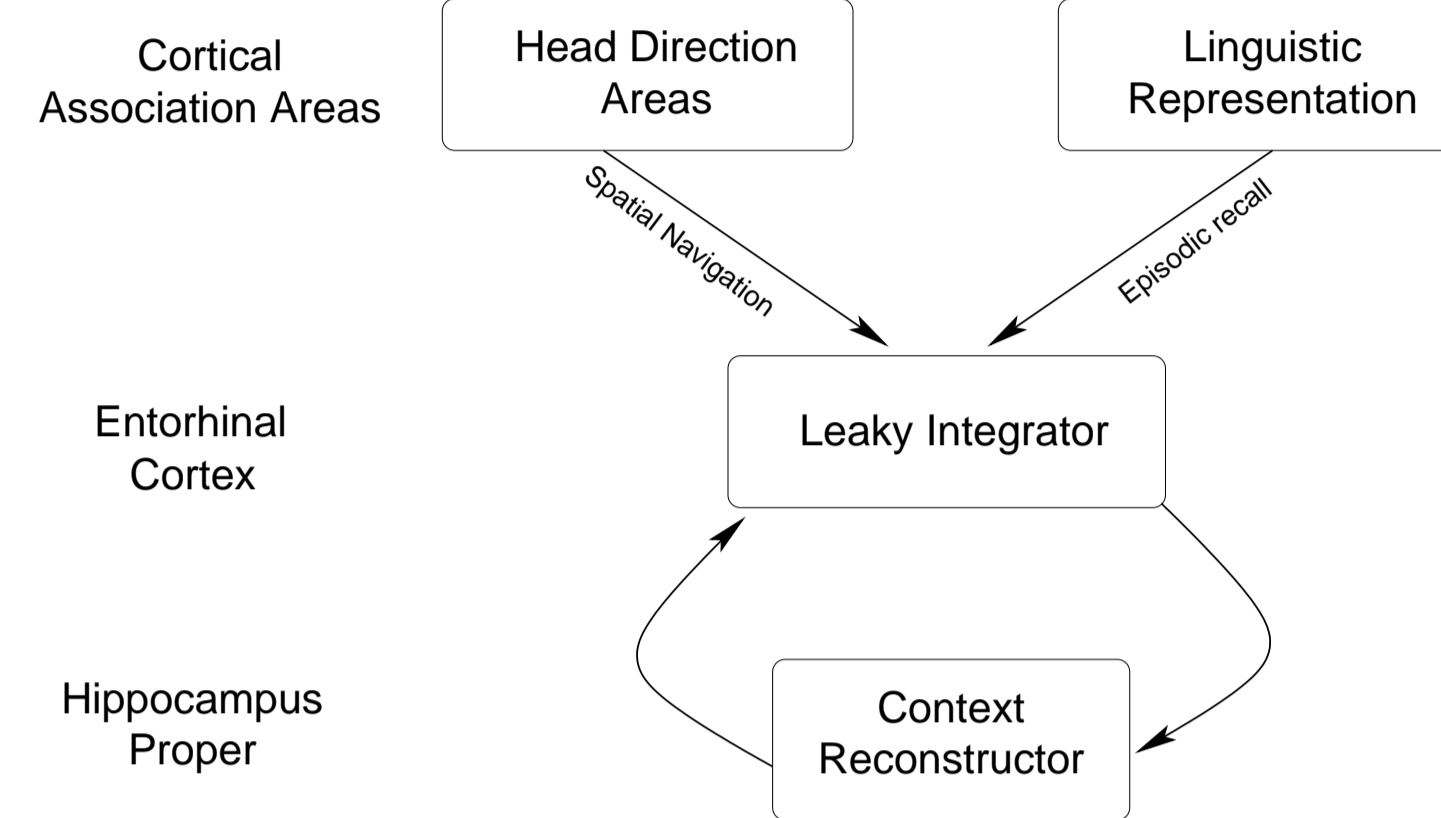


## the temporal context model (TCM)

Temporal context changes gradually over time (Howard & Kahana, 2002).

$$t_i = \rho_i t_{i-1} + \beta t_i^{IN}, \rho_i : \|t_i\| = 1$$

MTL in episodic recall and spatial tasks (Howard, Fotedar, Datey, & Hasselmo, 2005).



