ANALYSING THE CHANGES OF DISTRIBUTIONS IN MEMORY OVER TIME

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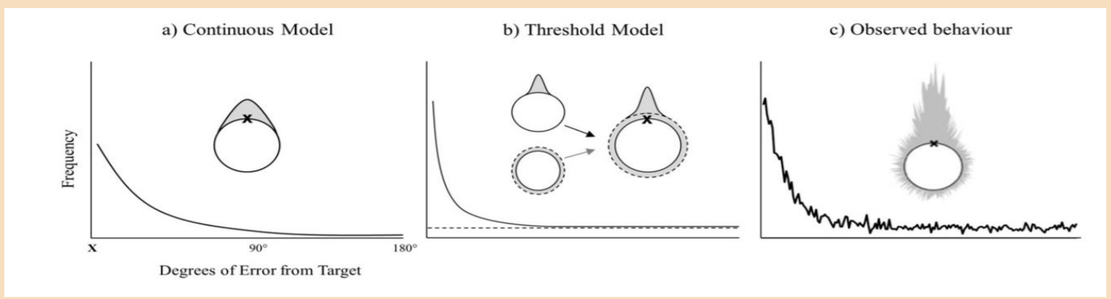
Background

The neural mechanisms for recollection still remain unclear. Recollection theories are broadly divided into two categories[1]:

1. **Continuous Recollection**: where cues always elicit some information
2. **Threshold Recollection:** 'All-or-Nothing', information is or isn't retrieved

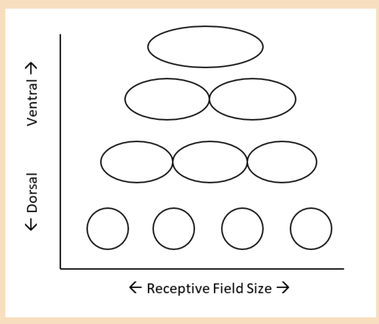
Continuous retrieval models predict normally distributed data, whereas threshold models predict a baseline of 'guessed' responses and clustered responses indicating 'Some-or-Nothing' retrieval. Experiments using precision measures of recollection indicate the latter[2]:



Aims:

1. To perform similar precision measures of recollection to investigate the effects of underlying distributions on performance, and the effects of time between learning and recollection.
2. Determine whether precision over time reflects hippocampus structure[3]

Hippocampal Place Cell Fields



Predicted Observation

Methods

Subjects:
19 right-handed, native English speakers

Stimuli:

- Two 100 word categories, ('Natural' and 'Man-Made') used for each distribution
- To create statistically similar categories, each word was given 3 'properties'
  1. **Latent Semantic Analysis** (measure of word '*relatedness*')
  2. **Word Frequency in English Language**
  3. **Word Length** (number of letters)
- Generated two 100 word categories through random iteration, making sure the normal distribution of each 'property' was **not** significantly different by t-test

Learning Phase

Participants are to learn a location on the circumference of a circle in association with a word from one of the categories.

Test Phase

Participants are now presented with a previous word. They now have to recall the circumference location for the given word

Distributions:

1. One category of words to be clustered (Von Mises Distribution) around a point on the circumference
2. The other category of words to be uniformly distributed around the circle

Time before testing:

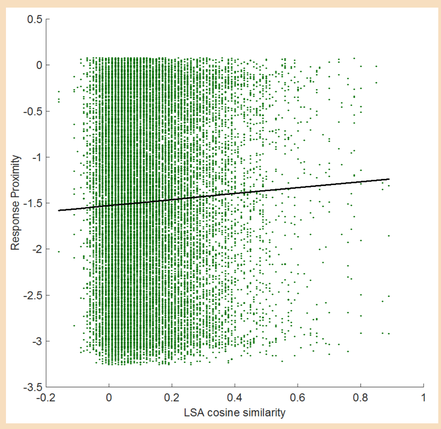
1. One group to be tested immediately after learning
2. One group to be tested 24 hours after learning

