Modeling Hippocampal-Cortical Interaction During Event Processing

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Summary

Our simulations support that...

- Shared situation model enhances inter-subject correlation[4].
- Hippocampus should saving episodic memories at event boundaries[1, 2, 3], because this is protective against retrieving lure memories.
- There is a speed-accuracy trade-off on the consistency criterion for recall.

Model

Cortex

- Context-dependent state prediction.
- Actively maintains the current situation model.

Hippocampus

- Encoding: store episodes.
- Retrieval: pre-load situation models.

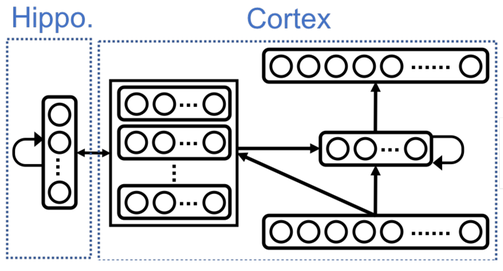

Figure 1: The model architecture. Cortex is an RNN that predict the next state, and it has a buffer. Hippocampus is another RNN with some encoding/retrieval mechanism.

References & Acknowledgement

[1] Ben-Yakov A., & Dudai, Y. (2011). J Neurosci
[2] Ben-Yakov A., Eshel, N., & Dudai, Y. (2013). J Exp Psychol Gen
[3] Ben-Yakov A., & Henson, N. (2018). biorxiv.
[4] Chen, J., et al. (2016). Cereb Cortex

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Task formulation

- **Schema**: The default transition matrix represent the schema.
- **Context**: The true ongoing situation model can alter the default transition matrix.

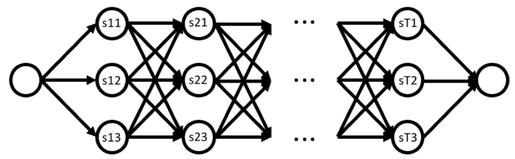

Figure 2: In this schema graph, each node represents an event and each edge has a default transitional probability.

Shared situation model enhances inter-subject correlation (ISC)[4]

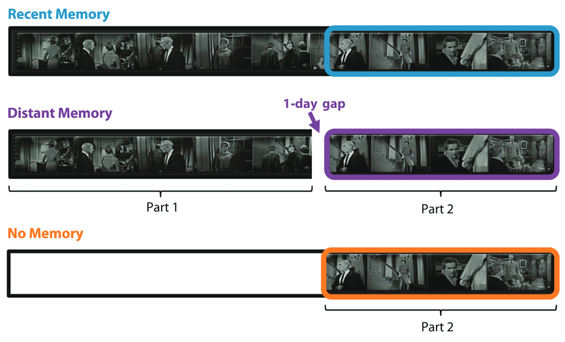

Figure 3: Experimental design[4]. Participants watched an episode of twilight zone movie while being scanned.

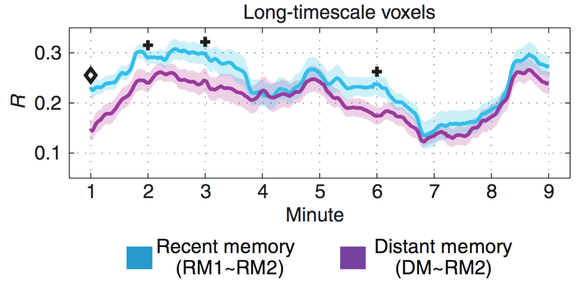

Figure 4: Empirical fMRI ISC[4] during the second half of the movie. DM-RM ISC gradually converged to RM-RM ISC.

ISC simulation

Model simplifications: Save the 1st part of the movie as 1 chunk and retrieve it during the 2nd part.

