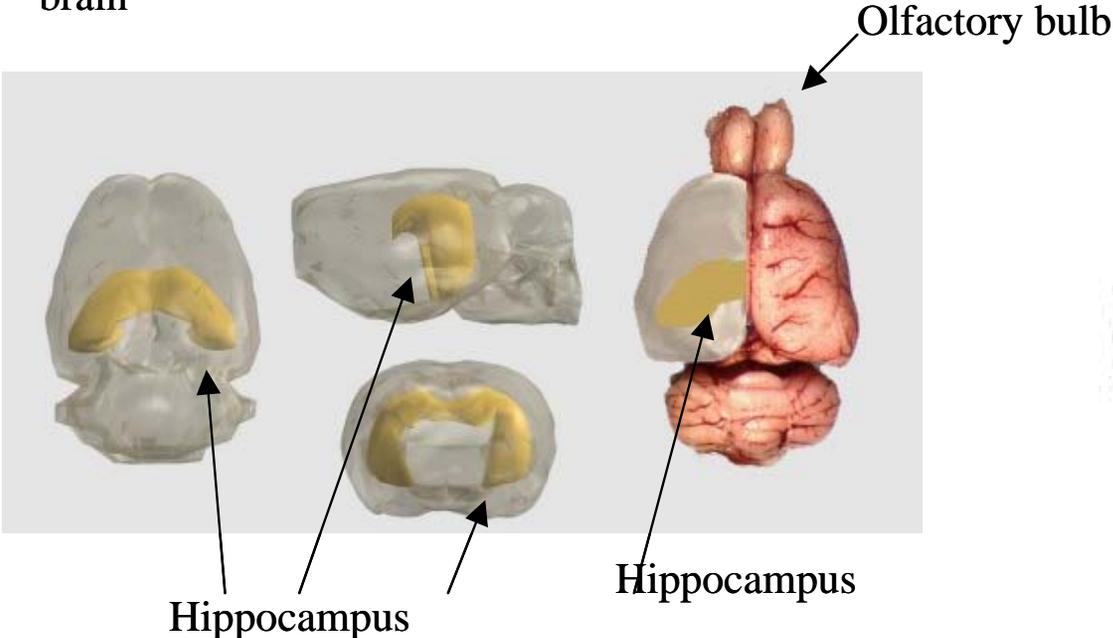
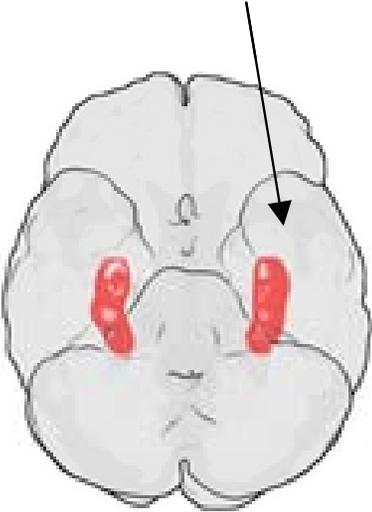


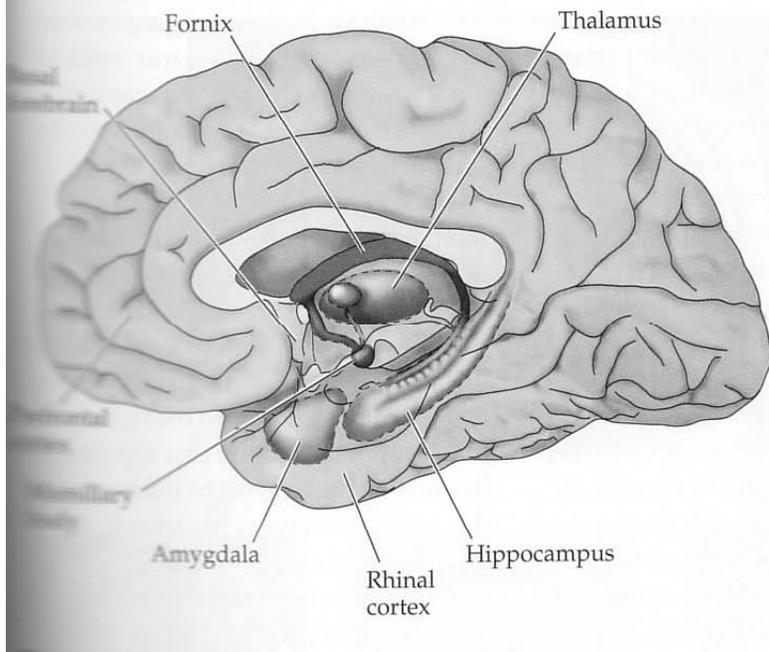
Location of the hippocampus in the rat brain



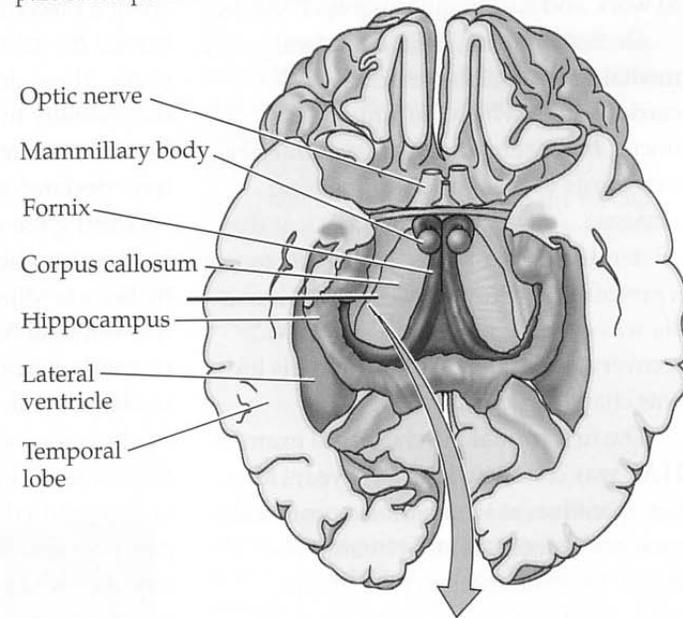
Location of the hippocampus in the human brain



(A) Brain areas associated with declarative memory disorders



(B) Ventral view of hippocampus and related structures with part of temporal lobes removed

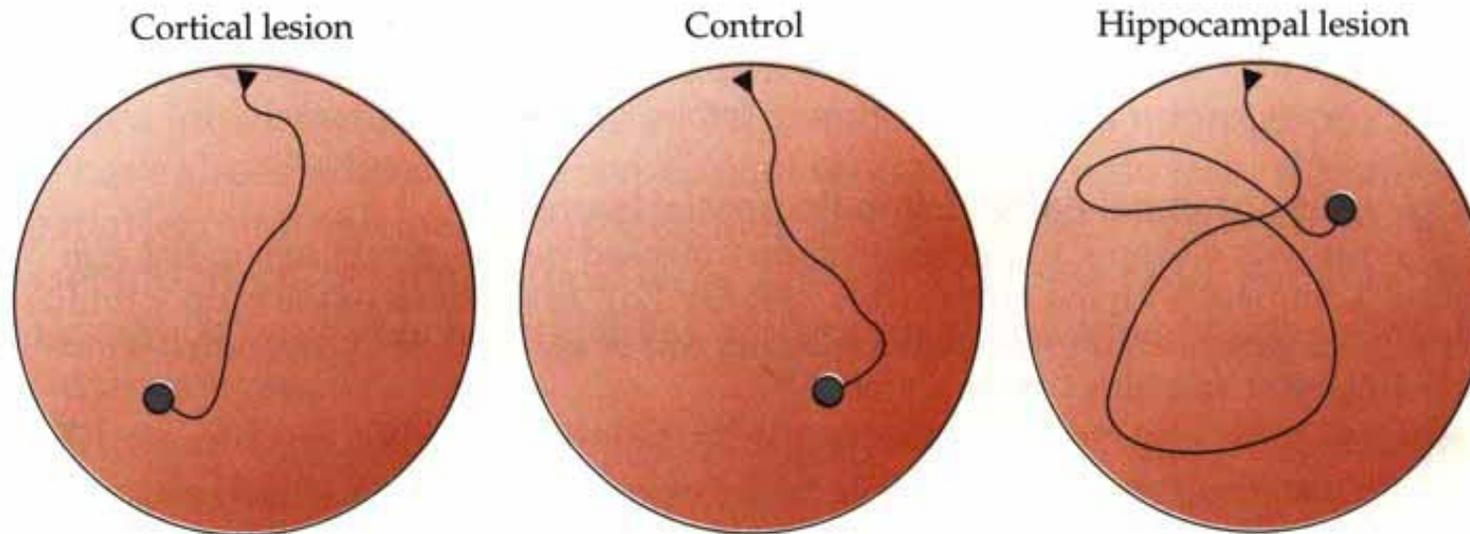


Hippocampus:

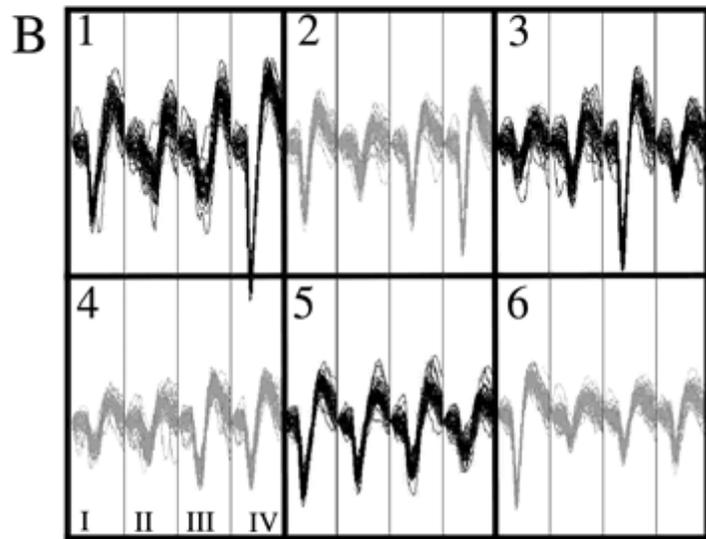
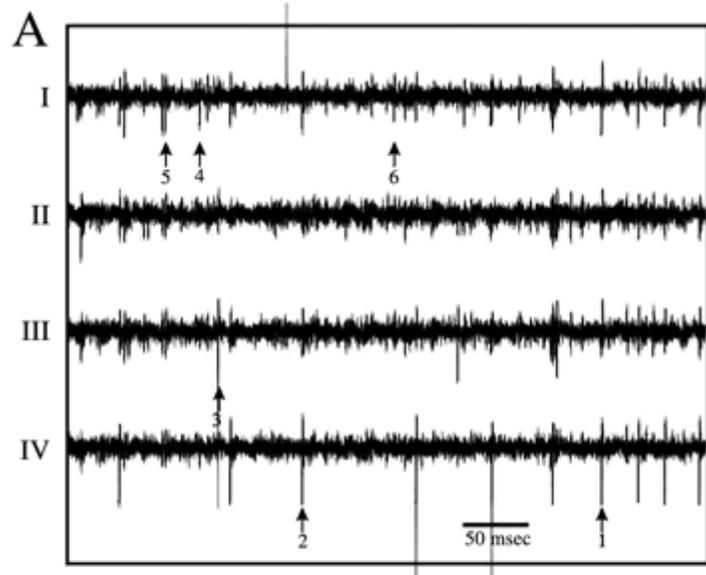
Thought to be involved in

