



The Temporal Contiguity Effect is Negatively Correlated with Episodic Memory Performance and Fluid Intelligence

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Introduction

- It has long been known that memory task performance predicts success on more complex tasks (Jacobs, 1887)
- In fact, memory tasks predict general cognitive ability, as measured by fluid intelligence (Unsworth & Engle, 2007)
- What is it about memory ability that makes it so predictive?



Introduction

- We've shown (Healey et al., 2014) that individual differences in recall dynamics (recency, primacy, temporal contiguity, semantic contiguity) account for over 80% of the variance shared between memory and intelligence
- Of the recall dynamics factors, temporal contiguity was the most influential in predicting both recall accuracy and intelligence
- There seems to be something "special" about temporal contiguity



Introduction

- *Research Question:* Why does temporal contiguity correlate with measures of fluid intelligence?
- Here, we will examine cognitive control processes and their role in this relationship between memory and fluid intelligence by altering the semantic structure of studied lists in free recall



Methods

- $N = 1,019$
- 15 lists, 16-words per list, Free Recall
- Manipulated list structure with a between-subjects design:
 1. Semantically related words – organized in clusters [$n = 347$]
 2. Semantically related words – same clusters, but shuffled across the list [$n = 335$]
 3. Randomly selected words, ignoring semantics [$n = 337$]



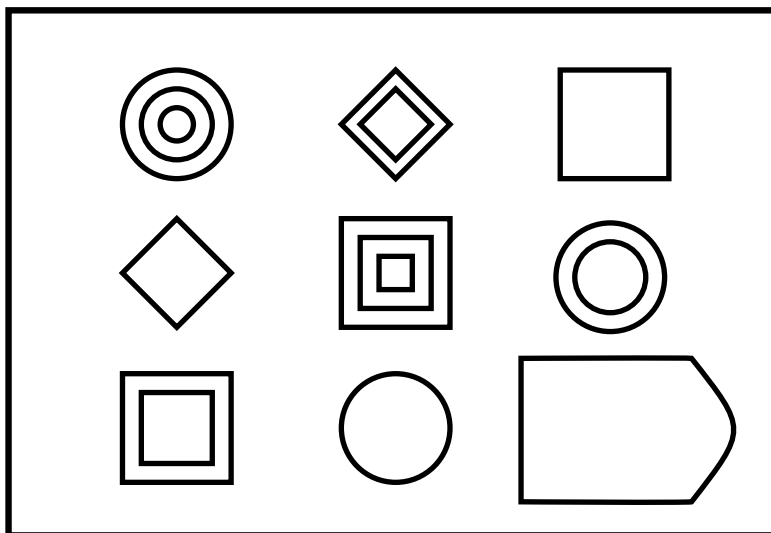
Methods

- Latent semantic analysis (LSA; Landauer & Dumais, 1997)
- Example:
 - Cluster A: *DANDRUFF, SHAMPOO, SOAP, SKIN*
 - Cluster B: *WHEEL, LEVER, MACHINE, TOOL*
 - Cluster C: *ANCHOR, CREW, DOCK, PORT*
 - Cluster D: *SCULPTURE, ARTIST, PAINTING, MUSEUM*
- Ordered cluster: $A_1 A_2 A_3 A_4 B_1 B_2 B_3 B_4 C_1 C_2 C_3 C_4 D_1 D_2 D_3 D_4$
 - Ordered to maximize semantic similarity both within cluster and between clusters
- Shuffled cluster: $B_4 A_1 B_2 D_1 C_4 A_4 B_3 D_2 B_1 D_4 A_3 C_2 A_2 C_3 D_3 C_1$



