Using an inverted encoding model to reconstruct spatial position and forward planning in a virtual reality environment

James W. Antony, Chris Baldassano, Mariam Aly, Nicholas B. Turk-Browne, Kenneth A. Norman
Princeton University

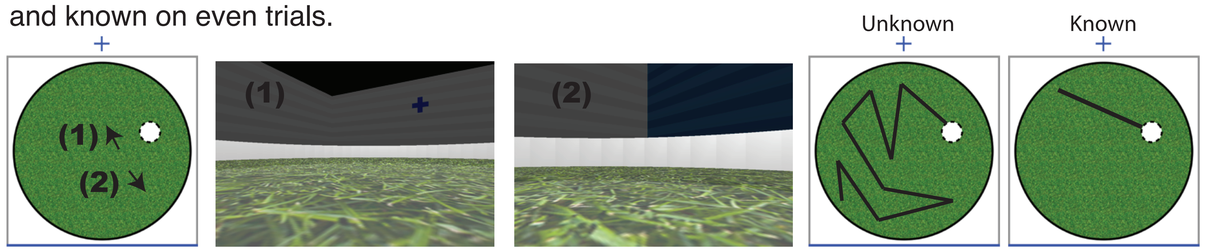
Introduction

Previous fMRI studies have shown that the hippocampus represents spatial location[1–5] and tracks path distance to target locations[6–9]. Additionally, many other regions contribute to these and other facets of spatial navigation, including angle orientation[3,4,10–12].

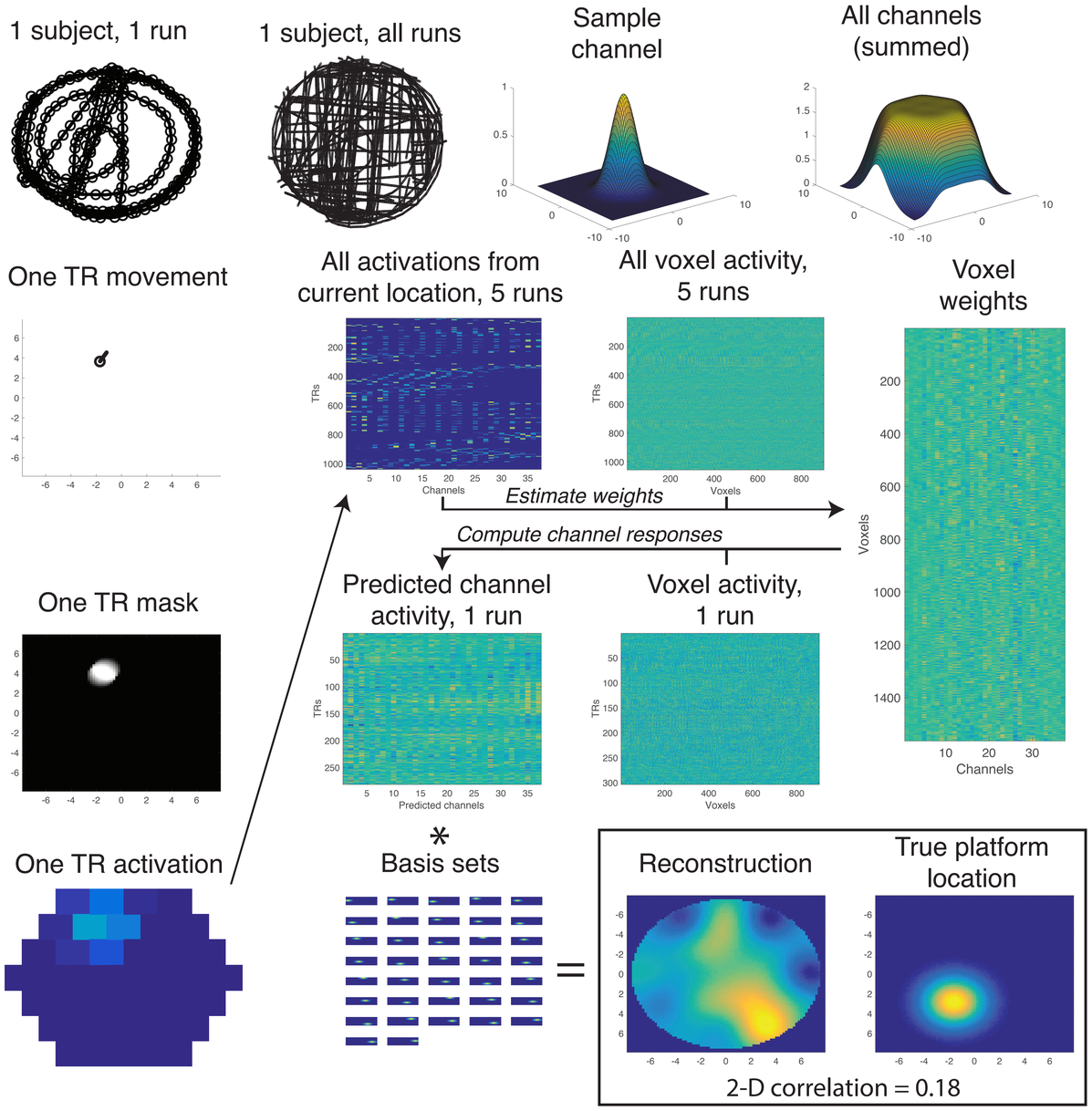
Major question: What can inverted encoding models[13] reveal about how spatial goals are represented?