Results

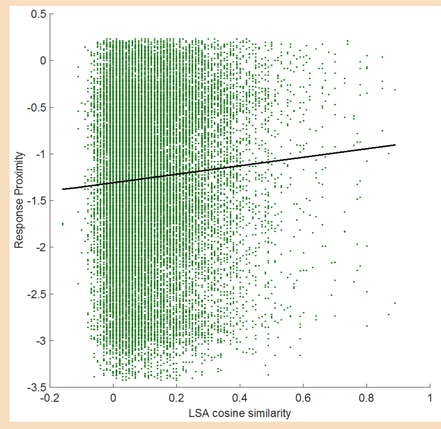
Key Finding and Correlations
We tested our proposed hypothesis initially, but did not find the hippocampal structure model to be statistically significant. From intuition we could see some correlations so we took a data driven approach to find correlations.

Semantic Relatedness and Response Proximity
One of the key findings was that the proximity of responses correlated strongly with 'semantic relatedness'. Participants tended to place words that were related in meaning closer together, with the effect being stronger when recalling 24 hours after learning.

Immediate Recall



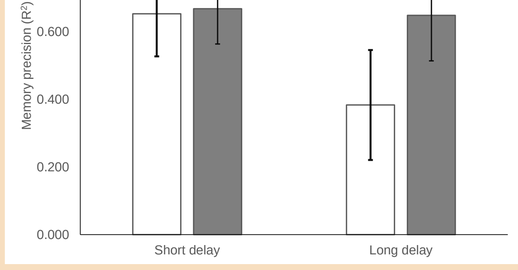
Recall after 24 Hours



Performance and Semantic Relatedness Dependence
We also looked at two other key areas **within** each distribution:

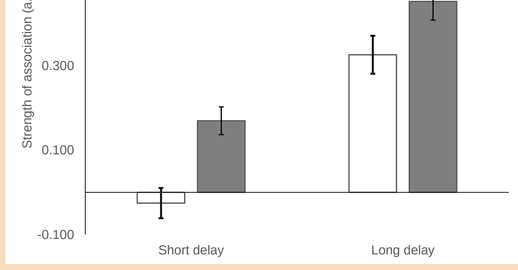
1. Performance over time
2. Sematic Dependence over time

Performance Over Time



- Memory precision (R^2) plotted by delay and underlying distribution.
- As the length of the retention interval increases, memory precision for uniformly distributed items decreases
- However precision for von Mises distributed items stays relatively high.

Semantic Dependence Over Time



- Strength of association between semantic similarity and response proximity plotted by delay and underlying distribution.
- In the immediate recall group there appears to be a dependence on semantic relatedness but not in the uniform
- However over time the dependence on both increases drastically

Conclusions

The data suggests people can extract rudimentary distributions based upon the semantic relatedness of words.

Upon immediate recall the dependence on these distributions remains low, as characterised by the high precision of answers in the immediate recall group.

The increased dependence on semantic relatedness after 24 hours suggests as memory accuracy decreases, participants relied on broader generalised patterns instead.

Interestingly, there is a greater dependence on semantic relatedness in the Von Mises distribution in both immediate and 24 hour delayed groups. This could suggest that once the clustered pattern is learnt, there either some interference effect or preferential encoding.

1. Murray, Jamie G., Catherine A. Howie, and David I. Donaldson. 2015. "The Neural Mechanism Underlying Recollection Is Sensitive to the Quality of Episodic Memory: Event Related Potentials Reveal a Some-or-None Threshold." *NeuroImage* 120 (October): 298–308.
2. Harlow, Iain M., and David I. Donaldson. 2013. "Source Accuracy Data Reveal the Thresholded Nature of Human Episodic Memory." *Psychonomic Bulletin & Review* 20 (2): 318–25.
3. Brun et. al 2008. "Progressive Increase in Grid Scale from Dorsal to Ventral Medial Entorhinal Cortex." *Hippocampus* 18 (12): 1200–1212.