- Open field (Quirk et al, 1992)
- Retrospective coding (Frank et al, 2000)
- Trajectory coding (*ibid*)

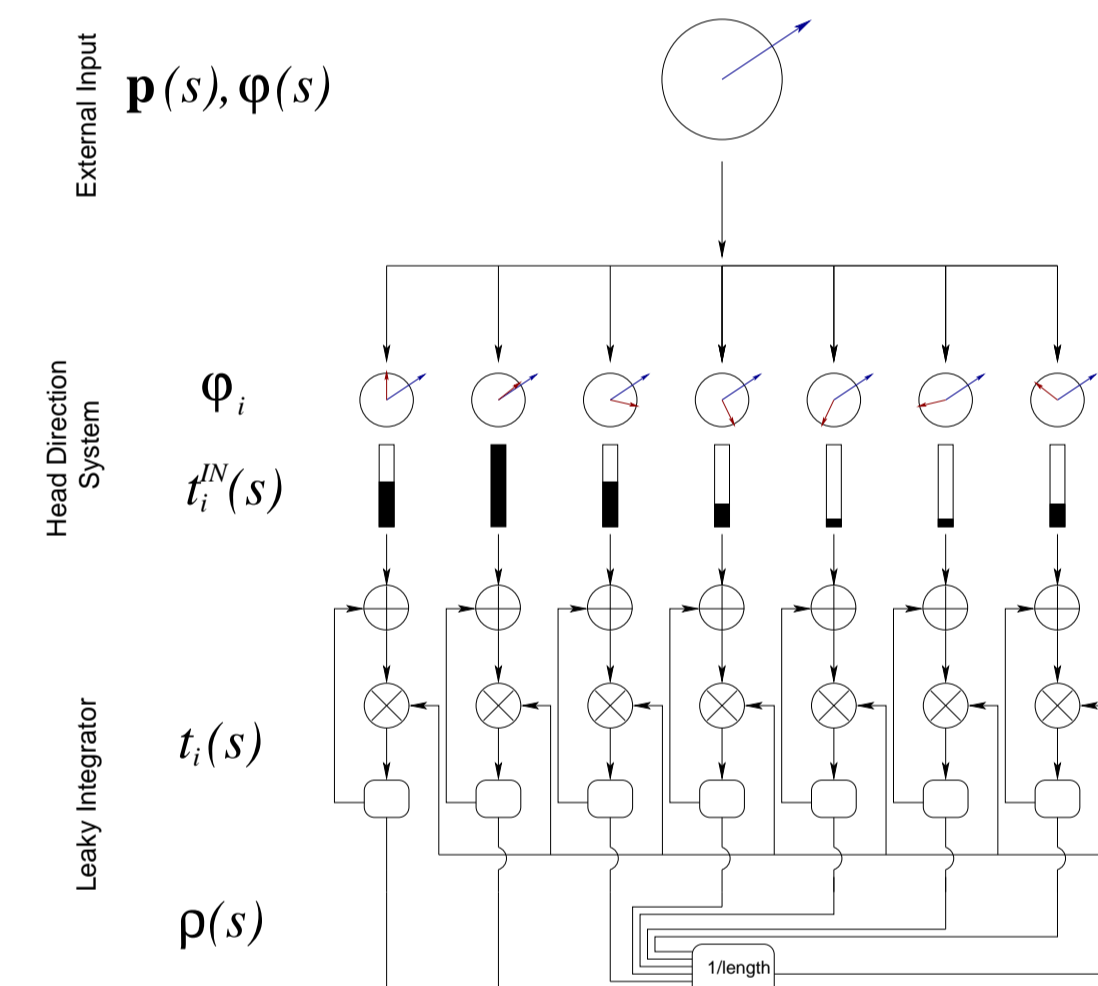
## implementing contextual evolution

Integrator cells (Egorov, Hamam, Fransén, Hasselmo, & Alonso, 2002):