Methods

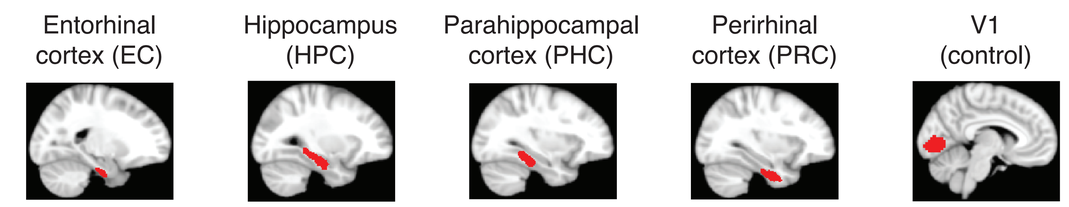
Participants (N = 26, 17 female) searched a 3-D environment for a hidden platform that changed location every other trial. Therefore, the platform location was unknown on odd trials and known on even trials.



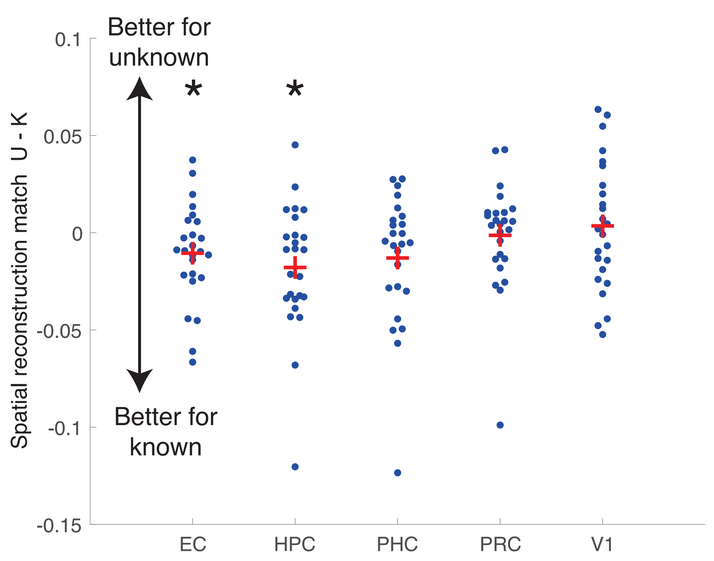
We created a set of hexagonally-arranged spatial information channels that activated at various points along the movement trajectory.



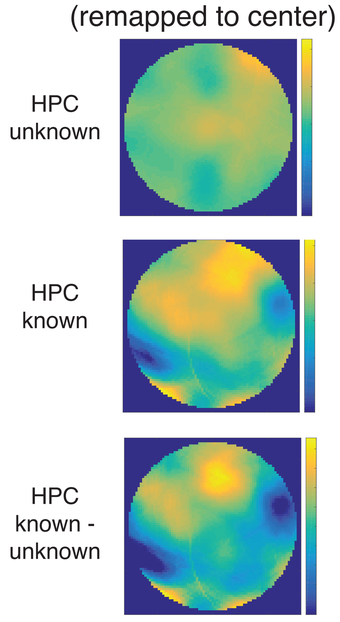
Results



Platform location reconstruction



Mean reconstructions (remapped to center)



Discussion

Better platform representation on known vs. unknown trials could reflect future spatial goals or proximity to the platform on known trials.

Future directions:

- Relate findings to behavior
- Run encoding model on heading angle orientation
- Create voxel inversion maps to understand neural architecture of spatial representations

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Please address questions or requests for reprints to jantony@princeton.edu.

References

1. Hassabis, D. et al. Curr. Biol. 19, 546–54 (2009).
2. Rodriguez, P. F. Hum. Brain Mapp. 31, 391–7 (2010).
3. Vass, L. K. & Epstein, R. A. J. Neurosci. 33, 6133–42 (2013).
4. Sulpizio, V., Committeri, G. & Galati, G. Front. Hum. Neurosci. 8, 716 (2014).
5. Brown, T. I. et al. Science. 352, 1323–6 (2016).
6. Howard, L. R. et al. Curr. Biol. 24, 1331–40 (2014).
7. Viard, A., Doeller, C. F., Hartley, T., Bird, C. M. & Burgess, N. J. Neurosci. 31, 4613–21 (2011).
8. Sherrill, K. R. et al. J. Neurosci. 33, 19304–13 (2013).
9. Morgan, L. K., Macevoy, S. P., Aguirre, G. K. & Epstein, R. A. J. Neurosci. 31, 1238–45 (2011).
10. Marchette, S. A., Vass, L. K., Ryan, J. & Epstein, R. A. Nat. Neurosci. 17, 1598–606 (2014).
11. Gourtzelidis, P. et al. Exp. Brain Res. 165, 273–82 (2005).
12. Jerde, T. A. et al. Exp. Brain Res. 187, 551–561 (2008).
13. Sprague, T. C., Saproo, S. & Serences, J. T. Trends Cogn. Sci. 19, 215–26 (2015).