Methods

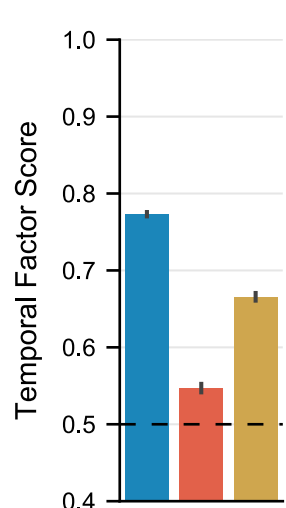
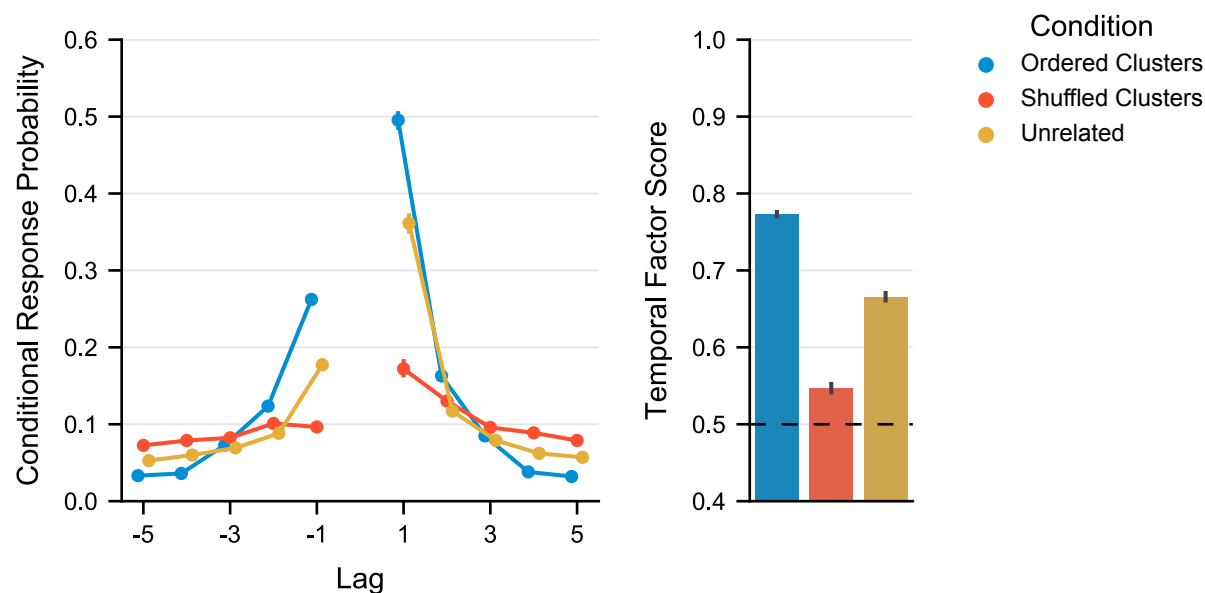
- Lastly, as a measure of fluid intelligence, participants took a computerized version of Raven's Progressive Matrices (Raven et al., 1998)





Results – Temporal Contiguity Effect

- In the lag conditional response probability curve, we see the expected effect:
 - A propensity for short lags and a forward asymmetry



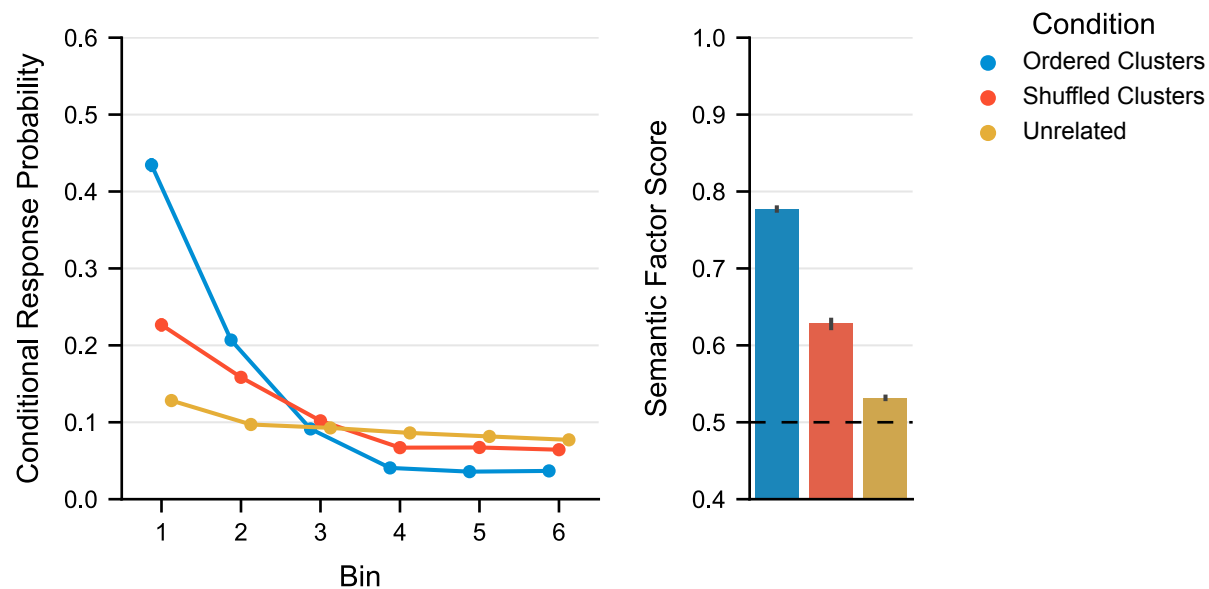
- Factor scores are a single value percentile score that indicates the strength of the contiguity effect (Polyn et al., 2009)
 - Chance value of 0.5
 - Will be an important measure in correlations to come