$$t_i(s) = \rho(s) [t_i(s-1) + \beta t_i^{IN}(s)],$$

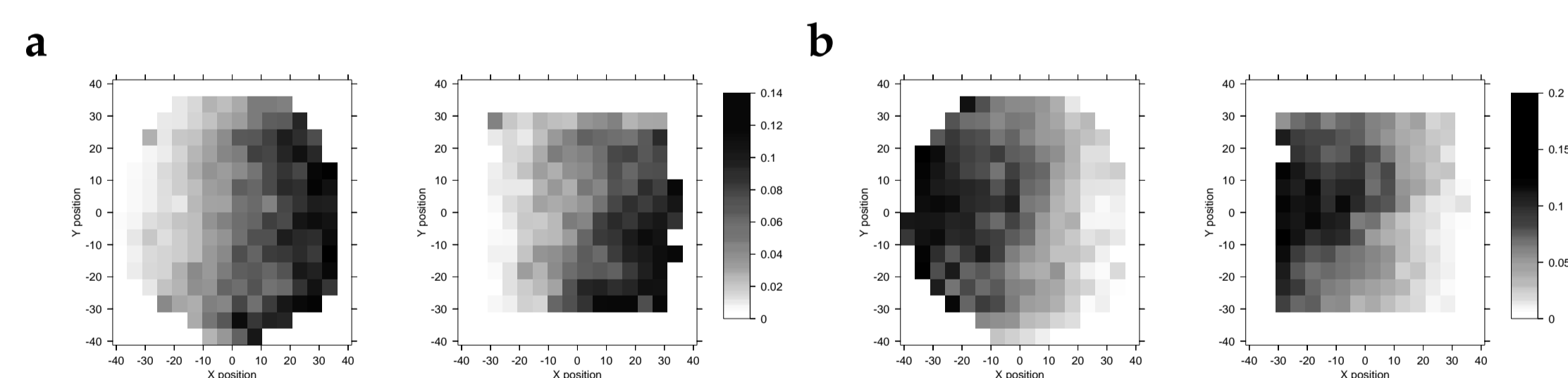
With gain  $\rho(s)$  a function of network activity (Chance, Abbott, & Reyes, 2002):

