# Short-term memory and spatial navigation: a model of temporally-varying context captures features of the place code in entorhinal cortex 939.18


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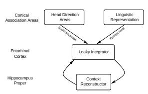
The medial temporal lobe participates in episodic recall and spatial navigation.

- Episodic recall: the recency effect using TCM (Howard & Kahana, 2002).
- Spatial navigation: the activity of cells in entorhinal cortex during movement.




## 1 The Temporal Context Model (TCM)

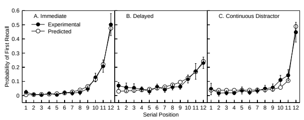
- Context is always the cue.
- The optimal cue for an item is its context.
- A state of context is an effective cue to the extent that it overlaps with that item's contexts.

$$\mathbf{t}_i = \rho_i \mathbf{t}_{i-1} + \beta \mathbf{t}_i^{IN}, \rho_i : ||\mathbf{t}_i|| = 1$$

### 1.1 Important properties of contextual evolution

1. For a given value of $\beta$, when given a series of orthogonal inputs, activity decays exponentially.
2. The change in context depends on the particular input.
3. When no input is given, the state of context does not change.

### 1.2 TCM Describes Recency Effects




- Consensus that LTR cannot be explained with STS.
- Considerable discussion about whether you need one model or two.

## 2 Properties of the Place Code in EC

- Noisy place fields in the open field.
- Correlated fields in similar environments (Quirk, Muller, Kubie, & Ranck, 1992).
- Trajectory coding in the W-maze.
- Retrospective/prospective coding in the W-maze (Frank, Brown, & Wilson, 2000).

### 2.1 Leaky integration of velocity

- The first integral of velocity is position.
- We need a representation of velocity…and an integrator.
- What would a leaky integrator give us?
- A weighted sum over recent movements.

### 2.2 A cellular implementation of temporal context

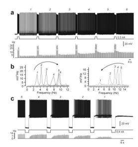
$$\mathbf{t}_i = \rho_i \mathbf{t}_{i-1} + \beta \mathbf{t}_i^{IN}, \rho_i : ||\mathbf{t}_i|| = 1$$

1. Something to provide velocity input.
2. A set of cells that continue to fire after their input is gone.
3. A way to normalize the length of **t**.

#### 2.2.1 Velocity input from head direction cells

- Fire depending on head direction.
- If gated by running speed, this is velocity.
- EC receives input from head direction cells in the parasubiculum.

#### 2.2.2 Integrator cells in EC



Egorov, Hamam, Fransén, Hasselmo, and Alonso (2002)

- Cells in EC layer V slice maintained firing rate for long periods of time.
- When presented with depolarizing current, they went to an increased stable firing rate.
- When given a hyperpolarizing current, a decreased, stable firing rate.

#### 2.2.3 Gain modulation and normalization

- Chance, Abbott, and Reyes (2002) showed gain in cultured cortical neurons is related inversely to total activity in a cortical network.
- Combined with integrator cells, this should result in a constant total network activation.

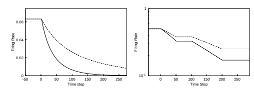
### 2.3 Implementing contextual evolution

Integrator cells:

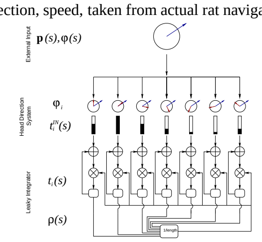
$$t_i(s) = \rho(s)\left[t_i(s-1) + \beta t_i^{IN}(s)\right],$$

With gain $\rho(s)$ a function of network activity:

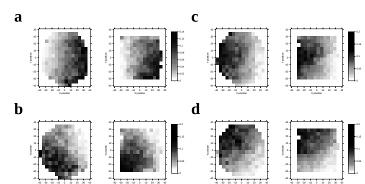
$$\rho(s) = \left\{\sum_i \left[t_i(s-1)\right]^2\right\}^{-1/2}.$$



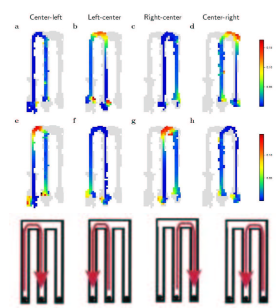
Head direction, speed, taken from actual rat navigation data.



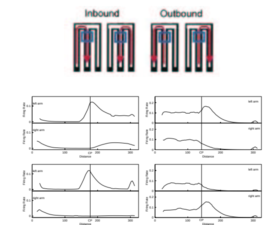

### 2.4 Open field results



### 2.5 W-maze results: Trajectory coding




### 2.6 Retrospective and prospective coding




## 3 Conclusions and directions

- The EC simulations used physiologically plausible mechanisms.
- Performing a computation proposed to explain the recency effect, the sims described most of the literature on the entorhinal place code.
- This suggests the MTL supports and updates a representation of temporal-spatial context.

## References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