Error bars throughout presentation are bootstrapped 95% confidence intervals



Results – Semantic Contiguity Effect

- Participants prefer to transition to the most semantically related word in the list
 - Semantic factor scores are above chance



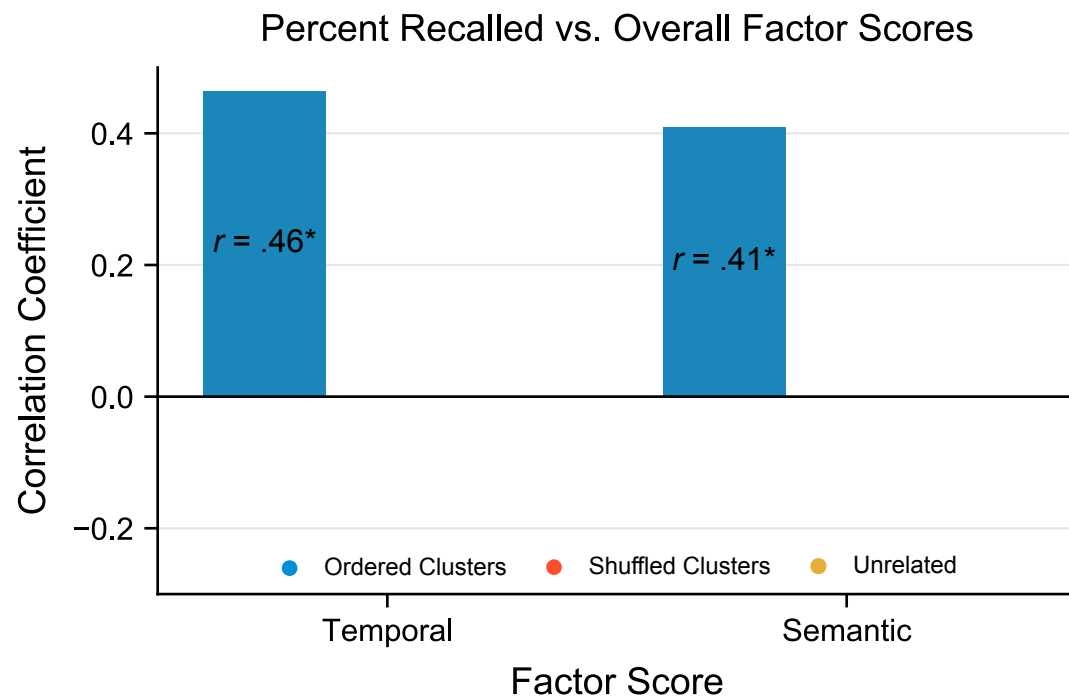


Hypothesis – Predicting Overall Recall

- In both the unrelated and ordered cluster conditions, employing a semantic and/or temporal strategy should improve overall recall
 - Especially so in the ordered cluster condition, because semantic and temporal strategies are congruent
- However, in the shuffled cluster condition, the semantic and temporal strategies are incongruent
 - Here, the semantic information is what is making the task easier, and those that utilize that information should perform better