$$\rho(s) = \left[ \sum_i [t_i(s-1)]^2 \right]^{-1/2}$$

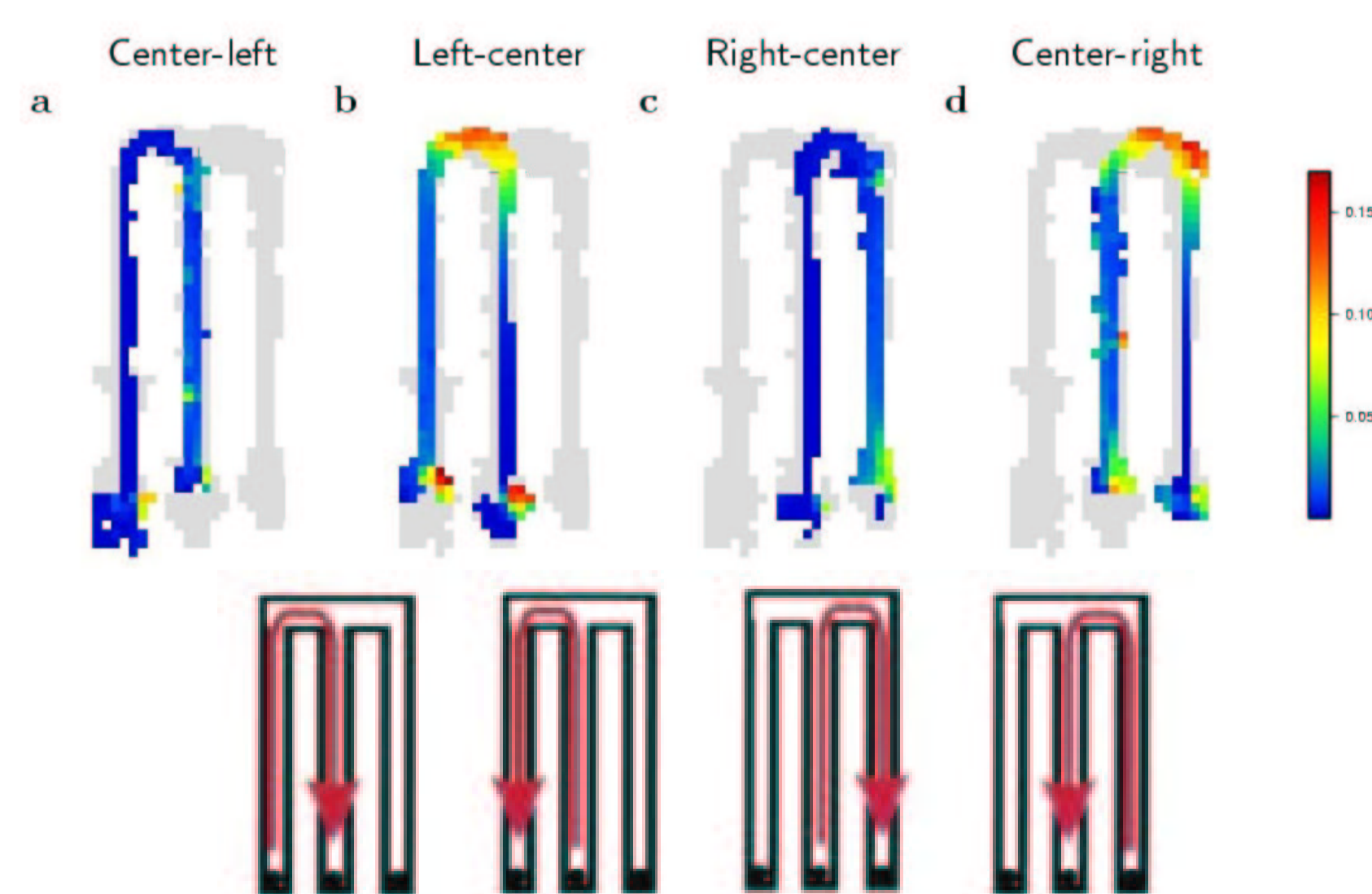


## previous results

Noisy place representation



Not really spatial



## questions

Is this quasi-spatial representation sufficient to describe the precision of the hippocampal place code (Wilson & McNaughton, 1993)?

Can the path-dependent  $t_i$  drive the path-independent place code in the open field?

## approaches to reconstruction

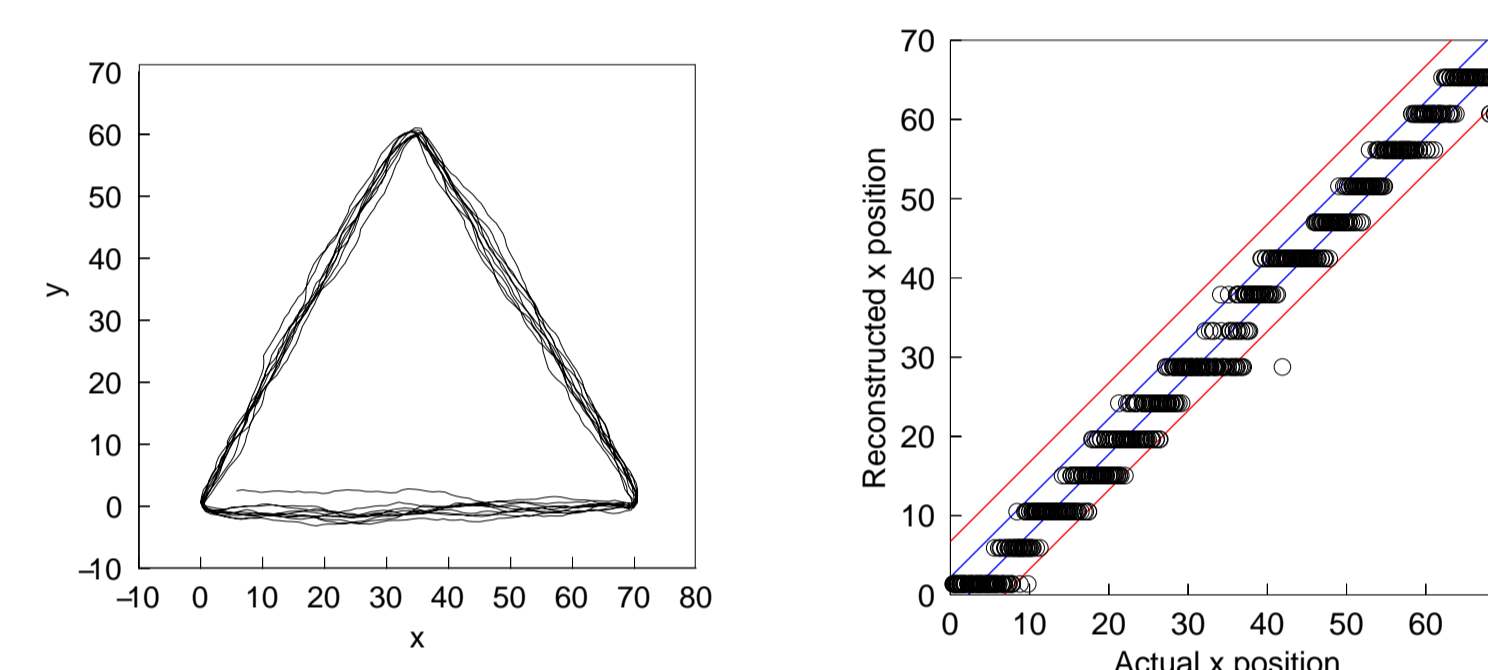
- Place cells as basis functions (Wilson & McNaughton, 1993). (Won't work because of path-dependence of cell firing.)
  - Bayesian reconstruction (Jensen & Lisman, 2000)
- Given firing rate vector  $f$ , find the position  $x$  that maximizes

