Local changes, global effects?

How localised is the effect of deformed boundaries on grid cells?

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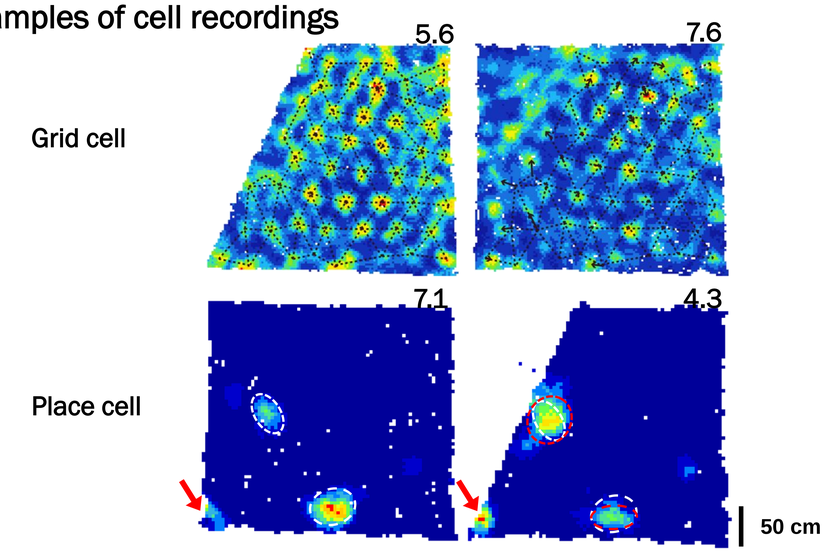
Introduction

Place cells and grid cells form key components of the hippocampal cognitive map. Studies have shown that grid cells' hexagonal firing patterns become distorted in polarised enclosures and near boundaries. However, the factors underlying these distortions are not well understood, largely due to the insufficient sizes of previously used enclosures. To see whether these distortions are truly global or localised near the shifted wall(s), we recorded grid and place cells from rats foraging in large enclosures. We also used a path-landmark integration model to look at possible causes of these distortions.

Methods

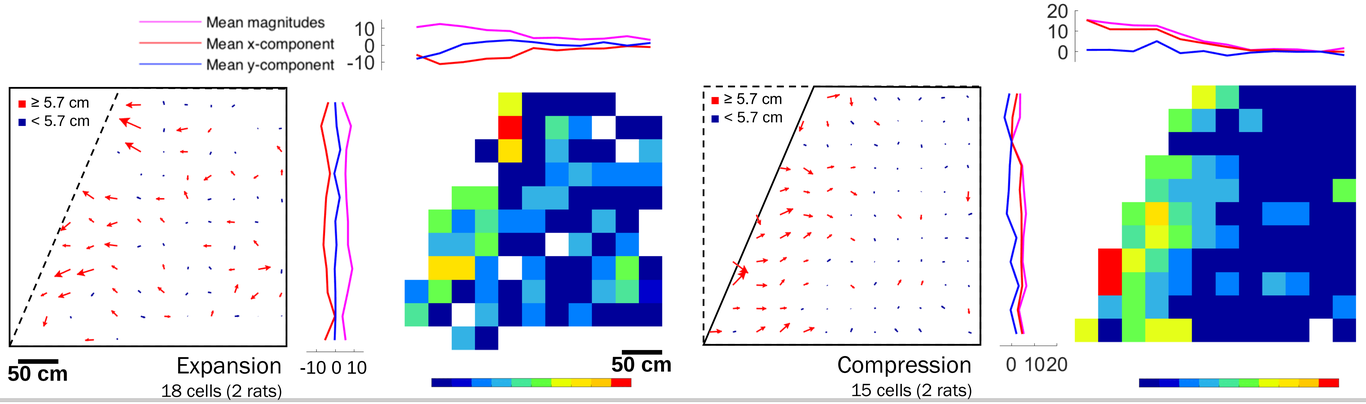
Rats were implanted with tetrodes or Neuropixels probes in hippocampal CA1 & CA3 and/or medial entorhinal cortex. The rats foraged in each enclosure for ≥70 minutes; each session consisted of two trials in different enclosures (2.8 m × 3 m).