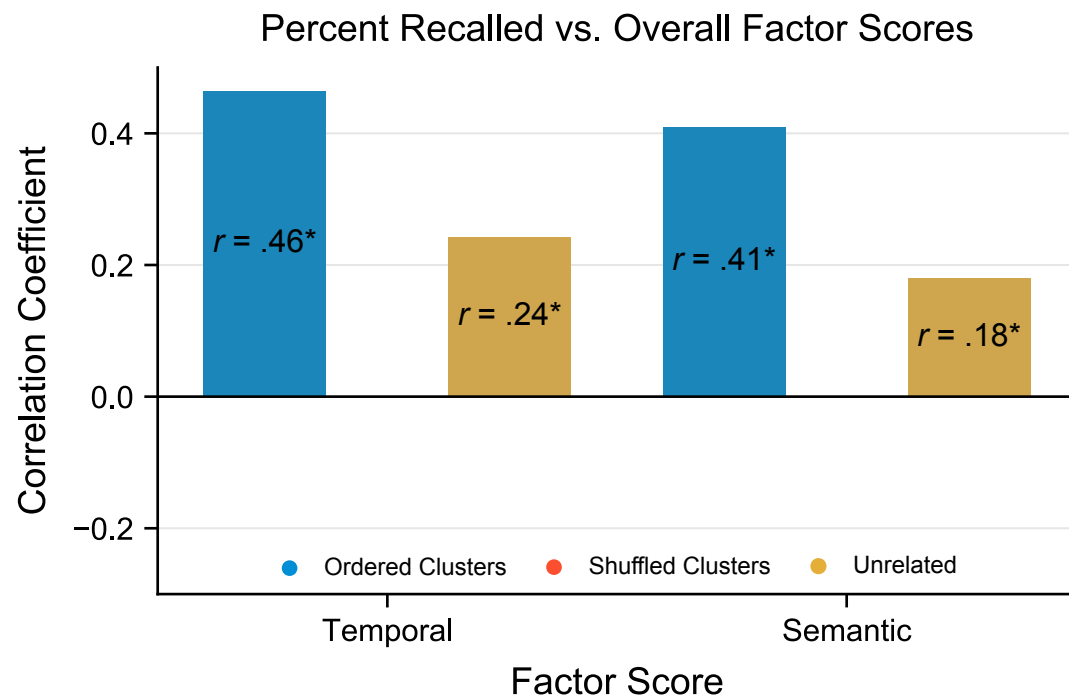
Results – Predicting Overall Recall



- In the ordered cluster condition, semantic contiguity is highly correlated with recall
- As is temporal contiguity



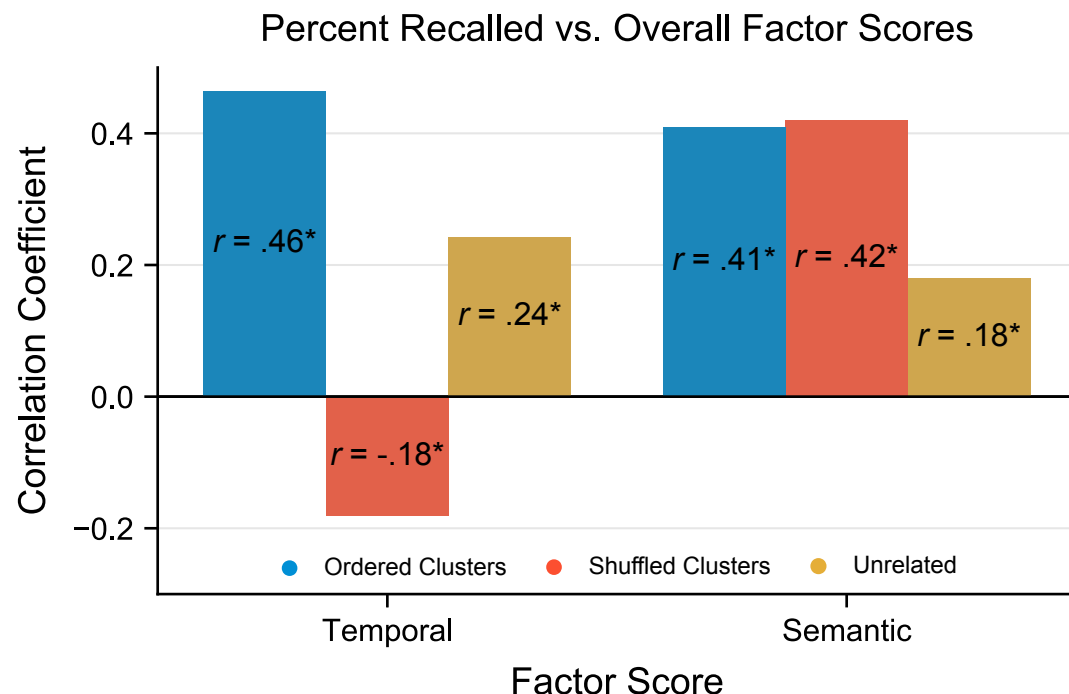
Results – Predicting Overall Recall



- In the unrelated condition, temporal contiguity is positively related to recall
- As is semantic contiguity



