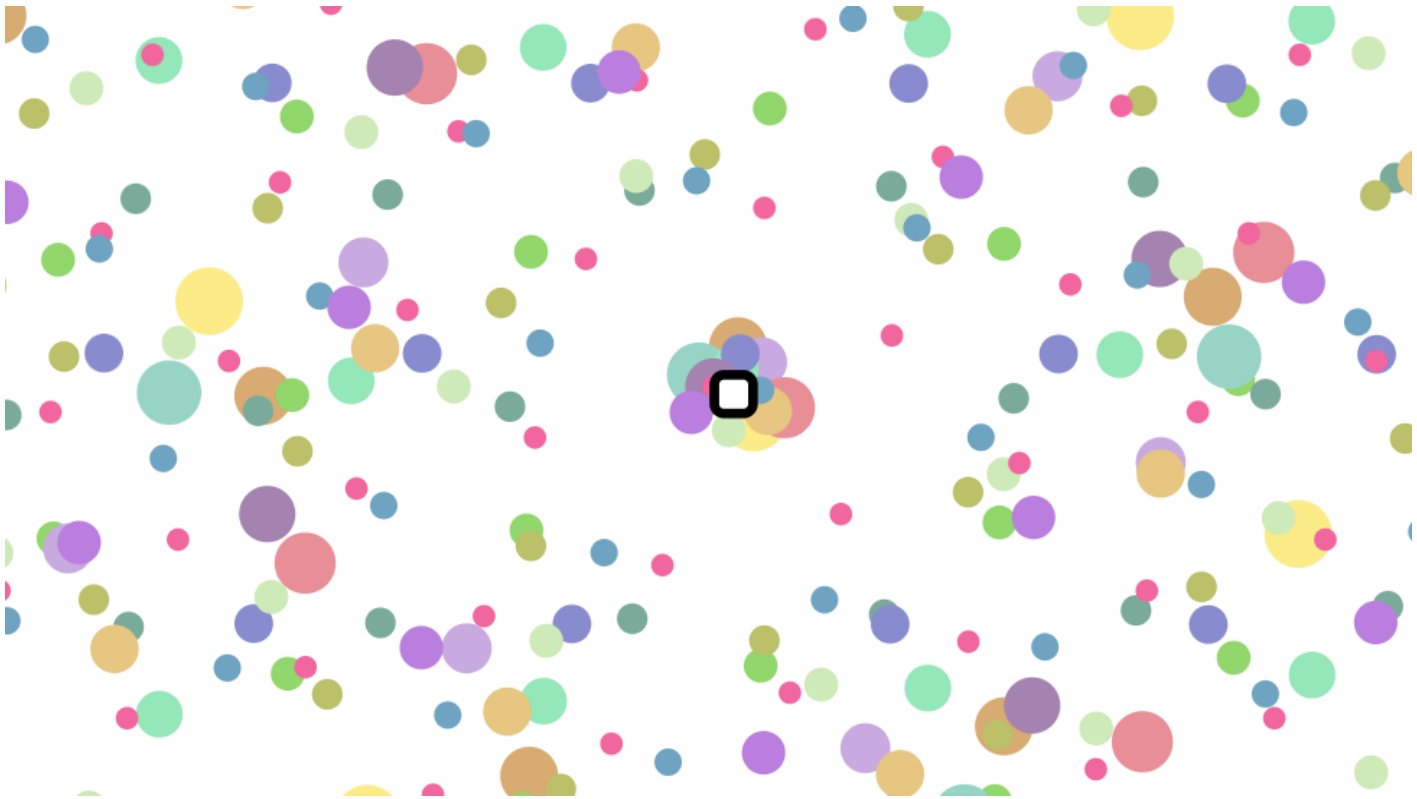
Scales & Orientations

Grid Cells can have various orientations and scales which play an important rule in unique representation of location.



Unique Path Integration

By combining the activity patterns of multiple grid cells with different spatial orientations and scales, the brain can create a unique and precise representation of an animal's location in its environment.