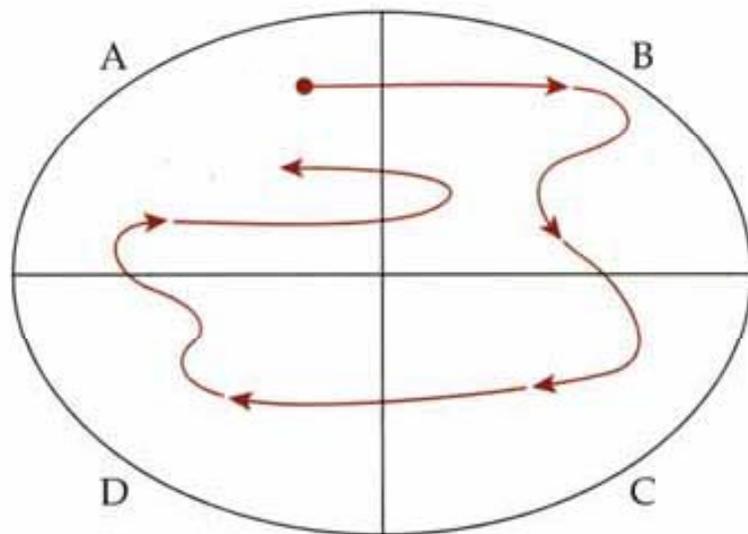
- 1) short term memory**
- 2) memory consolidation**
- 3) episodal memory**
- 4) spatial orientation**

Today:
Spatial representation, spatial coding, place cells?

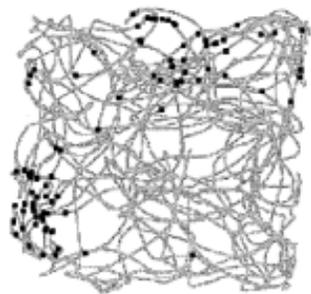
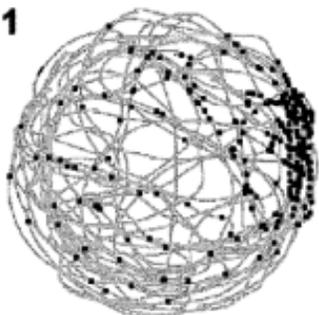




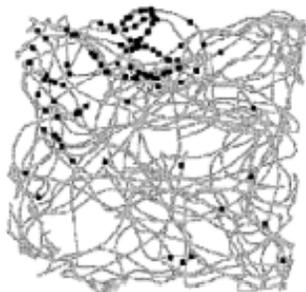
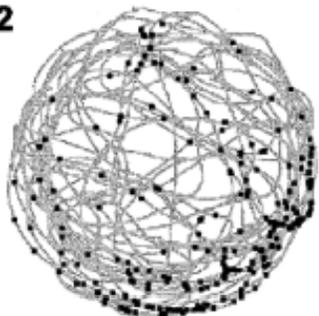




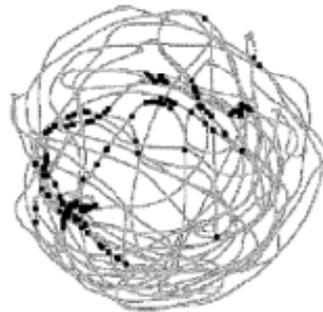
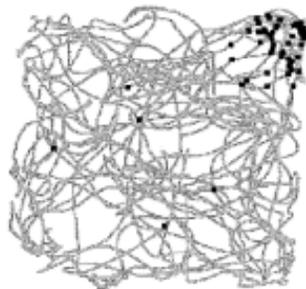
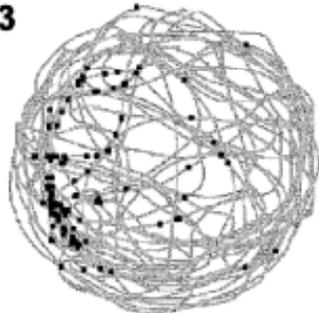
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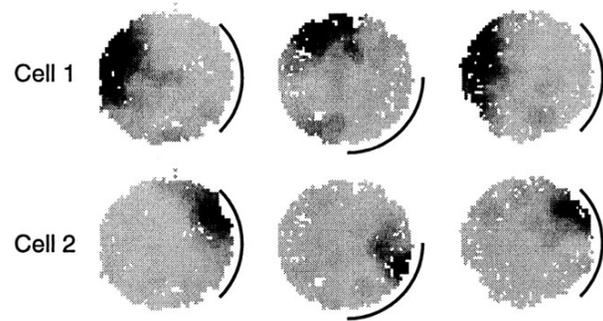
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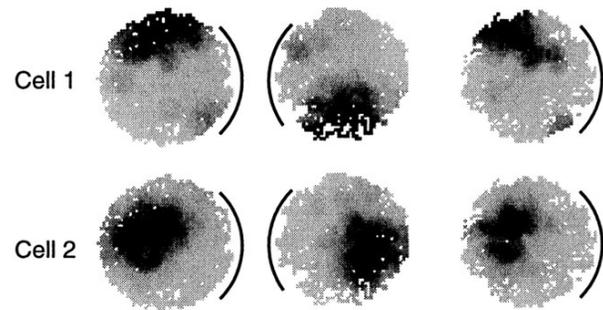
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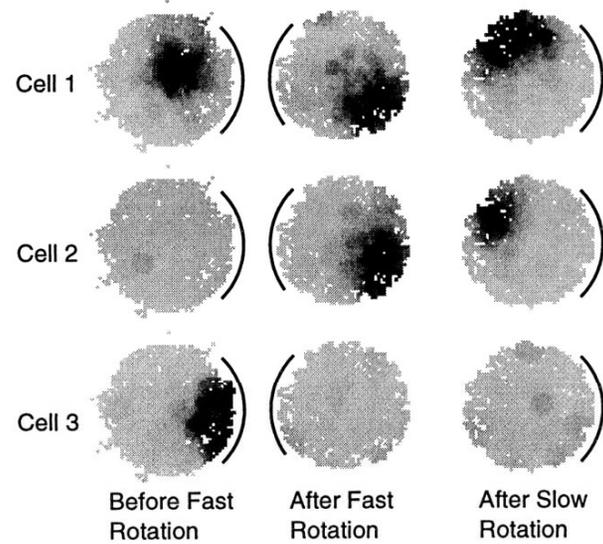
A 45 degree Rotation