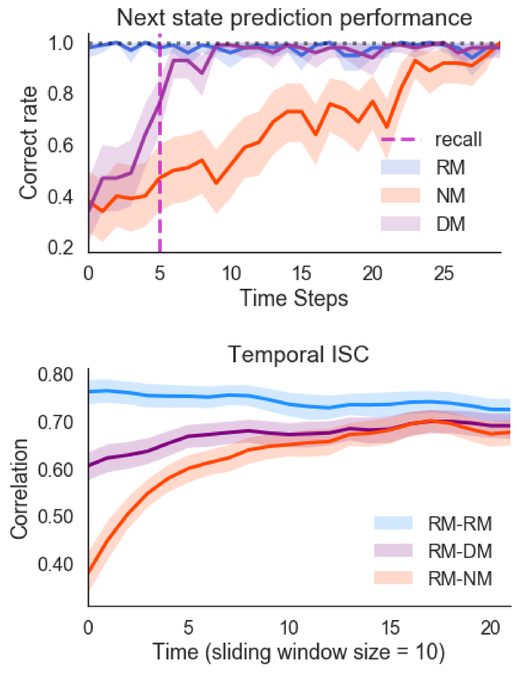

Figure 5: Top: Model state prediction accuracy. We forced all models to retrieve memory at t=5; Bottom: after functional alignment, the model ISC pattern qualitatively captures the empirical result[4] in Figure 4.

Parameterize the hippocampus

Retrieval:

- Retrieve the episode that matches the actively maintained situation model the most
- Min-match: a threshold on required consistency
- Reject episodes with any mismatch
- Inhibit recently retrieved memories.

Encoding:

- Chunk size: chunk the observed event sequence into episodes.
- Lure episode = actual episode + noise

Recall performance

Metric: how often does the model pre-loaded the required situation model parameters.

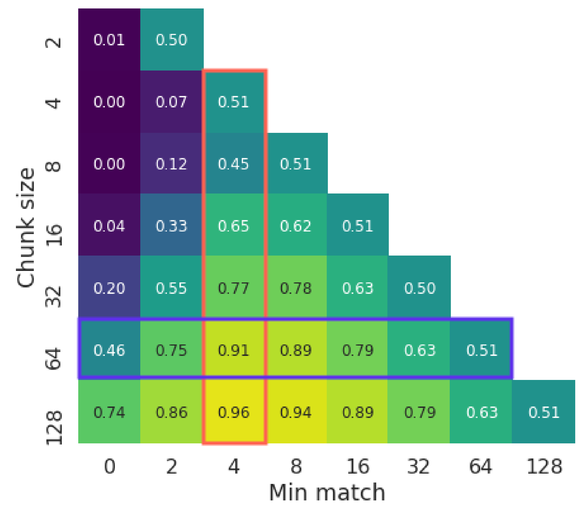

Figure 6: Recall performance with different combinations of chunk size and min match.

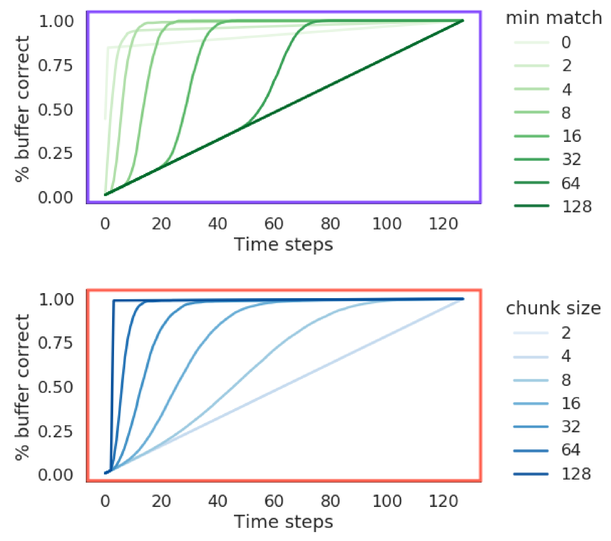

Figure 7: The correctness of the actively maintained situation model as event sequences unfold.

- Top: varying min match while holding chunk size fixed
- Bottom: varying chunk size while holding min match fixed