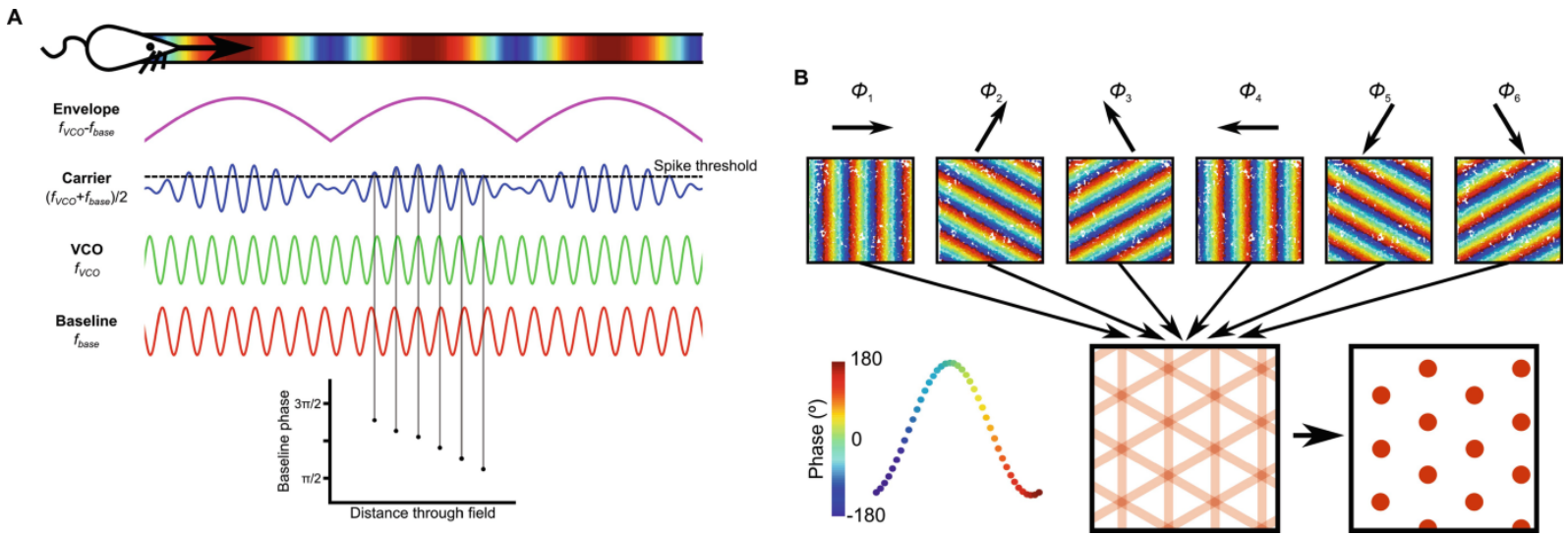
Computational Models of Grid Cells

There are three main computational models of grid cells.

- Oscillatory Interference Models: Use the interference patterns of neural oscillations to generate grid cell firing fields.
- Continuous Attractor Network Models (CAN): Simulate the stable activity patterns of grid cells using interconnected neural networks.
- Self-Organizing Models: Employ principles of self-organization to develop grid cell patterns through learning and adaptation.