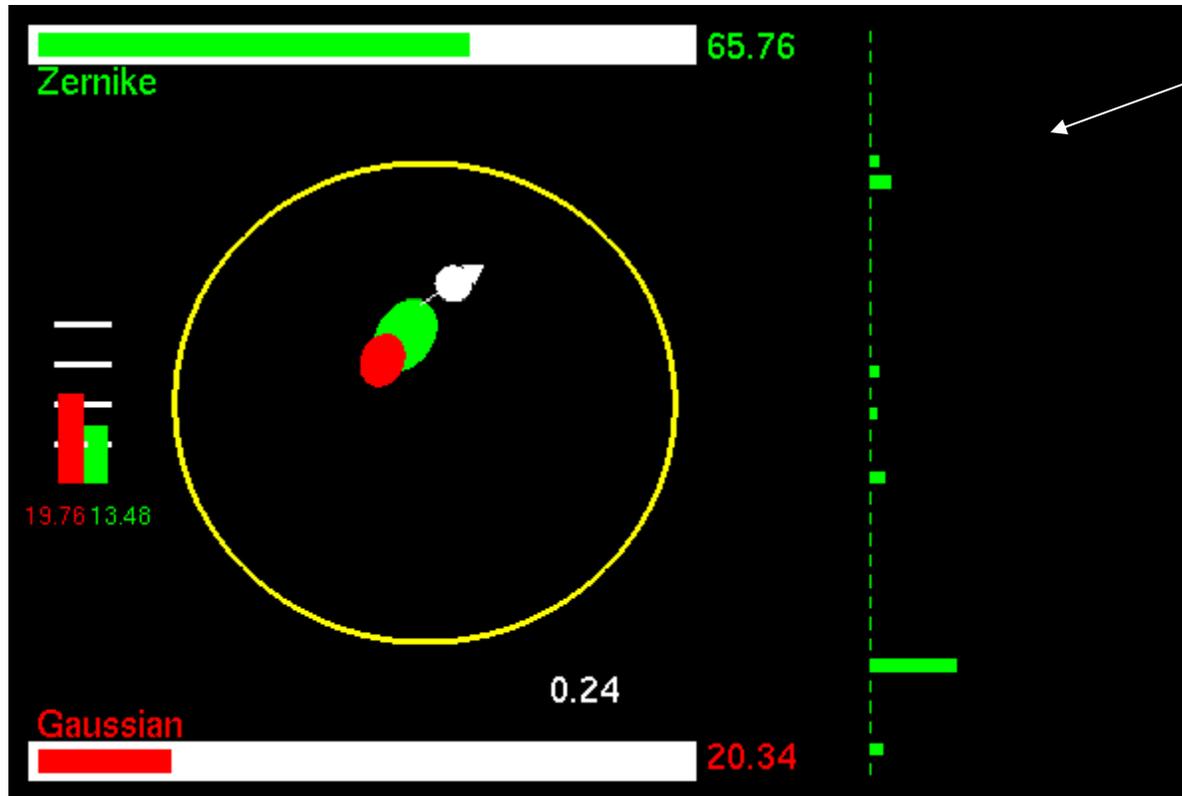
B 180 degree Rotation



C 180 degree Rotation



White rat: actual position. red and green: model predictions



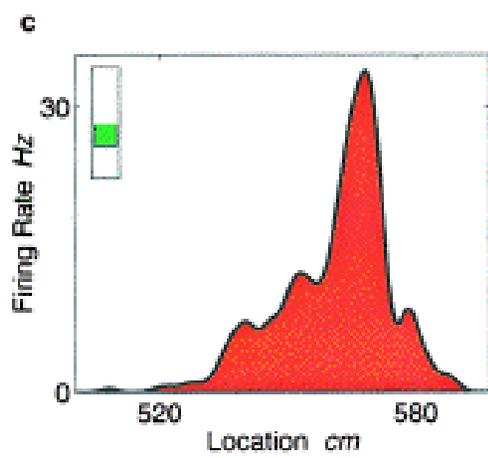
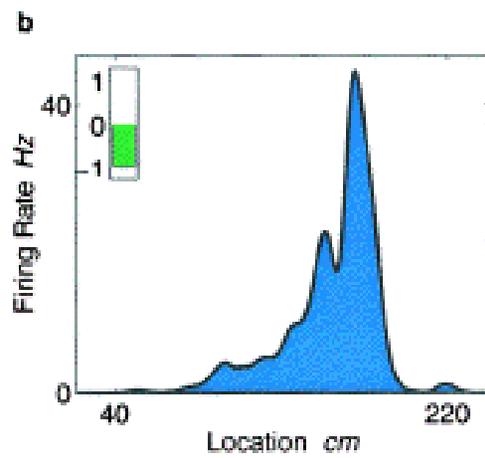
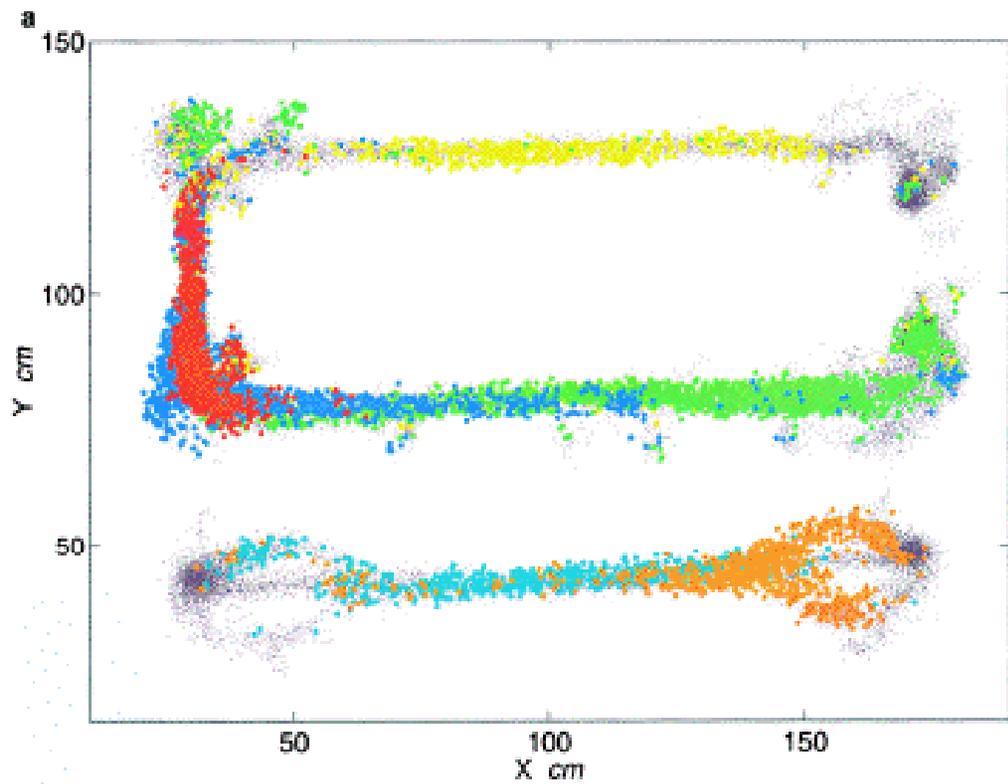
spiking activity of cells recorded in this animal

White rat: actual position. red and green: model predictions



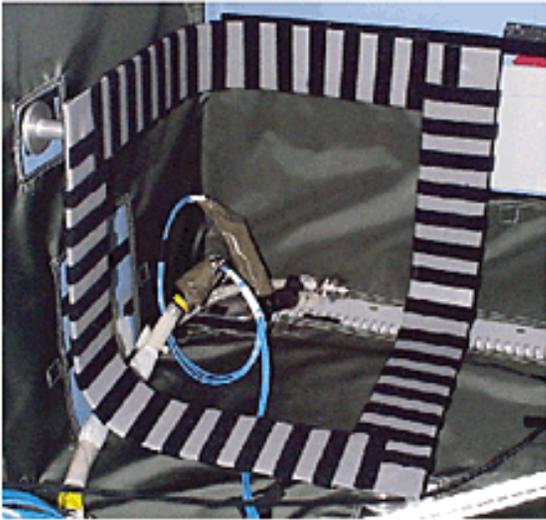
spiking activity
of cells
recorded
in this animal

Approach: at each time step, calculate the probability that rat is at coordinates (x,y) given the neural activity. The parameters of such a model are continuously updated and the model can predict the location of the rat better and better. The parameters can then give insight into the characteristics of the neural activity relevant to encoding position. The evolution of the parameters can give insights into the plasticity of the system.

