Compressed Temporal Representation During Visual Paired Associate Task in Monkey PFC and Hippocampus

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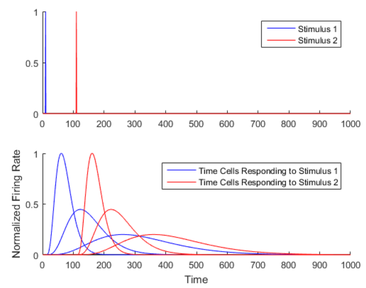
Background

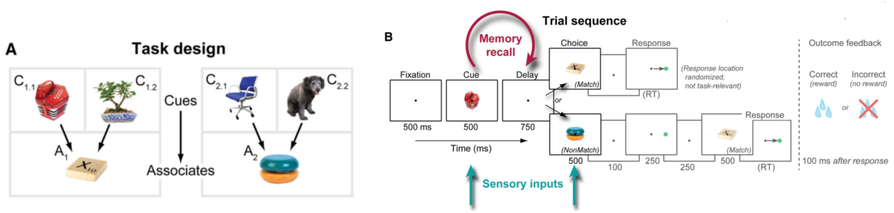
Recent models of memory depend on representations of a compressed temporal history, which we believe is coded for by time cells. However this would require the time cells to be stimulus selective, and many previous reports of time cells have not found stimulus selectivity in time cells. Here we identify stimulus selective time cells in monkey PFC and HPC in a visual working memory paired associate task.

Ideal Time Cells[2,4]



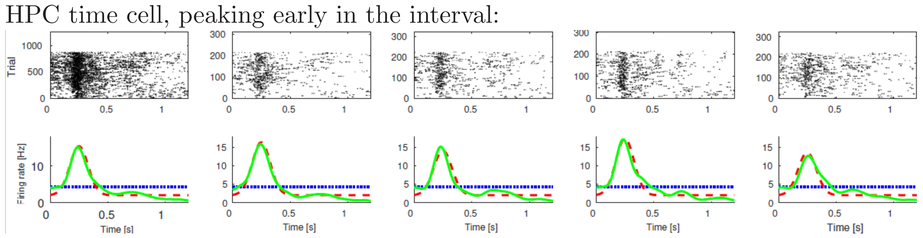
Experiment Used Visual Stimuli

This experiment featured a paired associate learning task with a 1.25 second delay between initial stimulus presentation and the associate stimuli.

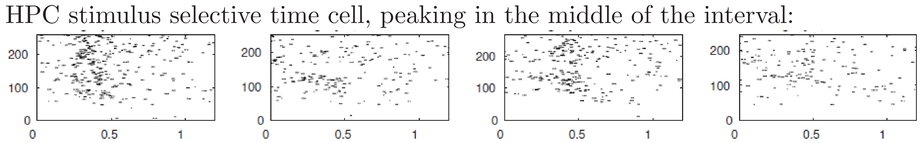


Example Time Cells

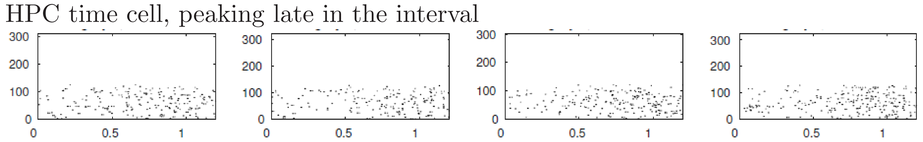
HPC time cell, peaking early in the interval:



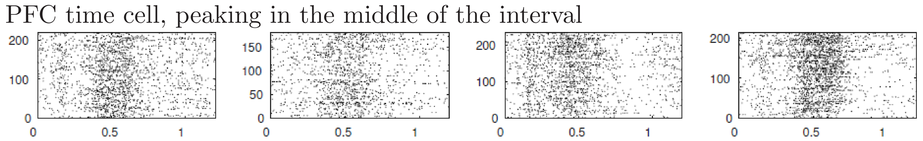
HPC stimulus selective time cell, peaking in the middle of the interval:



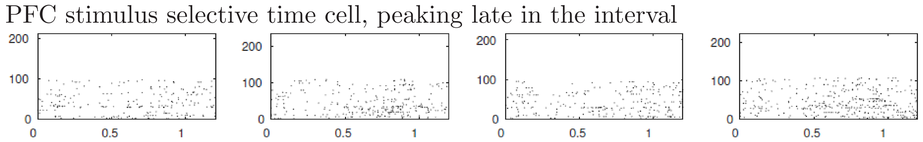
HPC time cell, peaking late in the interval