Results – Predicting Overall Recall



- In the shuffled cluster condition, semantic contiguity is positively correlated with recall
- However, temporal contiguity is **negatively** correlated with overall recall



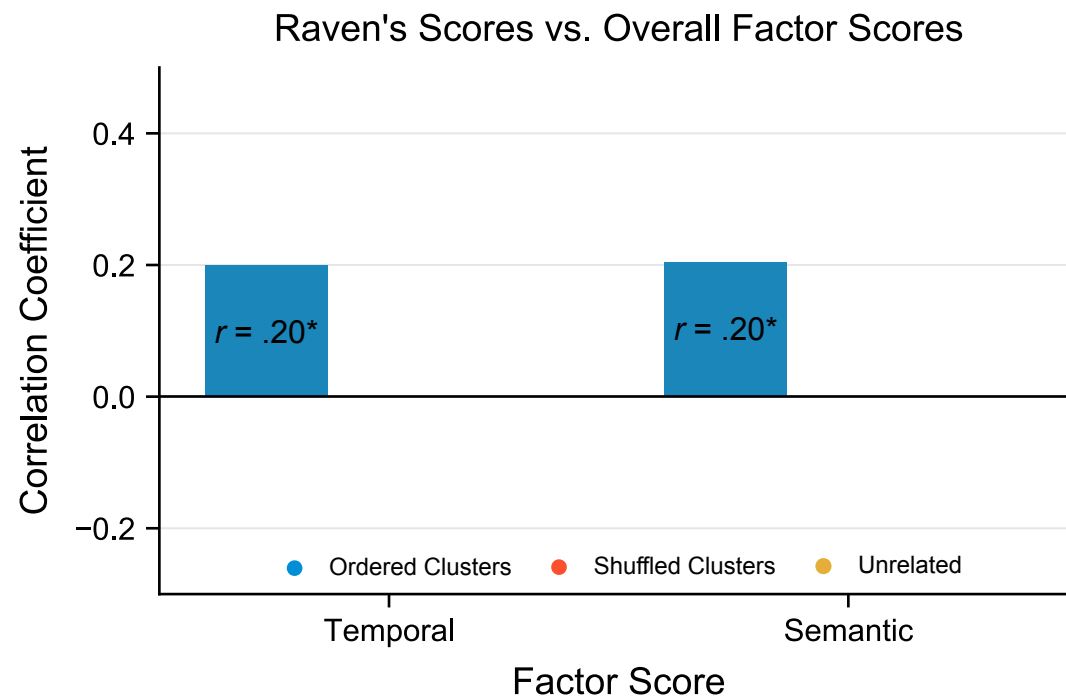
Hypothesis – Predicting Fluid Intelligence

- Recalling items in temporal order may require cognitive control (e.g., to reinstate prior states of mental context) as do fluid intelligence tasks like Raven's (Healey et al., 2014)
- In our task, the strong semantic structure removes the need to rely on temporal order for recall success
 - This makes the task easier and decreases the need for cognitive control
- If cognitive control is at the heart of the relationship between temporal contiguity and fluid intelligence, this would predict that there would be no relationship between temporal contiguity and Raven's scores
 - Therefore, we would expect a near-zero correlation in the shuffled clusters condition