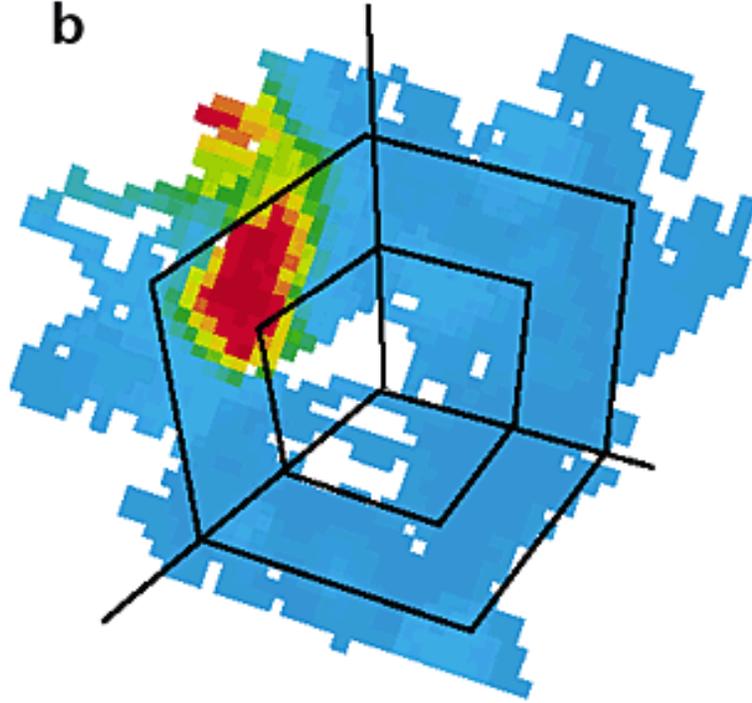


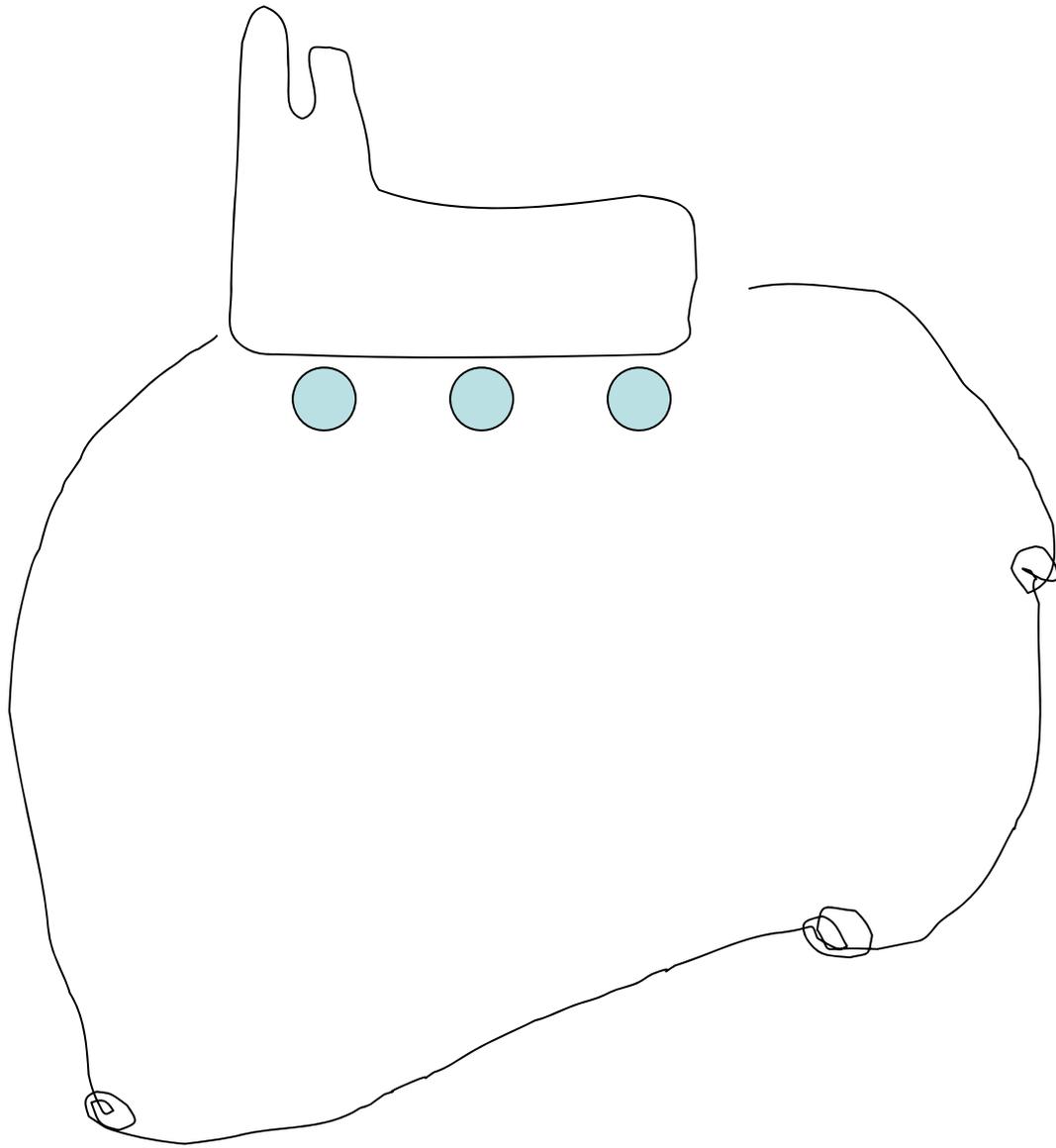
In space

a



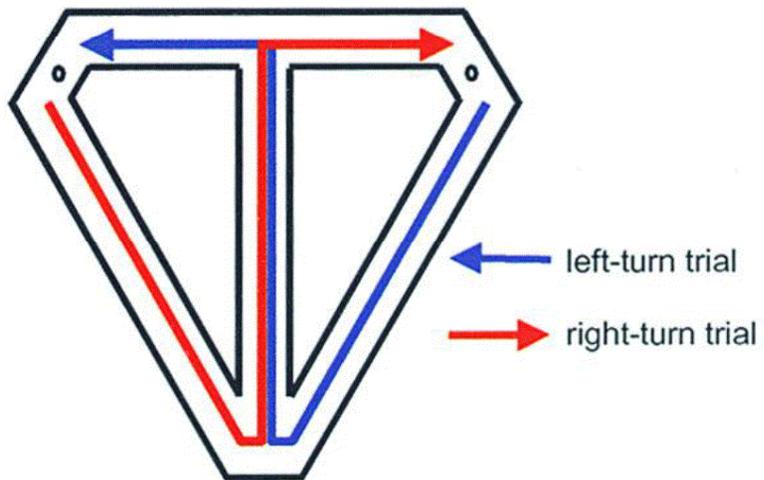
b



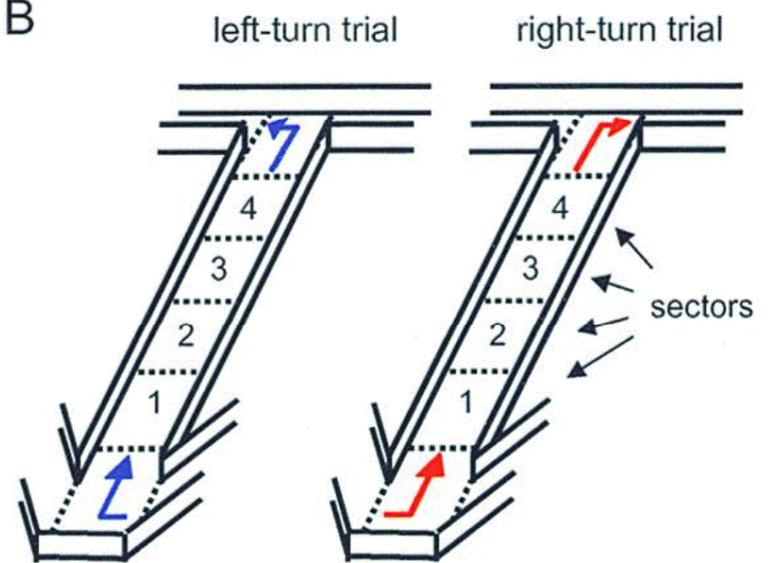


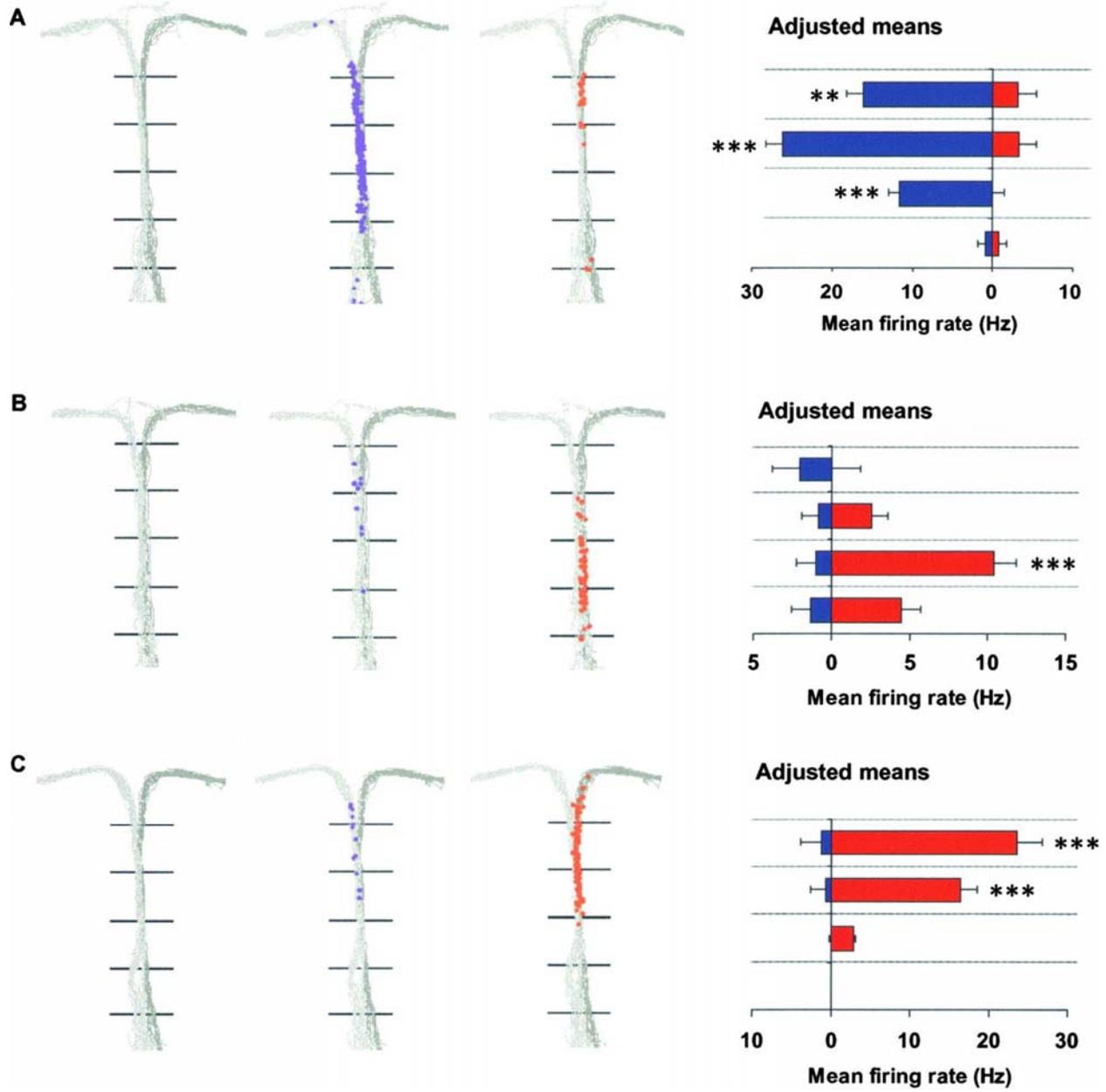
Cells fire only where there is food!

A

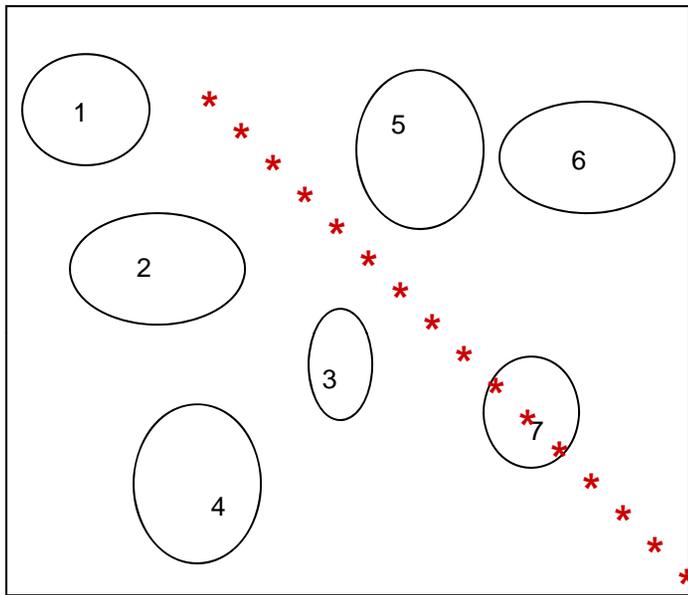


B



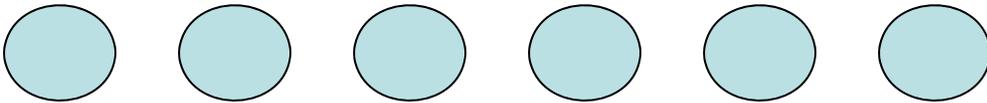
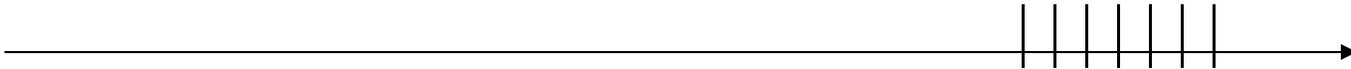
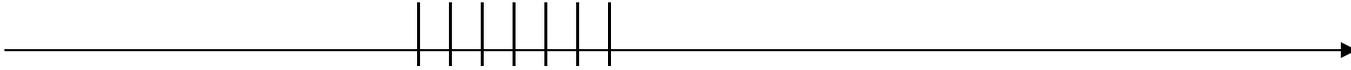
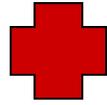


Exercise



You recorded from 7 neurons in the hippocampus while a rat was running around in a box. The circles represent each neuron's "place field".

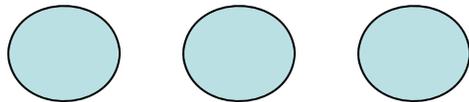
- What would you expect to see in your recordings while the rat followed the path depicted in red asterisks ?
- Could you predict the responses of an eighth neuron from those of the 7 neurons you recorded?



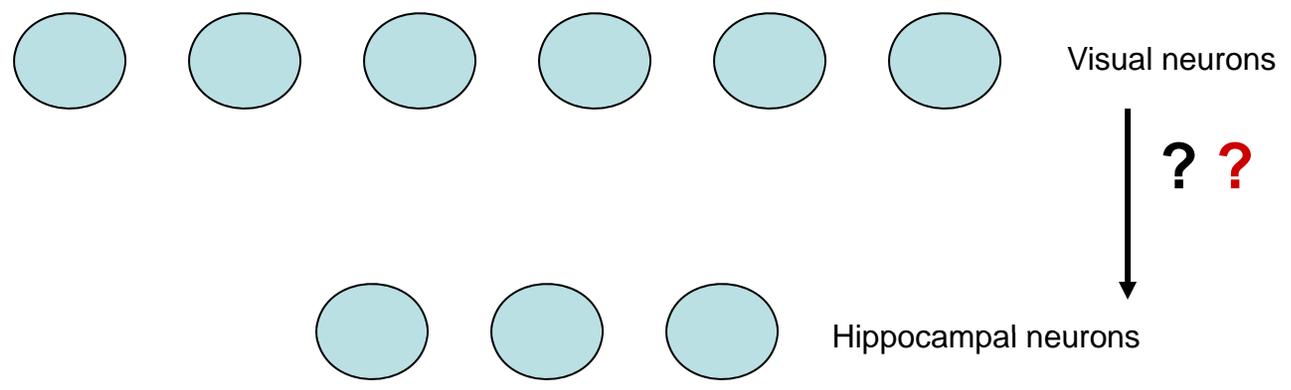
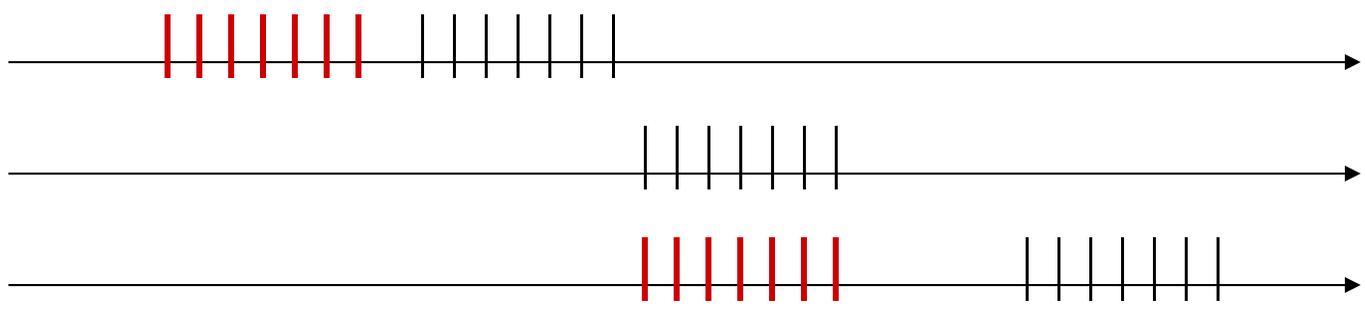
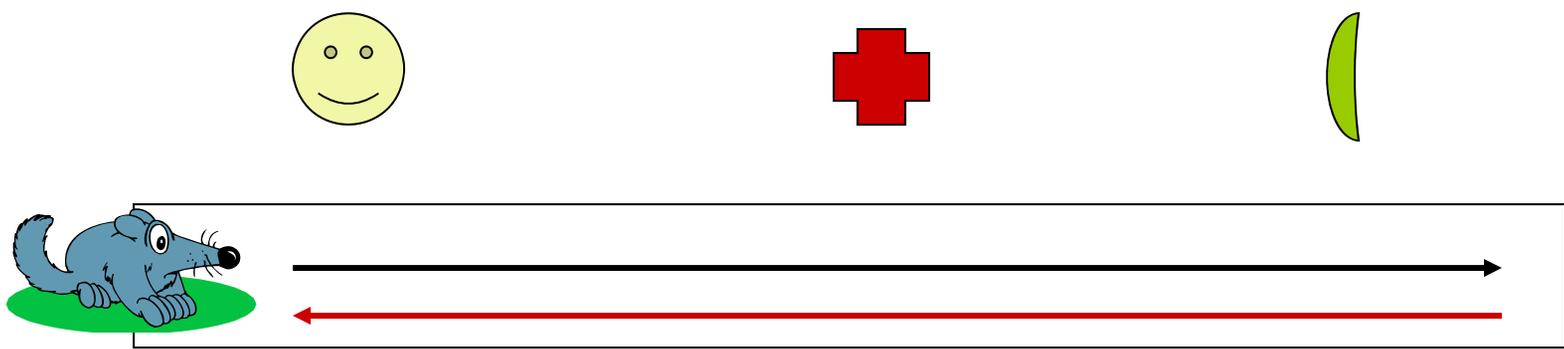
Visual neurons



?