$$P(x|f) = \frac{P(f|x)P(x)}{P(f)}$$

- Simulated paths (Brunel & Trullier, 1998)

$$\tau_\theta \dot{\theta} = -\theta + \hat{\theta} + \sigma_\theta \sqrt{\tau_\sigma} \eta(t)$$

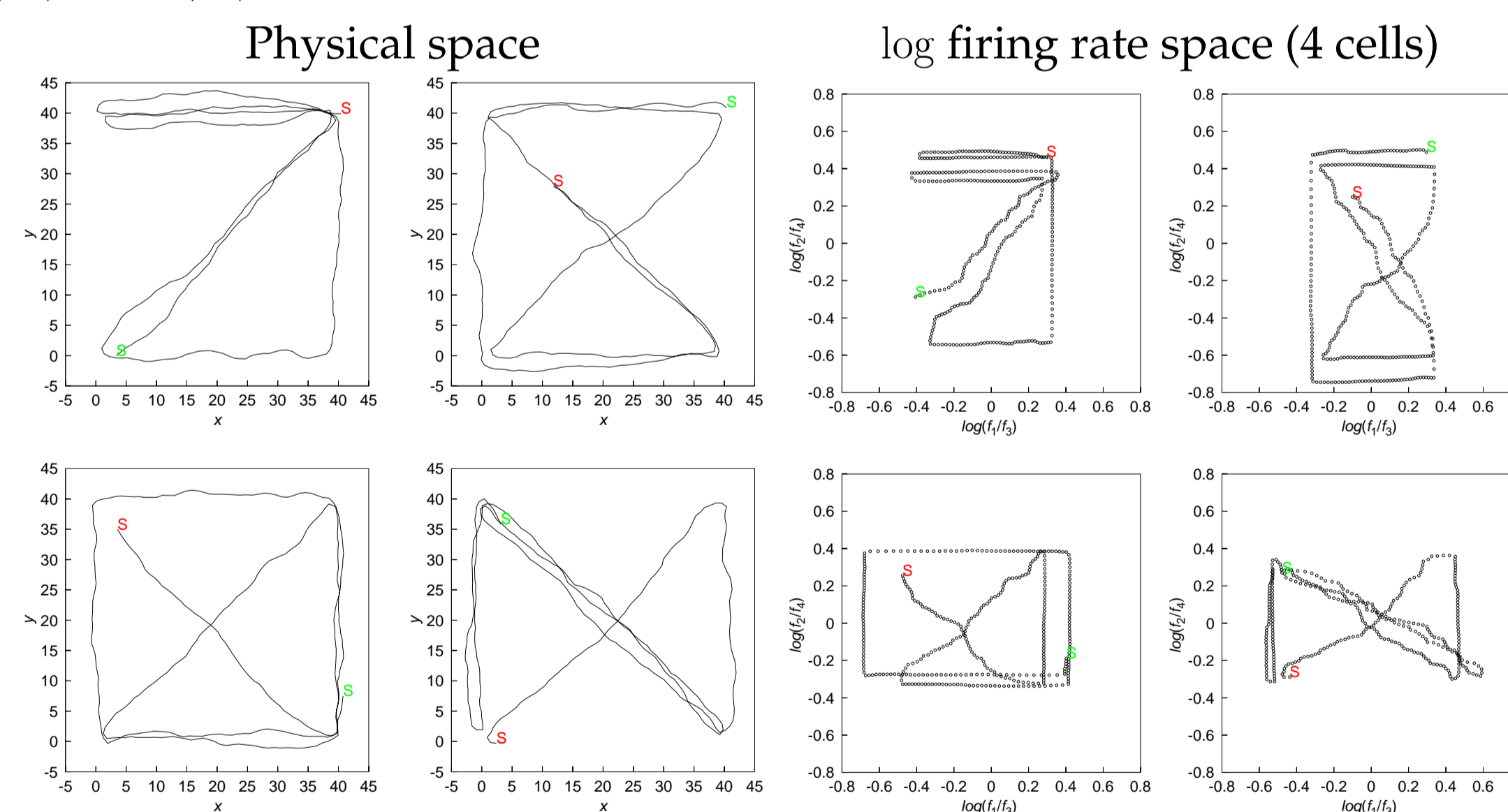
- Did OK in one-dimensional case
- Did not do well in open field
- Joint probability (adding cells doesn't help)



