Semantic and temporal structure in memory for narratives: A benefit for semantically congruent ideas

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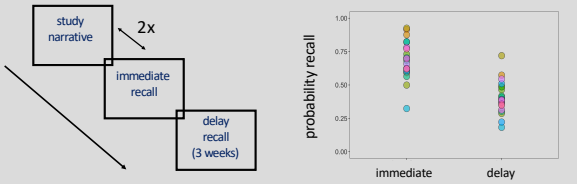
Overview

- Recall for narratives, if split into 'idea units' that are numbered according to chronological order, can be examined using analytic techniques developed for free and serial recall tasks (list-learning)
- Behavioral analyses of list learning tasks show the importance of semantic and temporal structure at recall. However, very little work has been done to characterize these structures in narrative recall
- We use standard analysis techniques from list-learning tasks, and a vector space model to characterize narrative recall dynamics

Narrative Recall Task

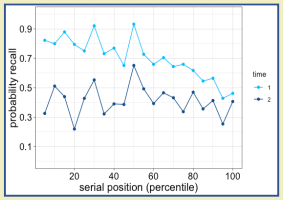
collected and shared by the Brown-Schmidt Lab at Vanderbilt

One fine day an old Maine man was fishing on his favorite lake and catching very little. Finally, he gave up and walked back along the shore to his fishing shack. When he got close to the front door, he saw it was open. Being of a suspicious nature, he walked to the door quietly and looked inside. There was a big black bear. It was just pulling the cork out of his molasses jug with its teeth.



Can we use free recall analysis techniques to characterize memory for narratives?

Serial Position Curve



We normalized the number of idea units per story by rescaling the data as percentiles.

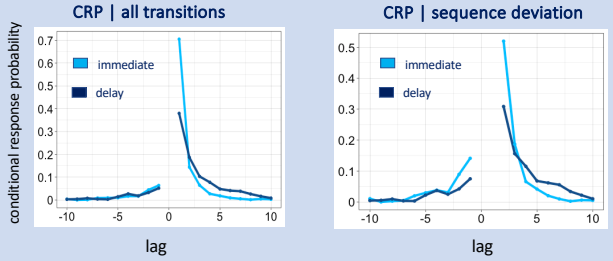
Narrative recall shows a steady decline in performance across serial position at immediate test - this effect is not present at delayed test

Suggests that temporal structure is less important for narrative recall over time

The temporal contiguity effect is weaker at a delay

Sequence deviations (anything other than a +1 transition) in the forward direction involve skipping ahead, and these transitions show a contiguity effect

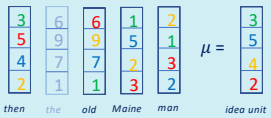
Deviations in the backward direction usually involve jumping backwards after skipping ahead (double conditional), and these transitions also show a contiguity effect

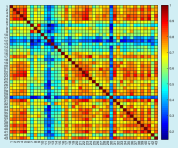


Characterizing Semantic Structure in Narratives

Model Methods: A semantic vector space model of narrative recall

- ***GloVe*** semantic vector space model (Pennington et al., 2014)
- We create idea unit semantic representational vectors, comprised of content words

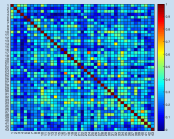




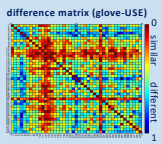
- We created a representational similarity matrix by calculating the cosine similarities of each pair of idea units
- Darker (blue) bands indicate idea units that are semantically distinct from other idea units in the passage

Universal Sentence Encoder (USE)

- Deep Averaging Network (DAN)
- Each layer learns a more abstract representation of the input. This depth allows the network to capture subtle variations.



Representational Similarity Analysis (USE & GloVe):



- Spearman rank correlation values: [0.27 – 0.52]
- All 6 stories were significantly more structurally related than would be expected by chance (10,000 permuted matrices)
- Numerically similar vectors in difference matrix seem to be isolated to ideas with low GloVe pairwise similarity

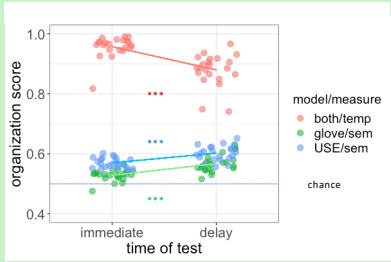
Semantic organization increases at delay, while temporal decreases

Temporal & Semantic Factor Scores (Polyn et al, 2009)

Measure of organization / clustering

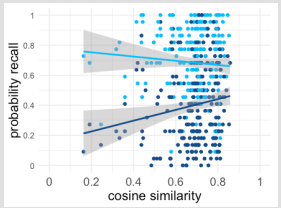
Factor score ranks the absolute value of the lag of actual : possible transitions

Temp	Immediate	0.96	$p < 0.001$
Temp	Delay	0.88	
Sem$_{glove}$	Immediate	0.53	$p < 0.001$
Sem$_{glove}$	Delay	0.57	
Sem$_{USE}$	Immediate	0.57	$p < 0.001$
Sem$_{USE}$	Delay	0.60	



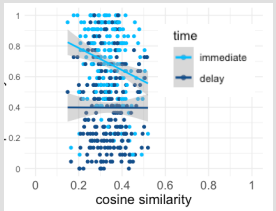
GloVe: Semantically congruent idea units are more likely to be recalled at delay

USE: Semantically incongruent idea units are more likely to be recalled at immediate test



GloVe
time B= -0.62***
cosine B= -0.14
time:cos B= 0.49*

USE
time B= -0.53***
cosine B= -0.72**
time:cos B= 0.71*



Conclusions

- We show that the temporal organization of narrative recall can be characterized using techniques developed for analysis of free recall tasks
- Semantic relatedness between 'idea units' within a narrative can be captured using a semantic vector space model: *However, there is a discrepancy between how different models predict recall.*

Future work will focus on:

- how these temporal and semantic trends can be generalized to capture and predict the nature of recall for narratives.
- characterizing which aspects of the idea units are being captured by different semantic vector space models

References

Pennington, J., Socher, R., and Manning, C. (2014). Glove: Global vectors for word representation. In *Proceedings of the 2014 conference on empirical methods in natural language processing* (EMNLP), pages 1532-1543.

Polyn, S. M., Norman, K. A., & Kahana, M. J.(2009). A context maintenance and retrieval model of organizational processes in free recall. Psychological Review, 116 (1), 129–156.

Acknowledgments

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