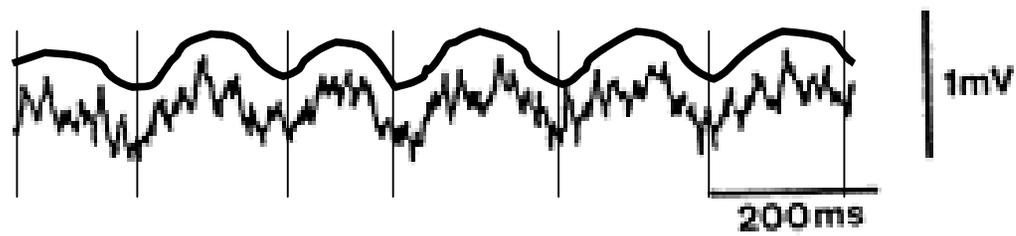
Hippocampal neurons



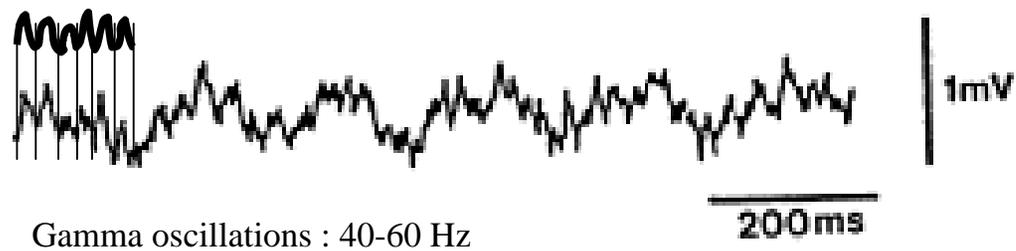
Is place cells the right name?



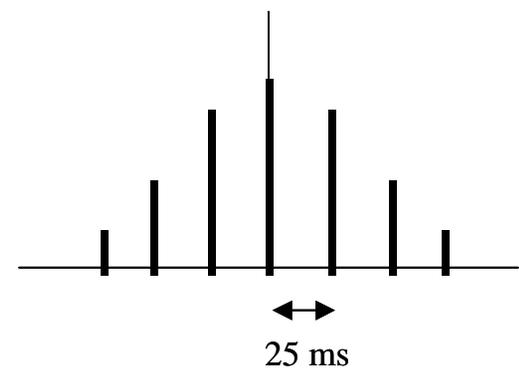
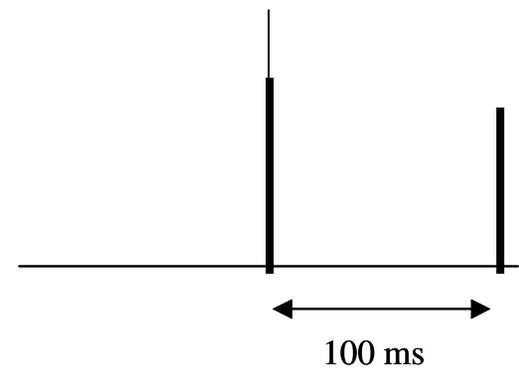
Simultaneous theta and gamma oscillations recorded in the rat hippocampus