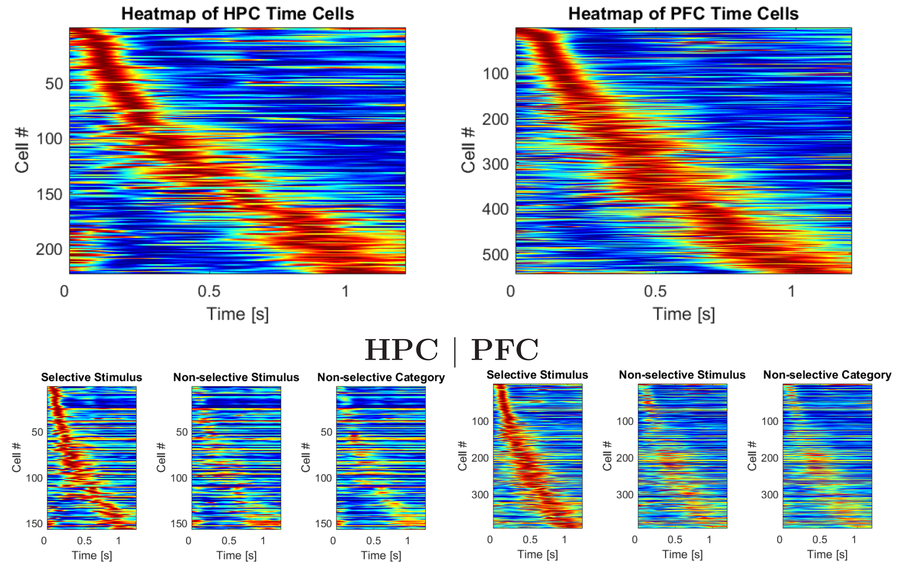
PFC time cell, peaking in the middle of the interval



PFC stimulus selective time cell, peaking late in the interval



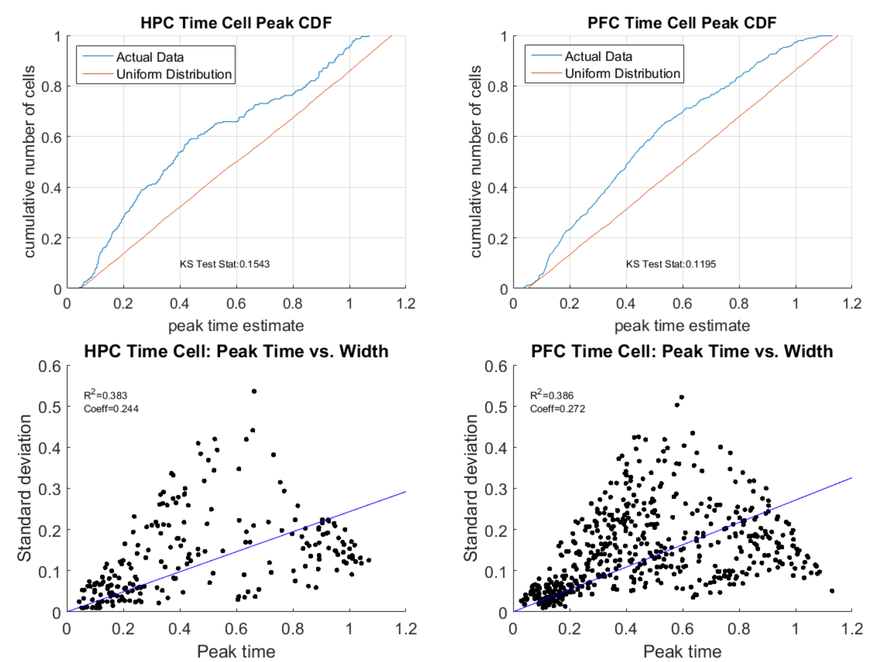
HPC and PFC Show a Temporal History



The time cells are stimulus selective, but not selective for predictive categories.

Temporal History is Compressed

Temporal history is compressed as shown by spread in time fields and decreasing number density of time cells with the passage of time.



Time cell width increases with time cell peak time.

Past, not Prediction

	HPC:875 Cells	PFC:1505 Cells
Time Cells	223	546
Stimulus Specific Time Cells	157	393
Category Specific Time Cells	19	59
Control Pairing	30,21	47,59

The time cells are stimulus selective, but not more selective for meaningfully predictive pairings of stimuli than control pairings of stimuli.

Results

These time cells

- Respond to visual stimuli
- Exist in both PFC and HPC
- Temporal coding is compressed
- Code for past stimuli

Modeling

We used a maximum likelihood estimation with a Gaussian model of time cells.
Using a hierarchical bayesian model as opposed to a maximum likelihood estimation will allow better quantification of the underlying assumptions about time cell distribution.[3]

References

[1] Scott L. Brincat, and Earl K. Miller. *Frequency-specific hippocampal-prefrontal interactions during associative learning.* Nature neuroscience 18.4 (2015): 576-581.
[2] K. H. Shankar and M. W. Howard. *A scale-invariant representation of time.* Neural Computation, 2012.
[3] Brandon M. Turner and Per B. Sederberg. *A generalized, likelihood-free method for posterior estimation.* Psychonomic bulletin & review, 2014
[4] Zoran Tiganj, Jason A Cromer, Jefferson E Roy, Earl K Miller, Marc W Howard. *Compressed timeline of recent experience in monkey lPFC.* bioRxiv, 2017