### ARTICLE

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# Hippocampal place-cell sequences depict future paths to remembered goals

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## **Future Reflections**

Past, present and future represented in hippocampus

Loïc Matthey

Tea Talk n°12

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Friday, 19 April 2013

### Introduction

- Hippocampus place cells
  - Represents animal location
  - \* Firing with respect to theta rhythm: theta sequences
- Place cells replay
  - Sequences of place cells reactivations. Correspond to prior behavioural trajectories.
  - \* During sleep and non-exploratory awake periods. Associated with Sharp-wave ripple events in LFP.
- \* What are they used for?
  - Remember goal? Past experiences? Define new routes?

Brad E. Pfeiffer & David J. Foster "Hippocampal place-cell sequences depict future paths to remembered goals" Nature, April 2013

#### Task

- Rats foraging for rewards
  - \* 2 phases:
    - Reward at Random location
    - Reward at Home location
  - Home kept fixed per day
  - Many trials, alternate Random / Home / Random / Home / etc
- Implant 4 rats with 40tetrode microdrive.
  - \* Record around 150-200 units.



#### Behaviour



### Place fields

#### Place cells

- Smooth histograms (2cm bins, 4cm gaussian kernel)
- Restrict to movements
  5cm/s

7.0	30.1	23.7	11.5	77.5	6.9	15.3	12.8	10.6	30.1	4.7	13.6	12.9 🔮	23.2	5.7
16.5	27.6	16.0	28.9	25.3	11.1	15.0	7.1	14.0	16.6	7.2	19.3	15.9	23.5	24.2
13.8	25.7	20.1	26.7	26.5	12.1	24.8	14.4	8.4	19.3	29.1	15.8	15.9	9.3	16.1
38.3	46.6	3.4	18.1	35.9	8.7	19.9	19.0	24.5	17.7	19.8	77.5	13.7	5.6	53.1
17.9	23.5	18.1	3.7	5.5	21.1	26.8	13.9	22.8	29.8	35.4	1.5	14.4	6.7	3.7
28.3	9.2	21.7	5.4	14.6	24.0	39.1	22.0	11.8	43.7	14.5	8.7	9.0	12.5	21.7
8.6	23.2	14.1	17.5	10.1	2.1	39.3	43.7	13.4	17.2	8.1	9.3	39.7	10.6	27.2
5.4	79.0	10.5	18.7	26.0	26.0	35.8	29.5	25.5	24.8	14.9	21.4	17.6	10.8	20.3
7.6	13.2	39.4	75.3	3.5	12.8	26.5	22.1	4.1	12.5	21.9	1,1	4.2	18.8	13.8
19.9	6.1	52.3	6.8	23.8	5.6	15.2	24.4	7.1	42.6	13.3	4.9	9.3	13.1	16.4
12.5	36.4	32.7	14.6	32.4	31.4	7.5	9.7	2.4	13.2	7.7	17.6	17.0	0	—— M
8.7	21.1	12.9	11.6	37.7	22.5	10.2	17.3	2.6	16.4	18.5	22.3	7.5		
9.9	6.5	31.4	8.6	14.9	5.0	13.9	18.5	9.2	29.7	64.9	21.2			
22.5	40.0	22.2	12.4	3.0	18.3	8.4	8.7	15.8	8.4	16.3	11.2			
14.7	19.2	8.9	5.7	14.4	15.8	12.7	19.9	5.2	19.3	21.3	25.1			

### Place fields

#### Bayesian decoding

- Poisson likelihood, independent units, using estimated tuning curves
- Time constants:
  - 250ms behaviour
  - 20ms events



### **Events** analysis



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#### **Events over-represent Home**

- Home-event: initiated while at Home
- Expected initiation bias.



#### Events reflect future behaviour



### Conclusion

- Observed hippocampal trajectory sequences predicting future behaviour
- Over-representation of goal location
- Indications for role of hippocampus in planning
  - Flexible cognitive map?
  - Substrate for inference?

#### The End

#### \* Questions?

#### \* References:

 Pfeiffer, B. E., & Foster, D. J. (2013). Hippocampal place-cell sequences depict future paths to remembered goals. Nature. Supplementary slides

#### Events over-represent relevant locations



#### Events reflect future behaviour

Events reflect current goal, depending on task