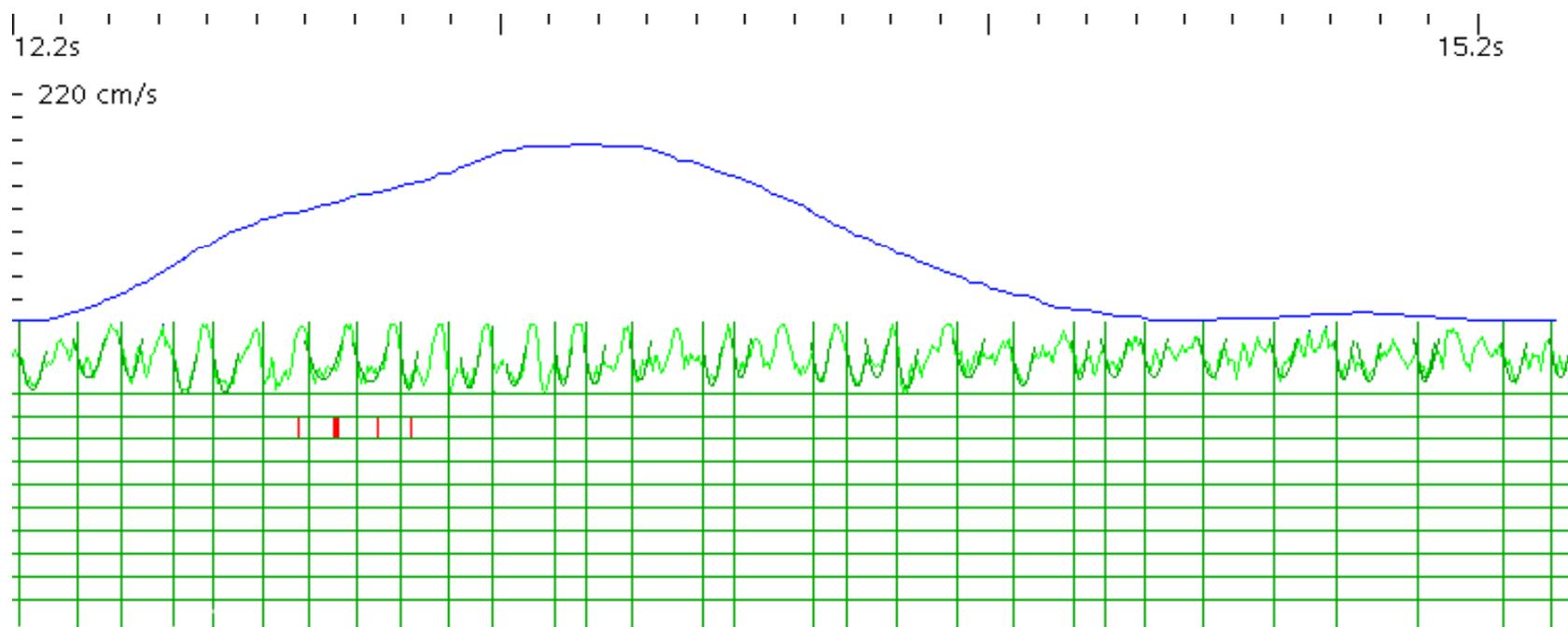


Theta oscillations : 4-10 Hz

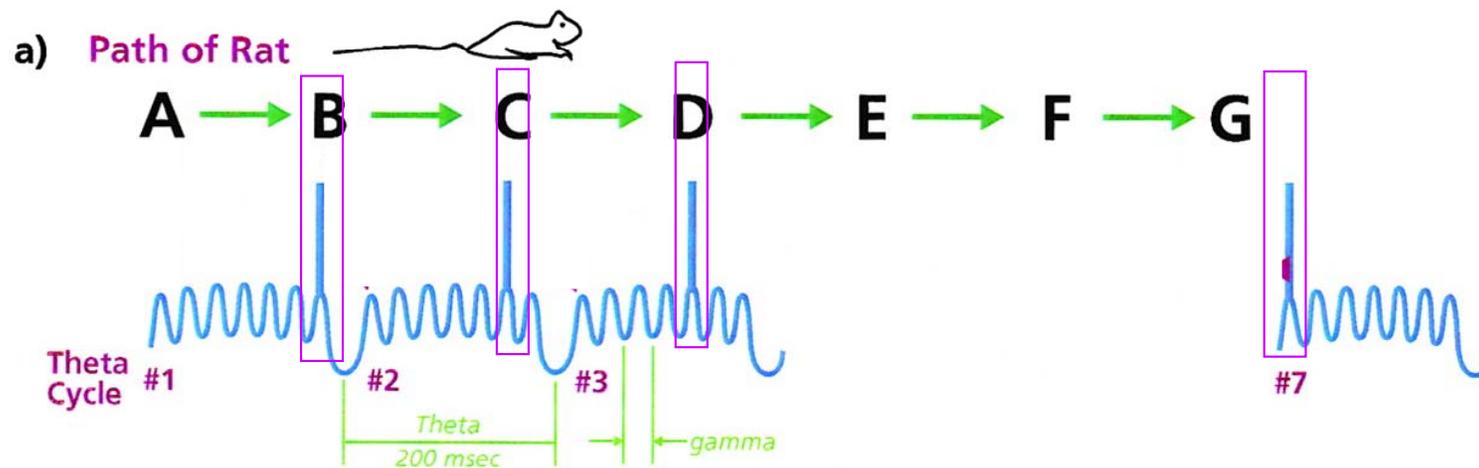


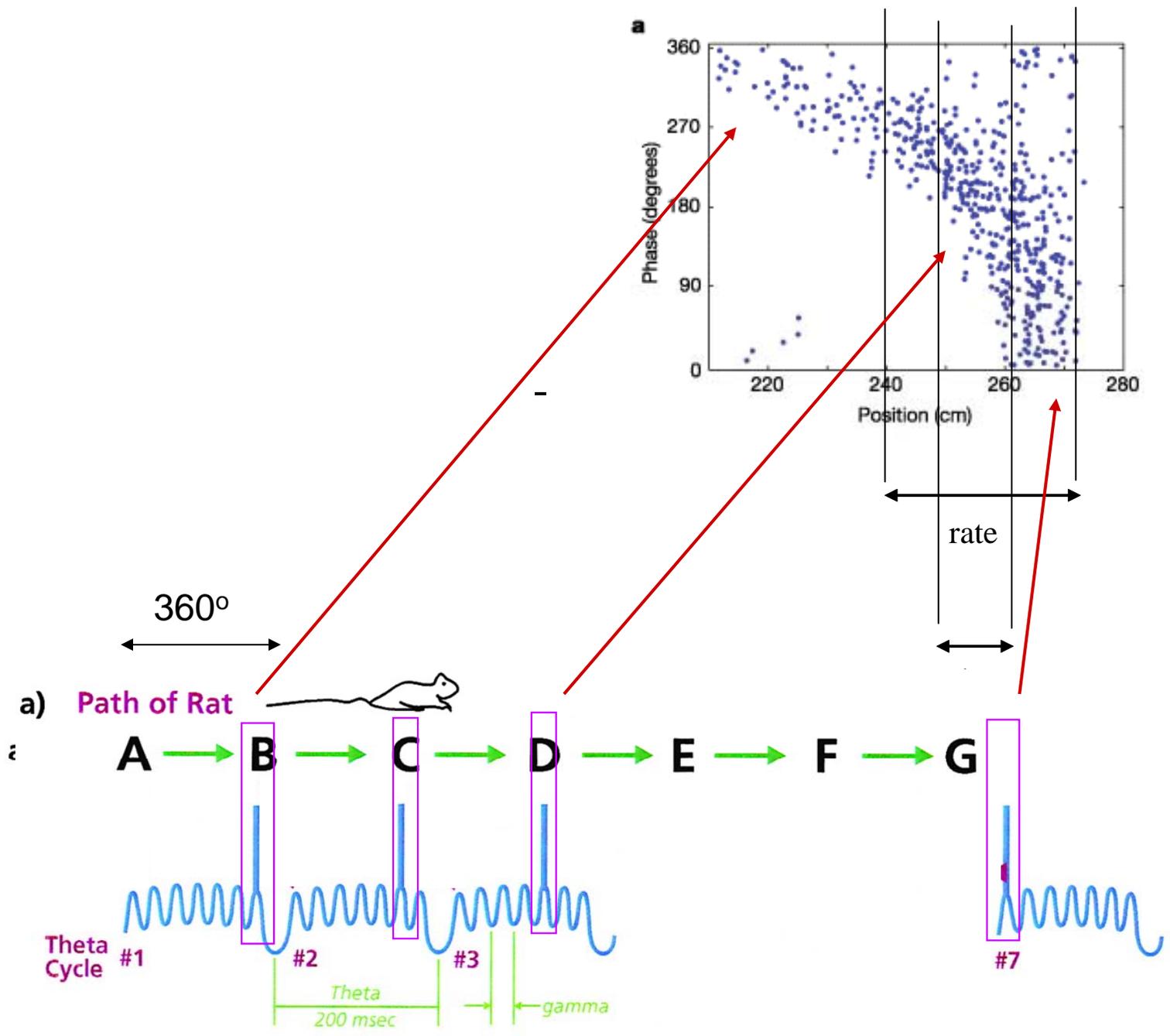
Gamma oscillations : 40-60 Hz

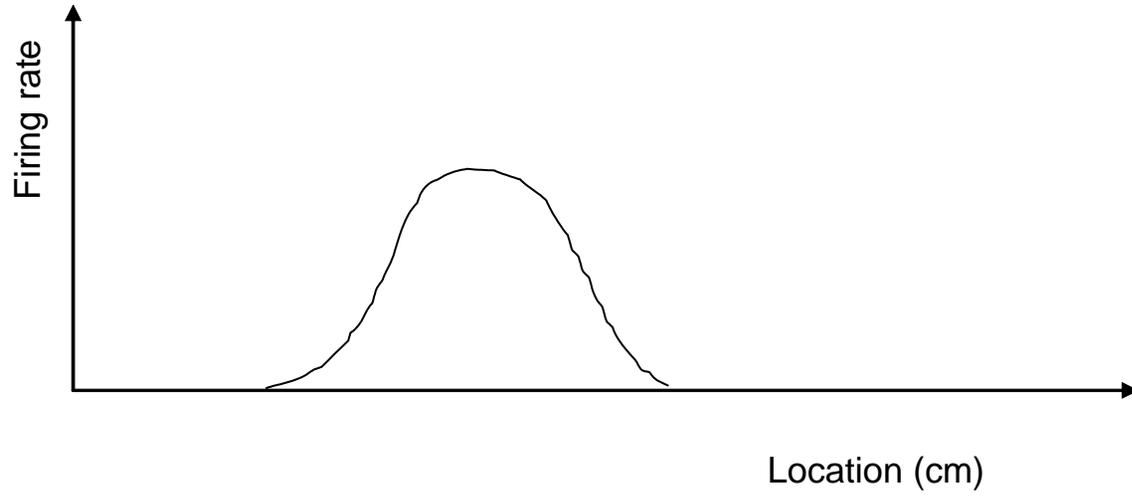


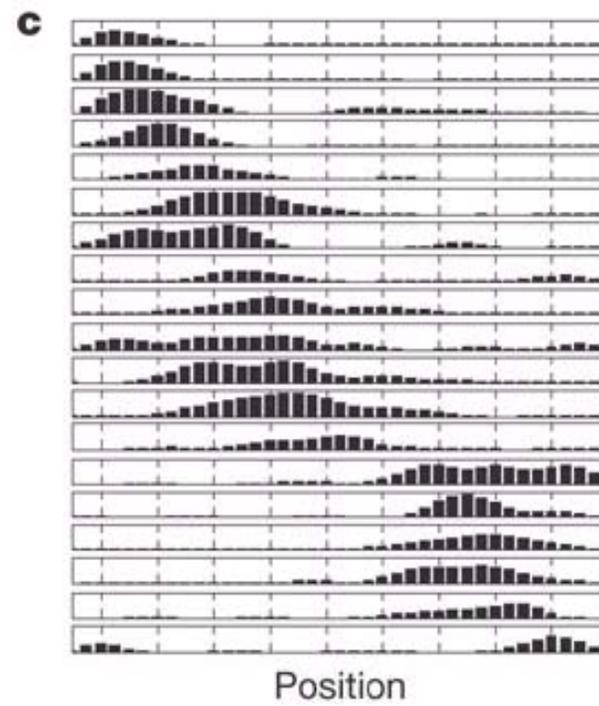
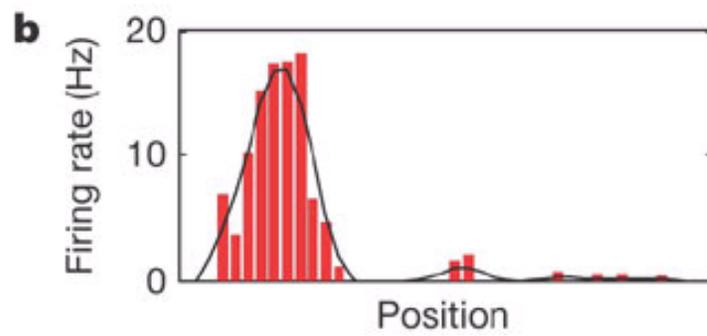
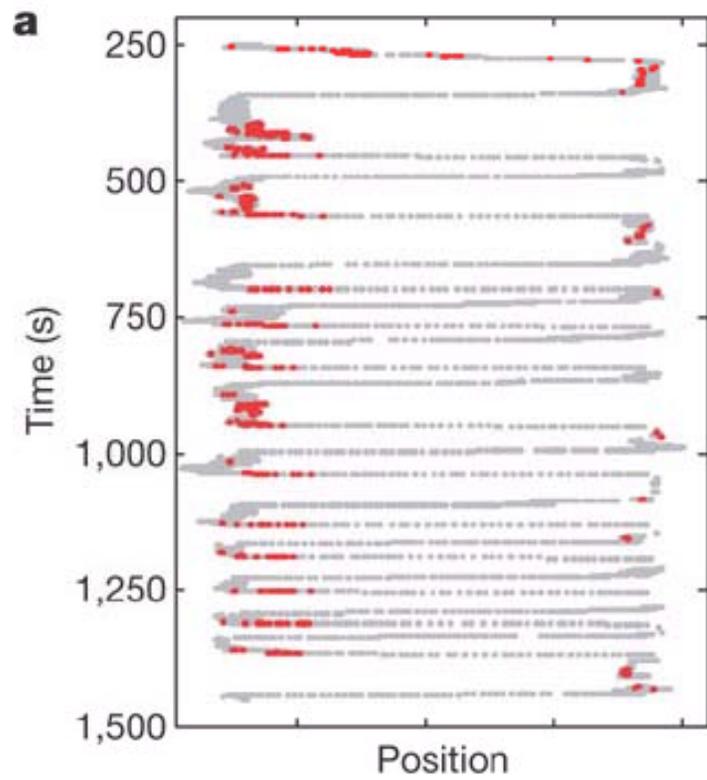


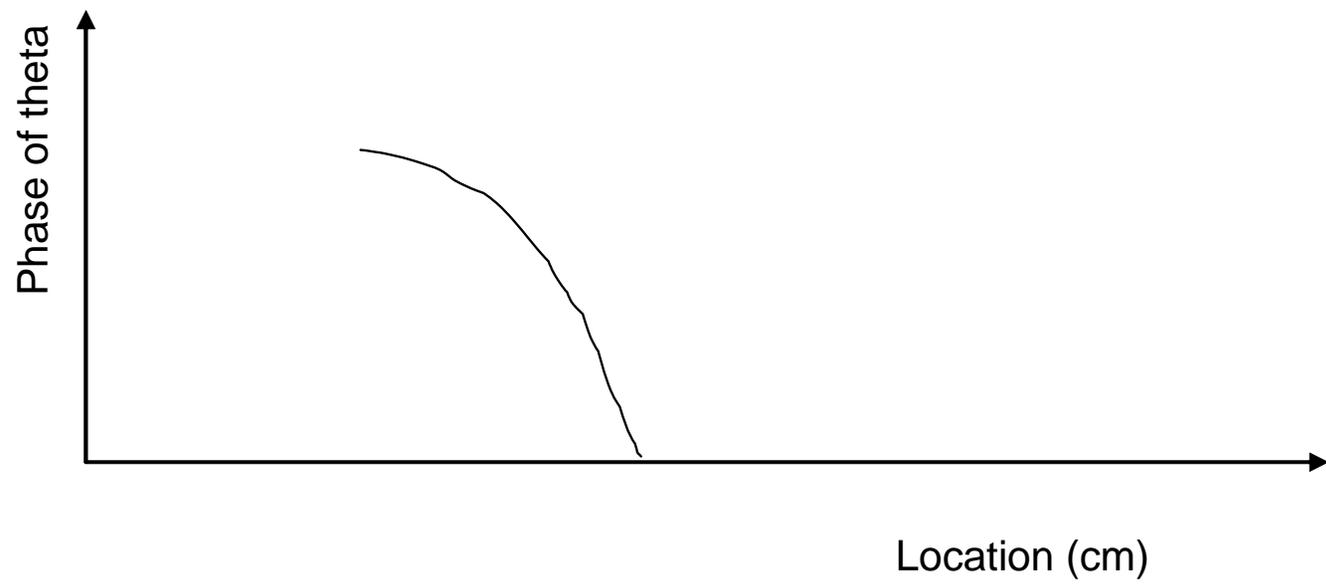
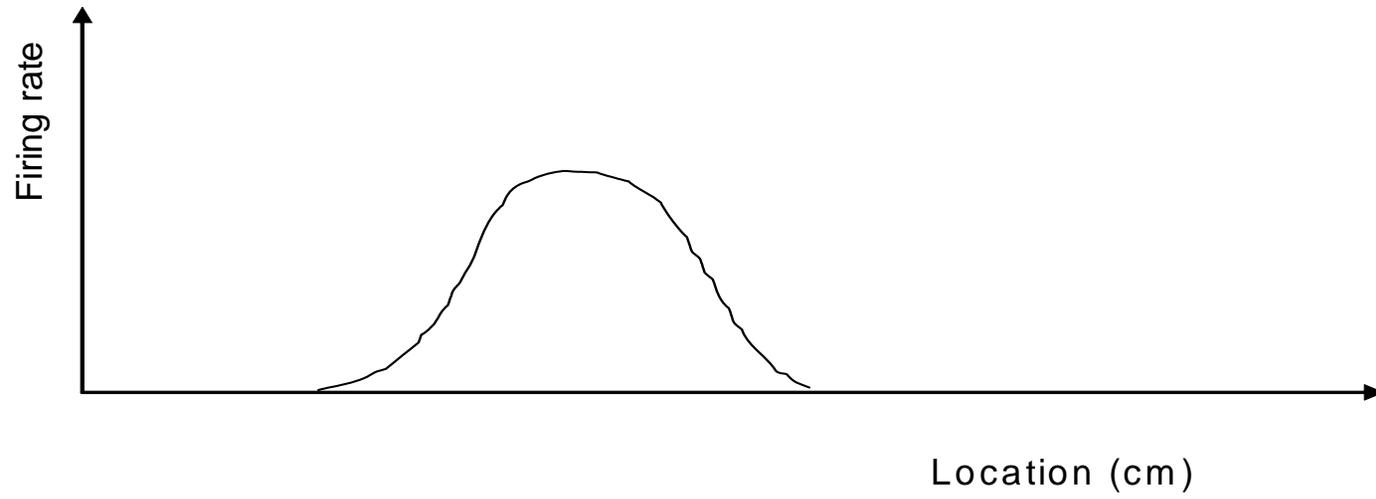
There are approximately 5-7 gamma cycles in one theta cycle; when a rat moves on a linear track, hippocampal pyramidal cells spike on a given gamma cycle depending on the rat's location (phase precession)