Results – Predicting Fluid Intelligence

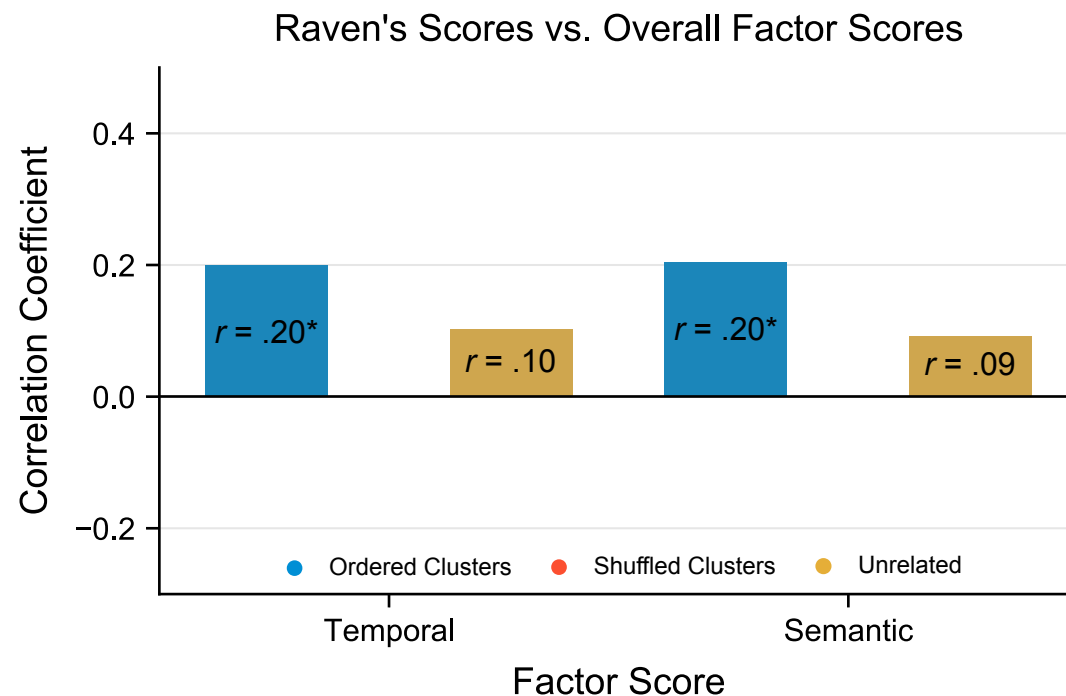
- Follows the same overall pattern as with overall recall
 - Positive relationship between Raven's and both factor scores in the ordered cluster condition





Results – Predicting Fluid Intelligence

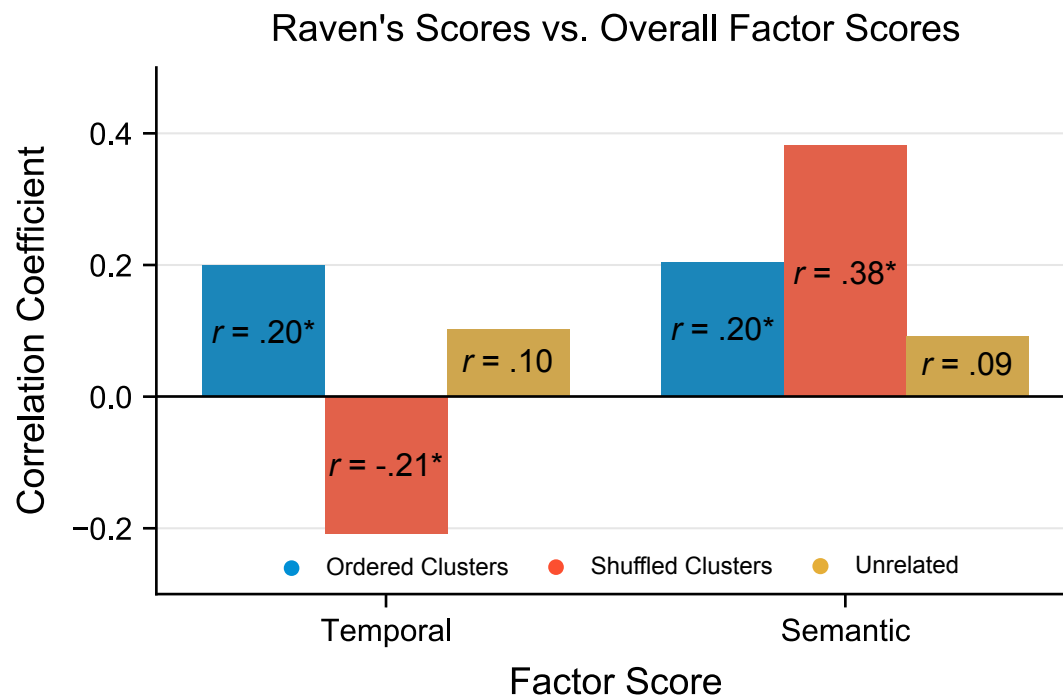
- Follows the same overall pattern as with overall recall
 - Positive relationship between Raven's and both factor scores in the ordered cluster condition
 - Also in the unrelated condition, to a smaller degree