## finding appropriate basis functions

$$t_i = \rho_i t_{i-1} + \beta t_i^{IN}, \rho_i : \|t_i\| = 1$$

Suppose we have 4 cells and the animal moves E-W for a very long time. From looking at  $f_1$  and  $f_3$ , we can locate position E-W. If the animal then moves N-S, both  $f_1$  and  $f_3$  change, but  $\log(f_1) - \log(f_3)$  does not.

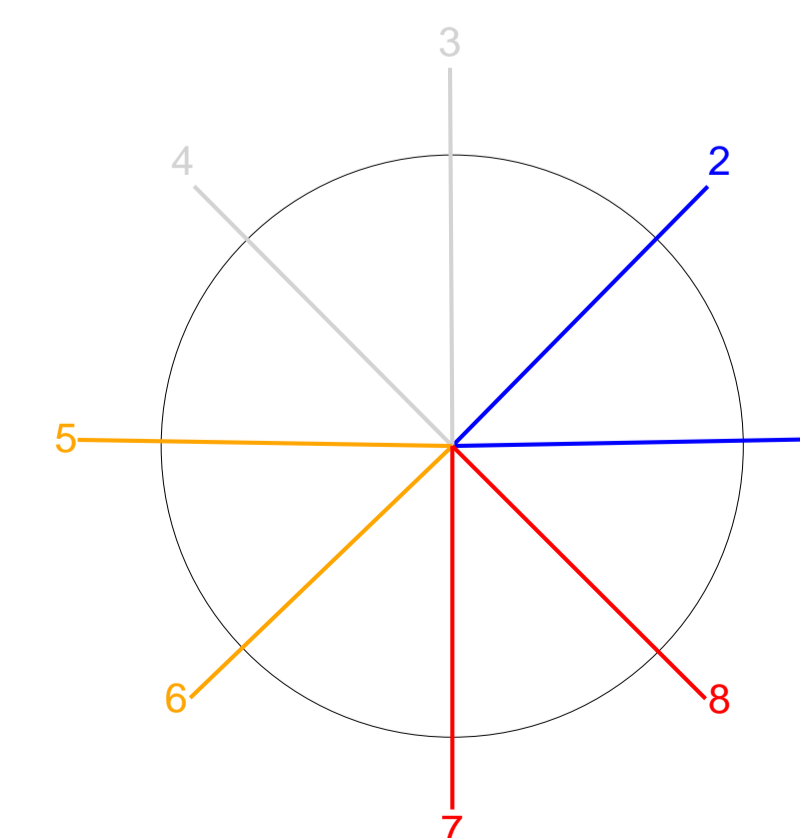


## linear model $\log(f)$

Simple linear regression to  $\log(f_i)$ :