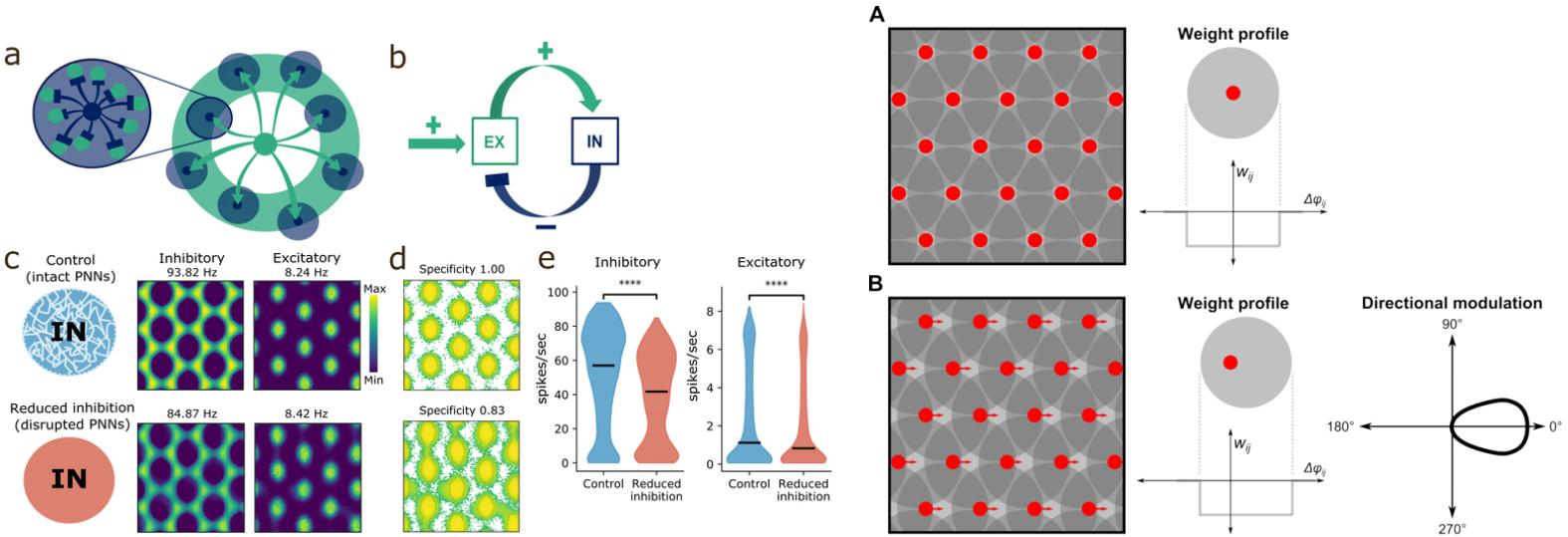
Oscillatory-Interference Model

Oscillatory Interference Models generate grid cell firing patterns by combining multiple neural oscillations at different frequencies to produce spatially periodic activity.



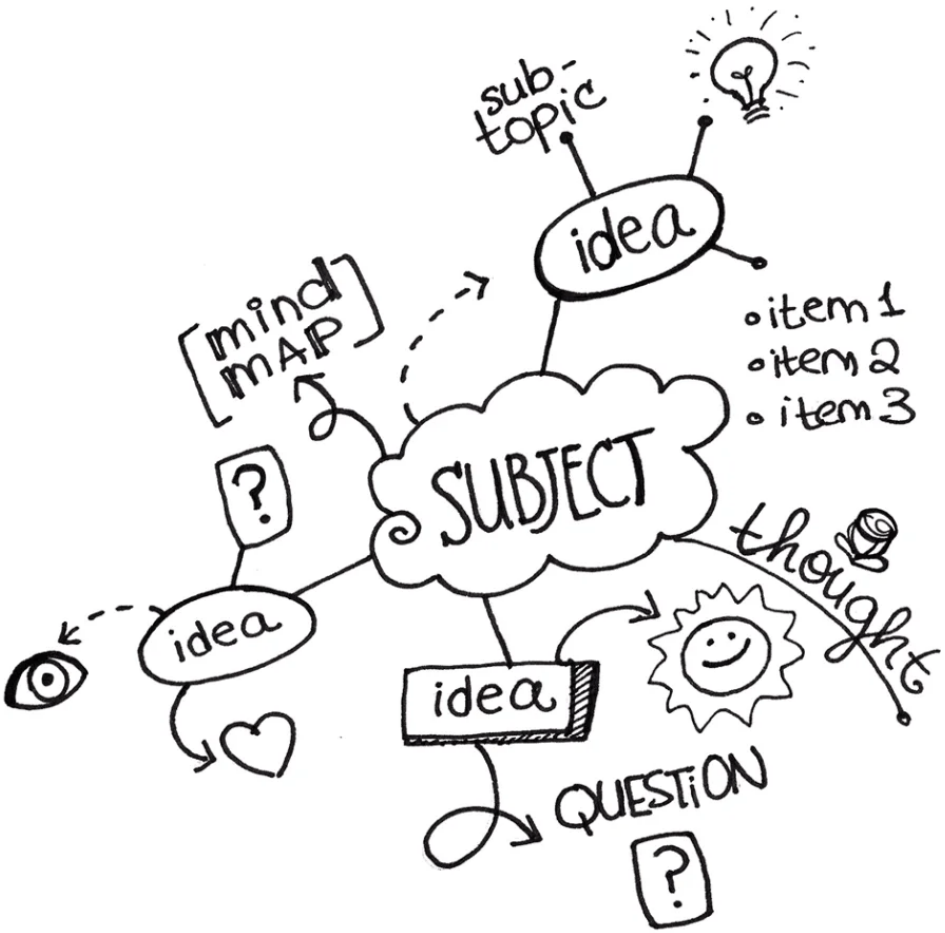
Continuous-Attractor-Network Model (CAN)

CANs simulate grid cell activity by using a network of interconnected neurons inhibiting a ring around themselves that maintain stable, continuous patterns of activity representing spatial locations.



Location, Real or Conceptual?

In the Thousand Brains Theory of Intelligence, grid cells are crucial for providing a spatial coordinate system that helps the brain construct accurate and detailed representations of the environment for intelligent behavior.



Where are grid cells in Neocortex?

Ahmad Subutai , Hawkins Jeff - 2019

It has been proposed that grid cells not only exist in MEC, but also all around the neocortex as an essential part of each cortical column locating at L6 layer.