Results – Predicting Fluid Intelligence

- Follows the same overall pattern as with overall recall
 - Strong positive relationship between Raven's scores and semantic factor scores in the shuffled clusters condition
- Temporal contiguity is **negatively** related to Raven's scores





Discussion

- *Research Question:* Why does temporal contiguity correlate with measures of fluid intelligence?
- More temporal contiguity <-> Better recalls <-> Higher fluid intelligence
- Does the shared need for cognitive control explain the relationship?
 - Memory for temporal order requires context reinstatement – which is taxing
 - Reasoning tasks too require cognitive control



Discussion

- We expected to see no relationship between fluid intelligence and temporal contiguity in the shuffled cluster condition
- However, what we see is a significant, **negative** relationship between:
 - Overall recall and temporal factor scores
 - Raven's scores and temporal factor scores
- An alternative hypothesis
 - The "hard" part of the memory task is not context reinstatement, per se, but is identifying and using the best associative dimension



References

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- Unsworth, N., & Engle, R. (2007). The nature of individual differences in working memory capacity: Active maintenance in primary memory and controlled search from secondary memory. *Psychological Review*, 114, 104 – 132.



Thank you!

Feel free to contact us with any questions or comments:

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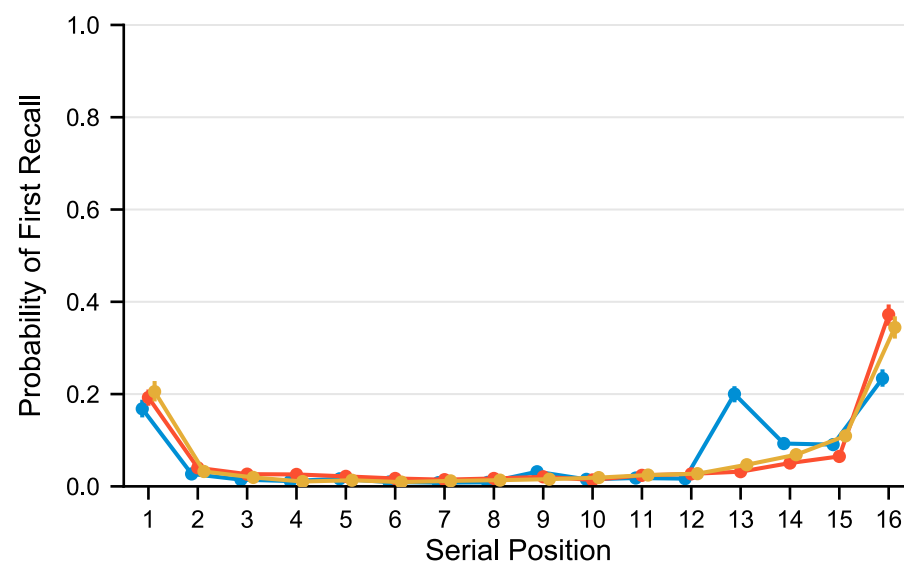
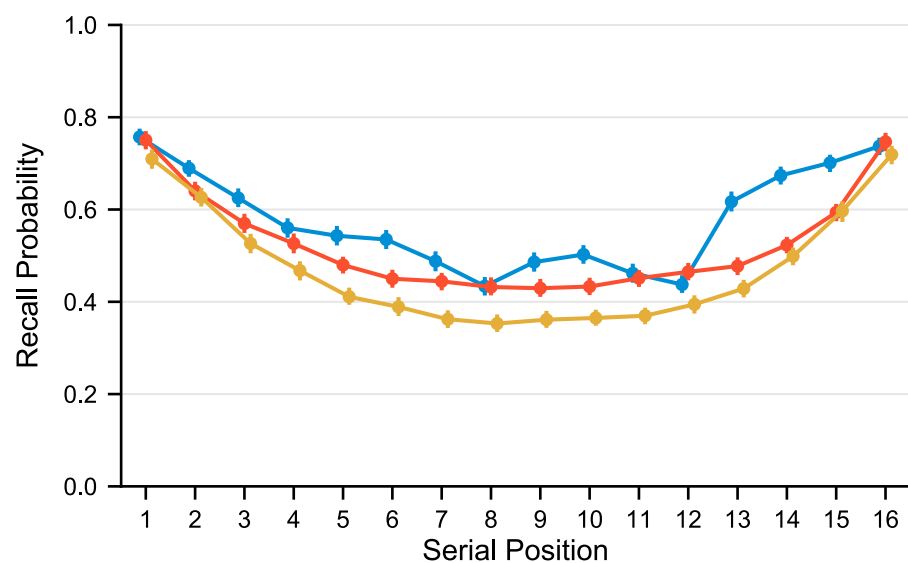