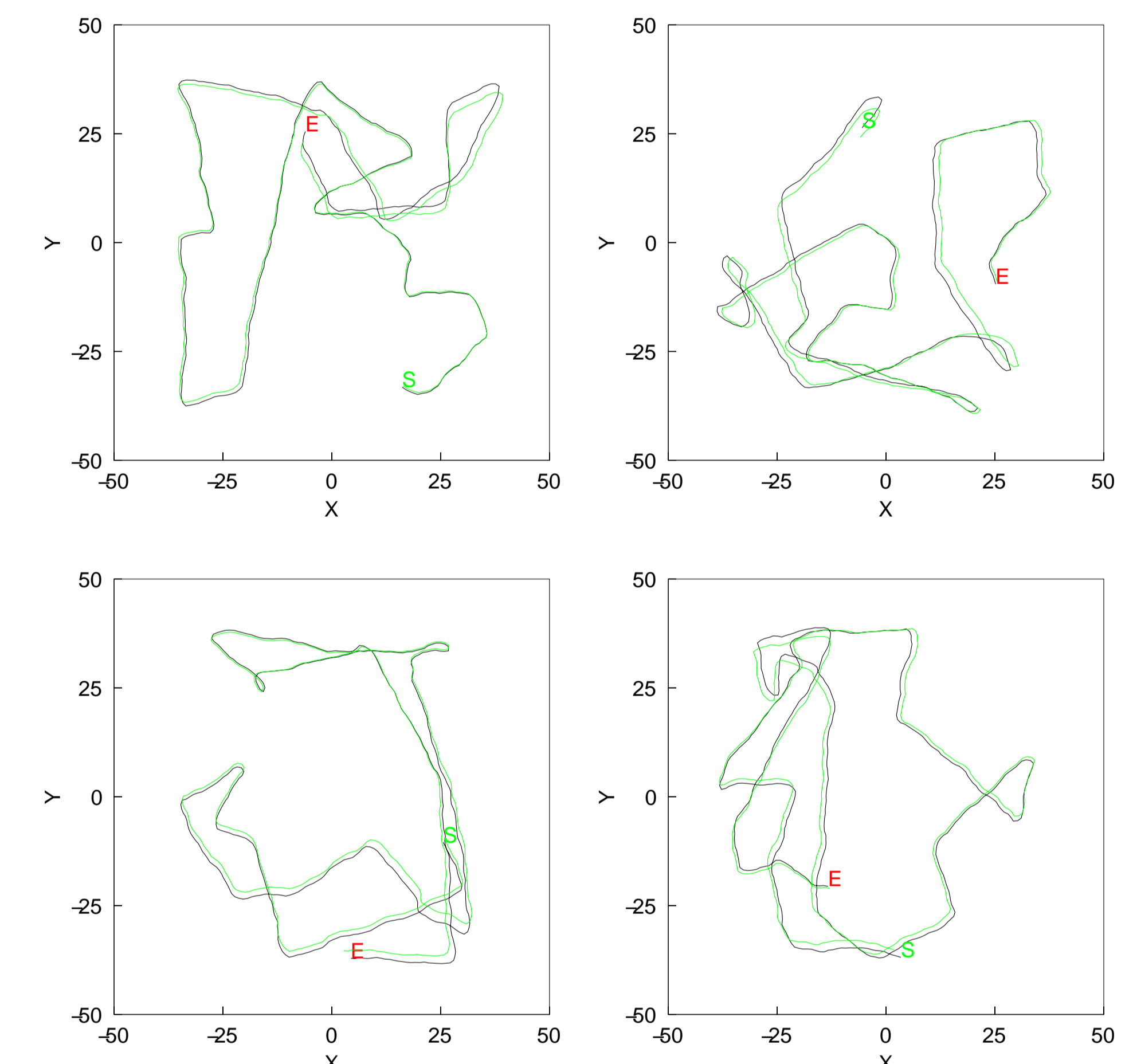
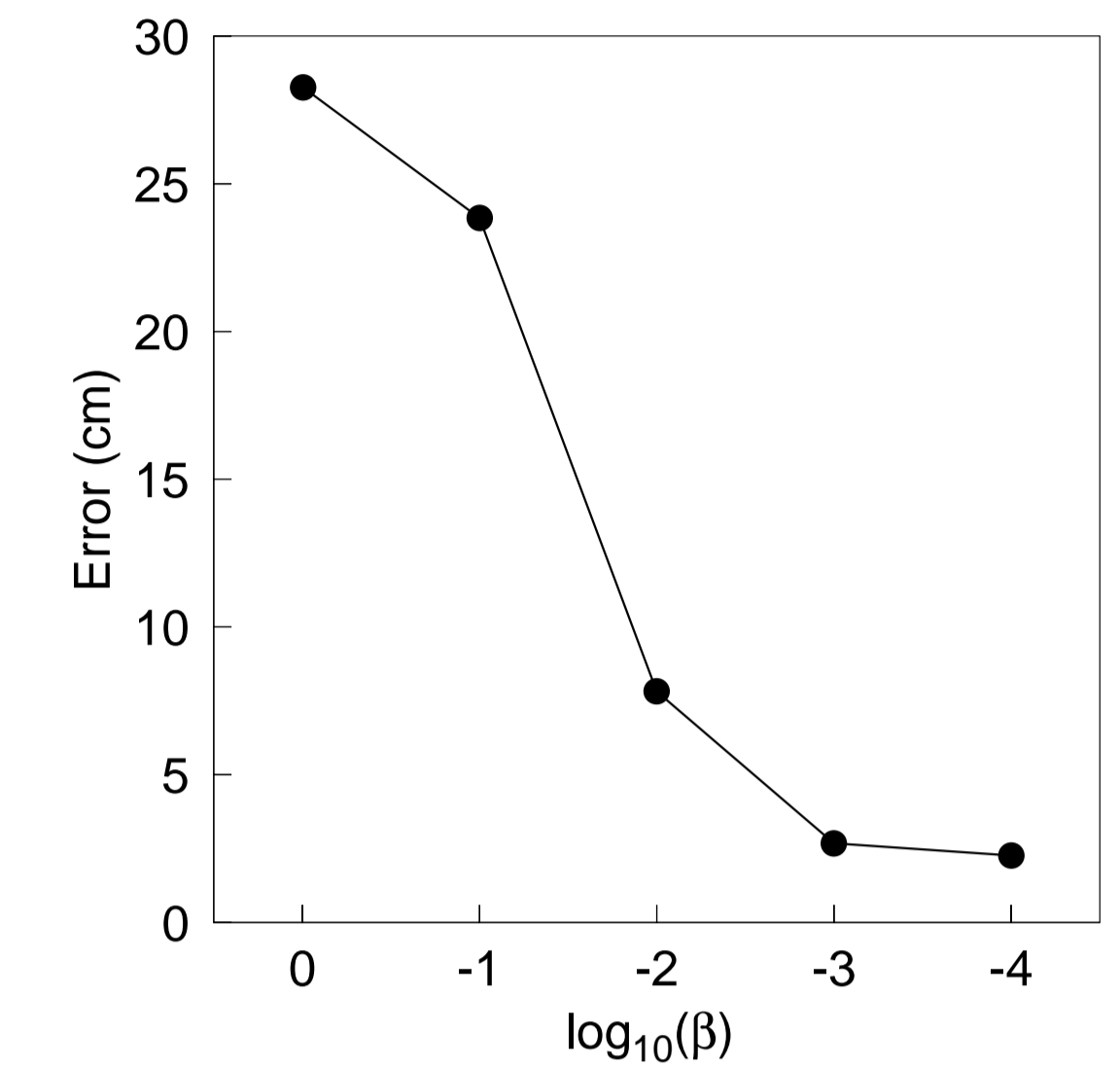
$$x = a + \sum_i b_i f_i$$