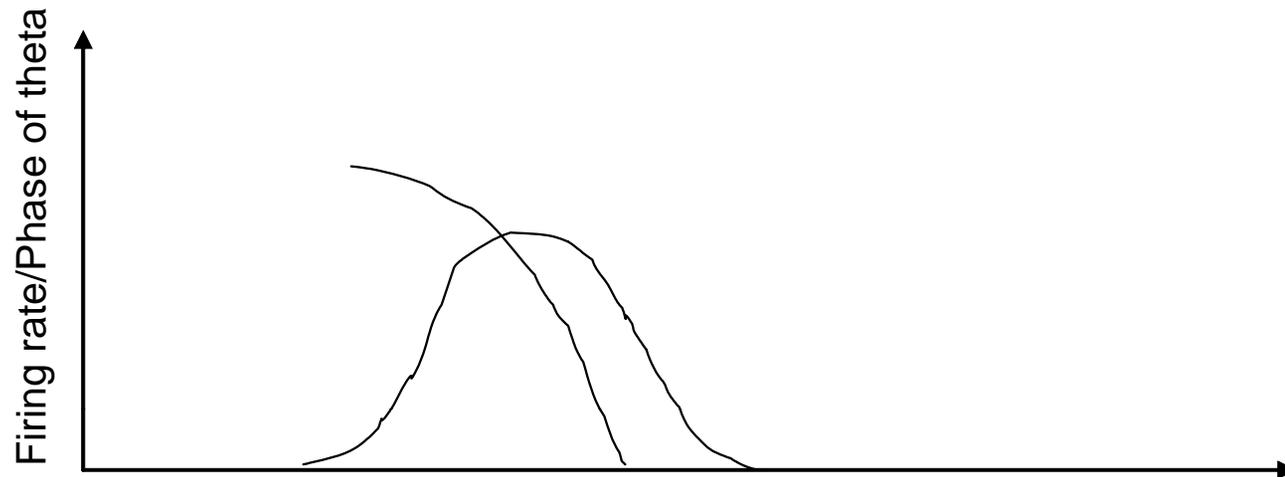












Location (cm)

*Spatial resolution of
spike alone*



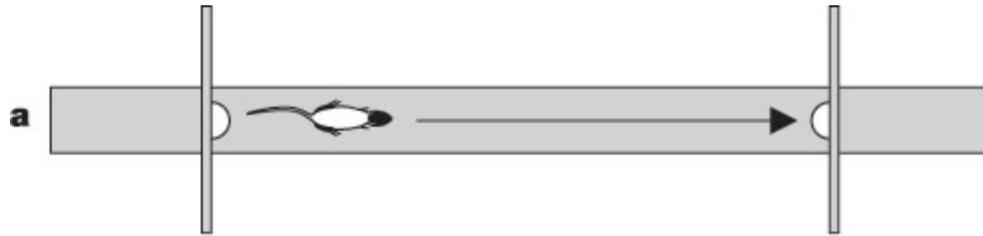
Spatial resolution of phase

Does rate alone convey information?

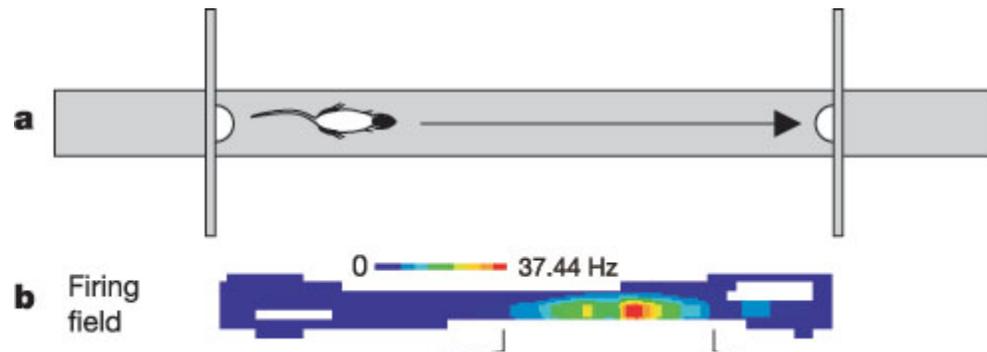
Nature **425**, 828-832 (23 October 2003) | doi:10.1038/nature02058;
Received 15 May 2003; Accepted 15 September 2003

Independent rate and temporal coding in hippocampal pyramidal cells

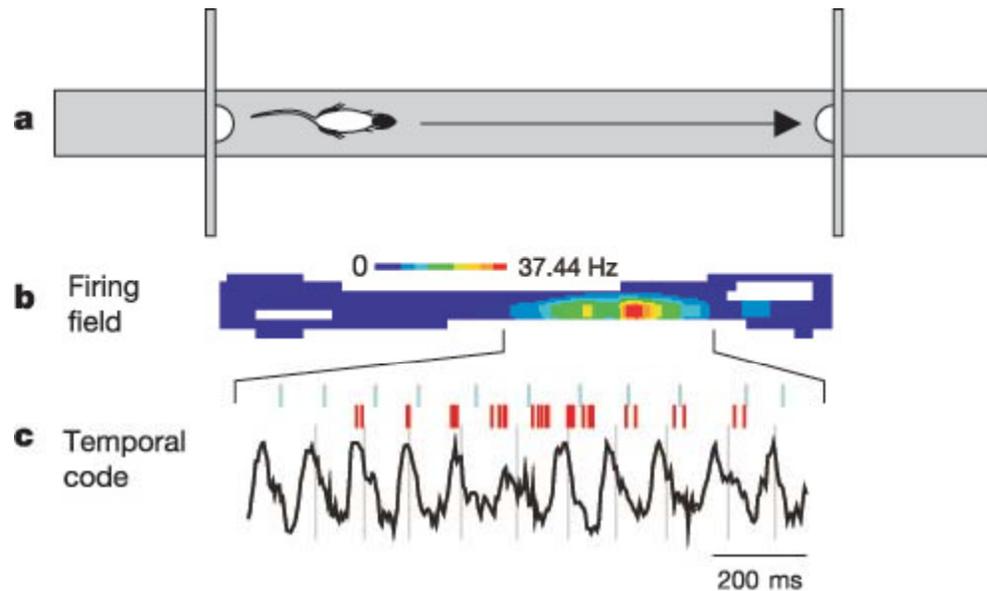
John Huxter^{[1,3](#)}, Neil Burgess^{[1,2](#)} & John O'Keefe^{[1,2](#)}



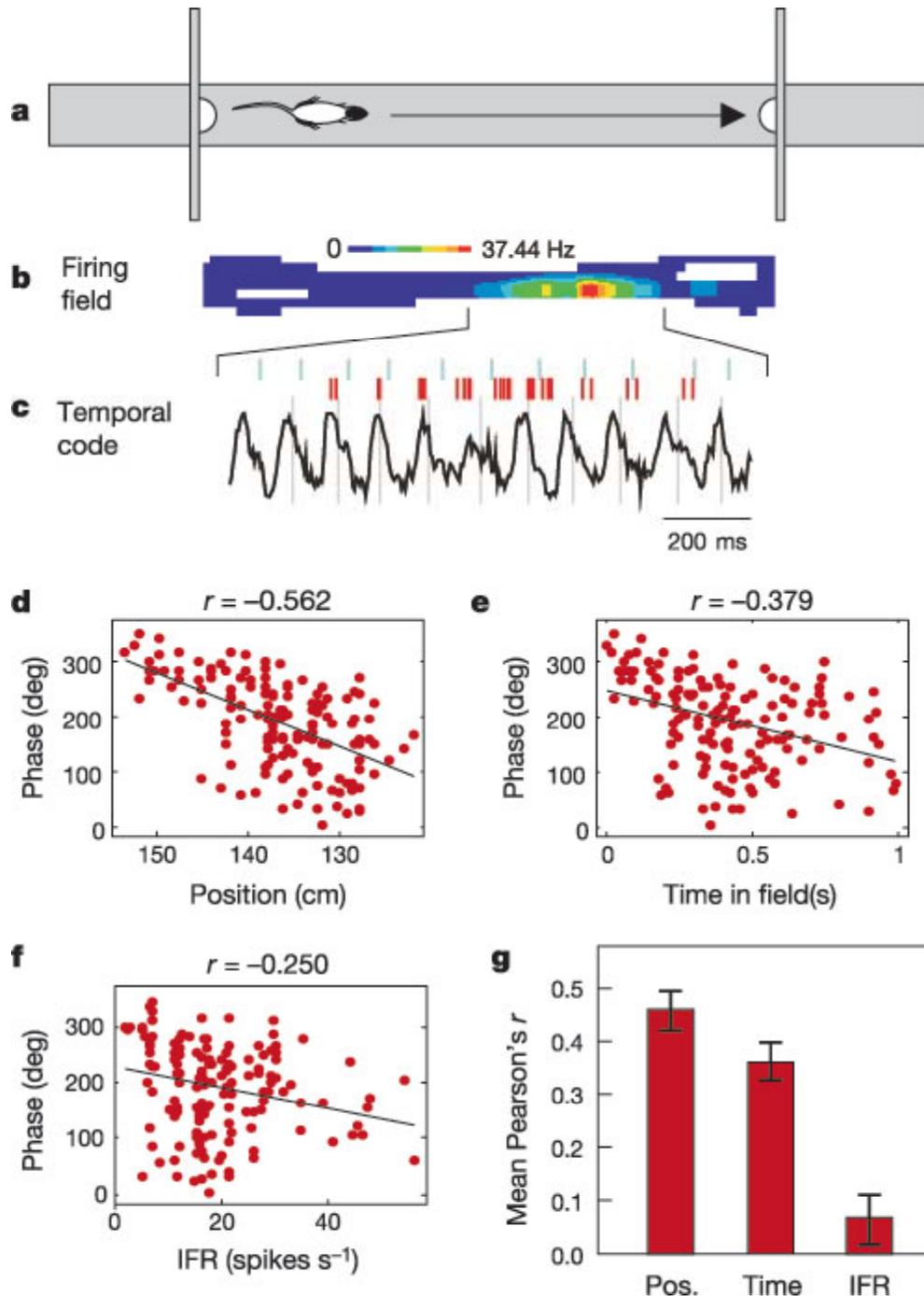
a. Behavioural task: rat shuttles back and forth along linear track between food rewards contained in cups attached to movable walls.