Examples of cell recordings



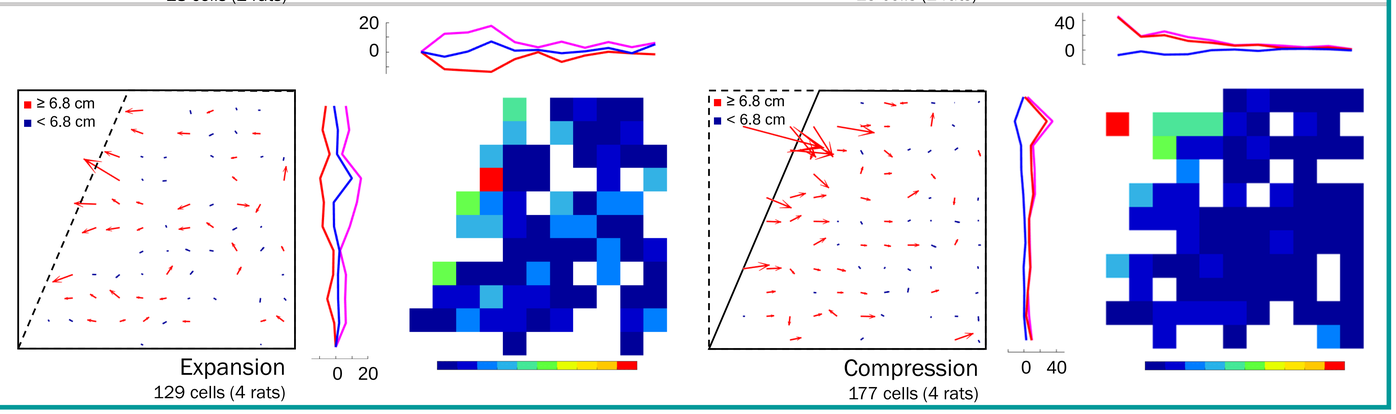
Grid cell field shifts

- Fields shifted largely in the direction of the shifted wall.
- During compression, significant shifts formed a strip 1.0m wide, parallel to the shifted wall.
- During expansion, significant shifts were observed across the enclosure in different directions.

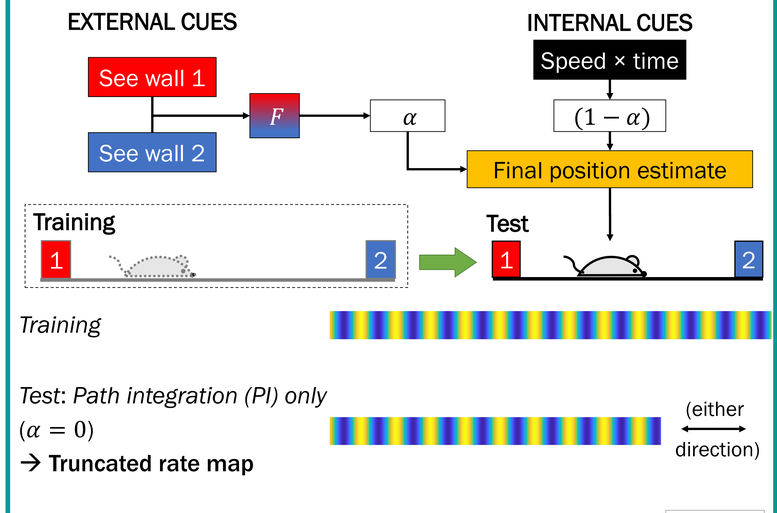


Place cell field shifts

- Fields moved similarly to grid cells' fields. However, many other fields appeared or disappeared.
- Place field shifts were larger than grid field shifts, but more variable vertically.



The path-landmark integration model captures rate map distortions



Summary

- Grid cell rescaling in compression trials does not completely scale with enclosure size, suggesting an non-uniform rescaling.
- Modelling suggests that grid cell distortions could be caused by path dependence and/or asymmetric weighting of landmark cues.

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