- Eight cells with evenly spaced preferred directions.
- Regression coefficients  $b_i$  reflected symmetry.



## reconstructed position

- Only eight cells
- Reconstruction error decreases with  $\beta \dots$
- ... to a size much smaller than a rat



## conclusions

- Good spatial reconstruction with only eight simulated cells.
- Path-independent position from log of pairs of opposing cells
- TCM remains a viable model of MTL function.

## references

Brunel, N., & Trullier, O. (1998). Plasticity of directional place fields in a model of rodent CA3. *Hippocampus*, 8(6), 651-665.

Chance, F. S., Abbott, L. F., & Reyes, A. D. (2002). Gain modulation from background synaptic input. *Neuron*, 35(4), 773-82.

Egorov, A. V., Hamam, B. N., Fransén, E., Hasselmo, M. E., & Alonso, A. A. (2002). Graded persistent activity in entorhinal cortex neurons. *Nature (London)*, 420(6912), 173-8.

Howard, M. W., Fotedar, M. S., Datey, A. V., & Hasselmo, M. E. (2005). The temporal context model in spatial navigation and relational learning: Toward a common explanation of medial temporal lobe function across domains. *Psychological Review*, 112(1).

Howard, M. W., & Kahana, M. J. (2002). A distributed representation of temporal context. *Journal of Mathematical Psychology*, 46(3), 269-299.

Jensen, O., & Lisman, J. E. (2000). Position reconstruction from an ensemble of hippocampal place cells: contribution of theta phase coding. *Journal of Neurophysiology*, 83, 2602-2609.

Wilson, M. A., & McNaughton, B. L. (1993). Dynamics of the hippocampal ensemble code for space. *Science*, 261, 1055-8.