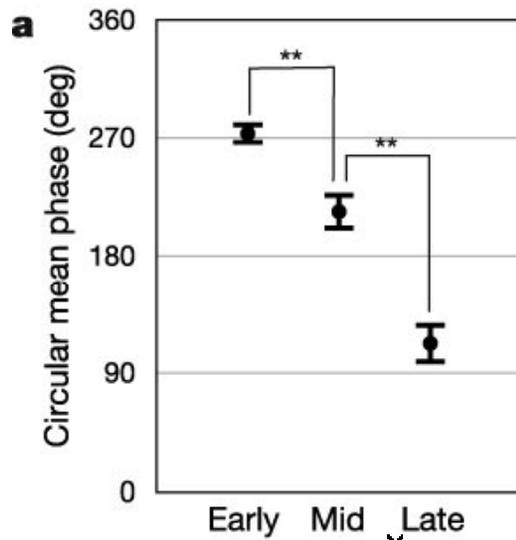
b, False-colour firing field of a place cell created from multiple runs in the eastward direction.



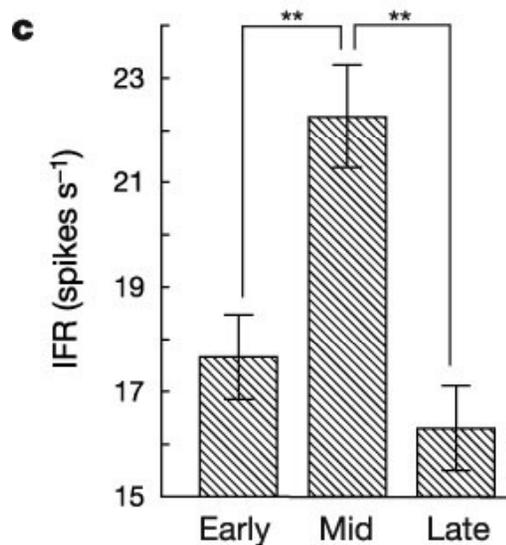
c, EEG theta rhythm and place cell firing (in red) for the same cell on a single eastward run. Ticks above the spikes indicate + to - zero crossings ($0^\circ/360^\circ$ phase) for each theta wave, lines through theta waves indicate 270° . Bursts of spikes occur at higher than theta frequency causing each successive burst to move to an earlier phase of the theta cycle, despite initially rising, then falling firing rate. Theta cycle phase of spikes for multiple runs from a place cell is plotted against position



Rate of bursts is higher than theta : as a consequence cells fire earlier and earlier during theta (phase precession) Phase and rate co-vary



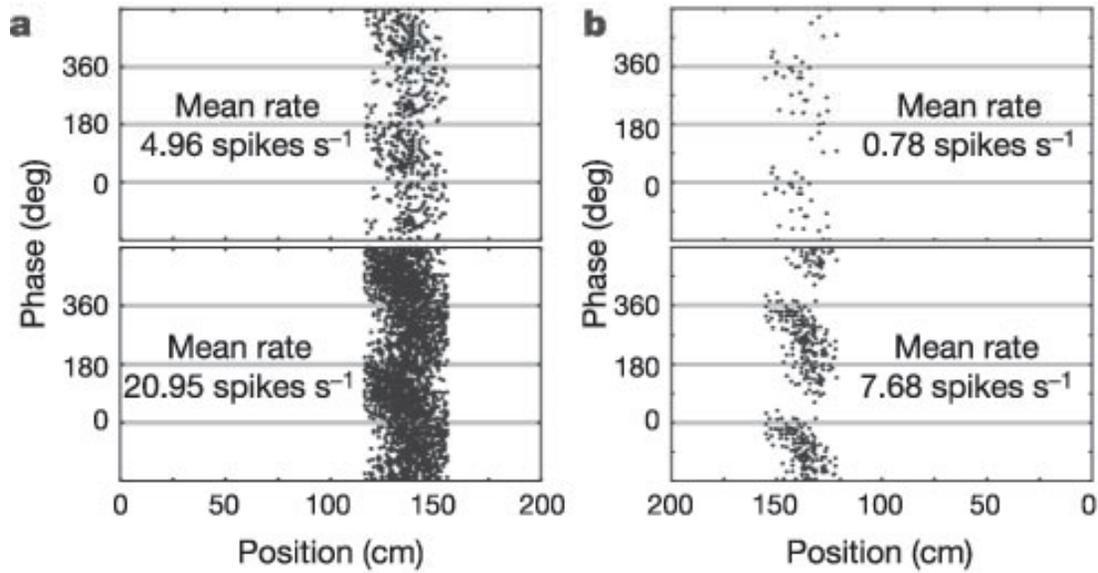
a, Phase depends on location, being highest in the early third of each field, lower in the middle third, and lowest in the late third.



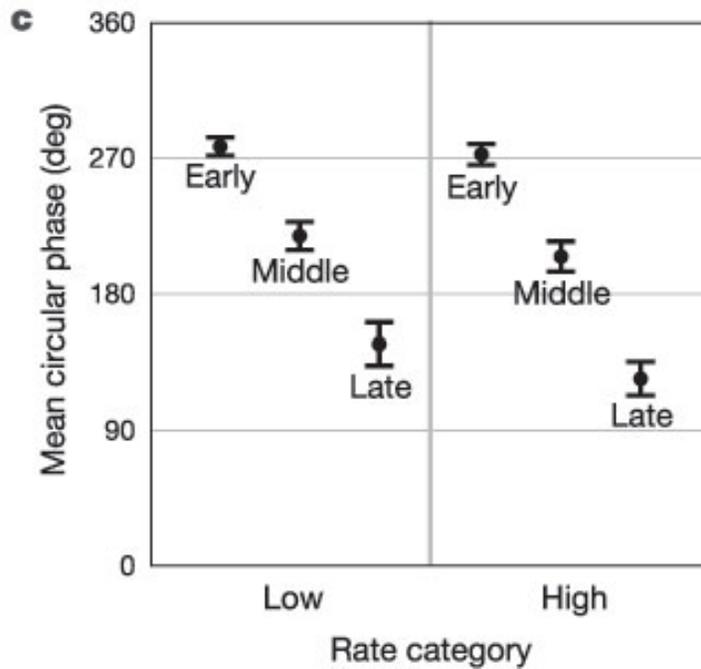
x

c, IFR starts low, increases in the middle third and then decreases in the late part of the field.

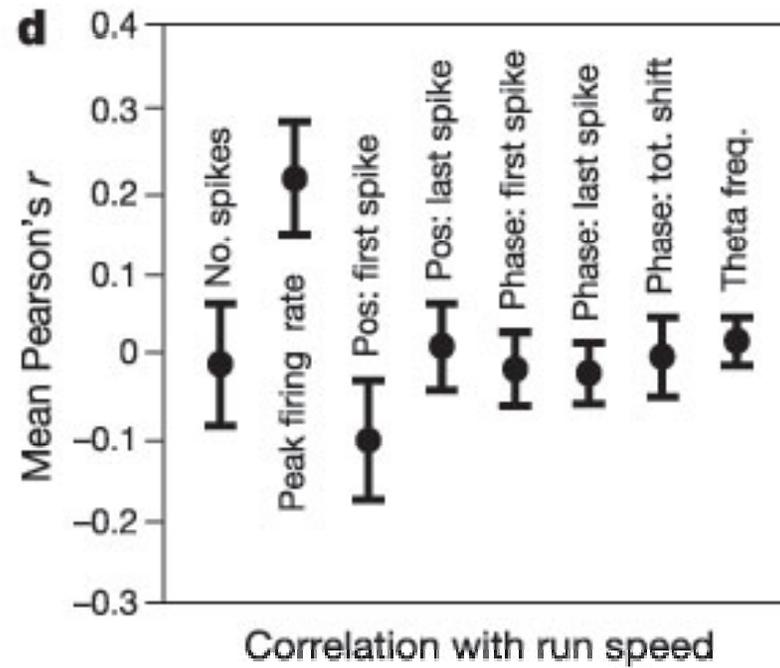
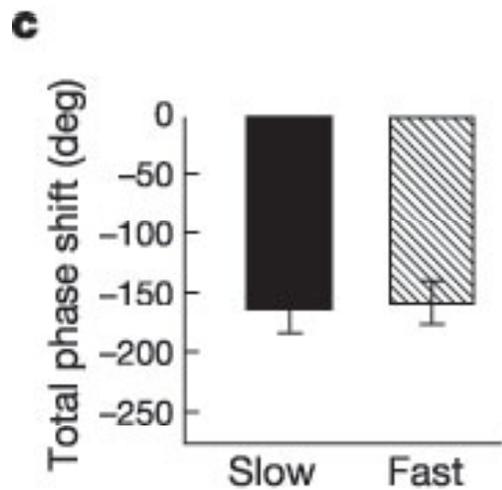
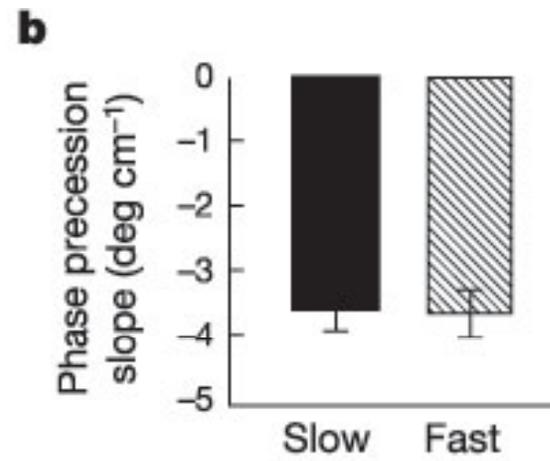
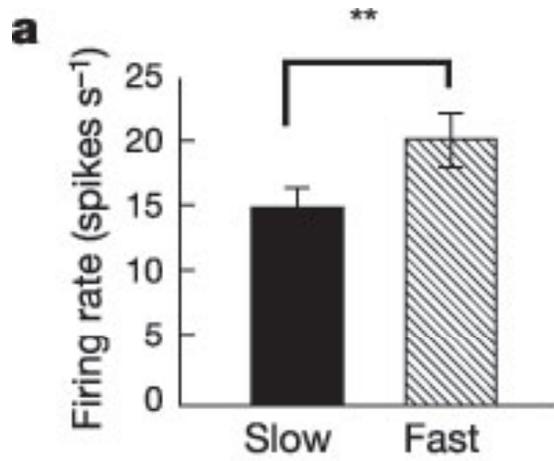
IFR: Instantaneous firing rate



Rate does not affect phase



Phase and rate can be independent – do they encode different variables?



Rate correlates with running speed!