Supplemental Slides



SPC / PFR

- Unsurprising serial position curve and probability of first recall curve

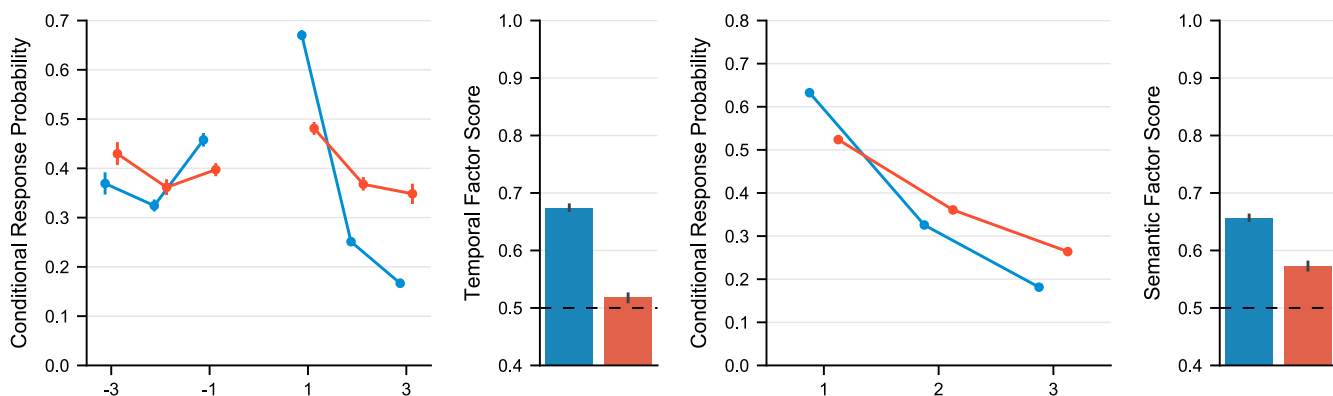


Condition
● Ordered Clusters ● Shuffled Clusters ● Unrelated

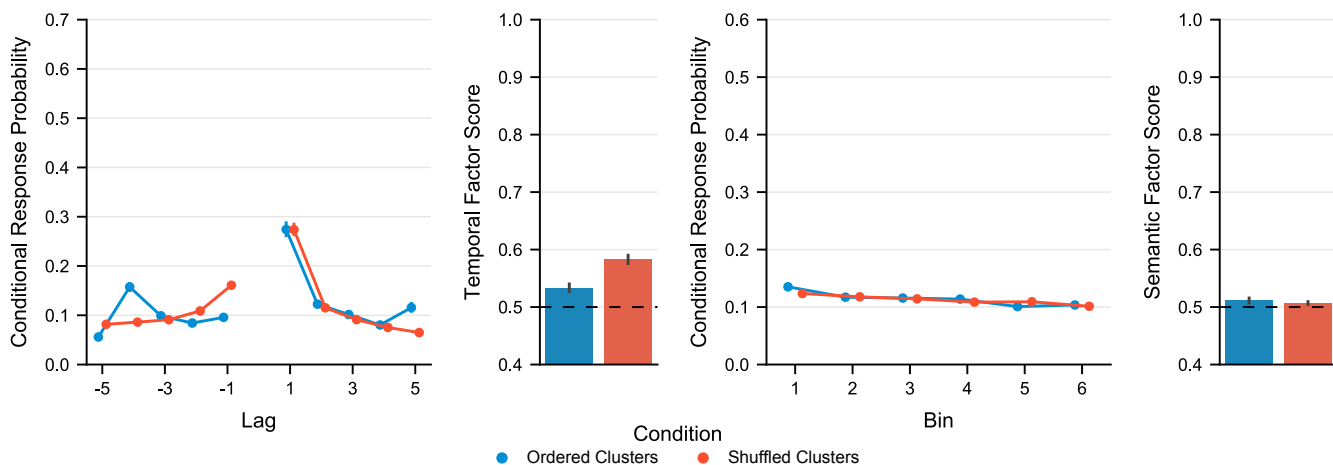


Within / Between Cluster Analyses

Within Cluster:



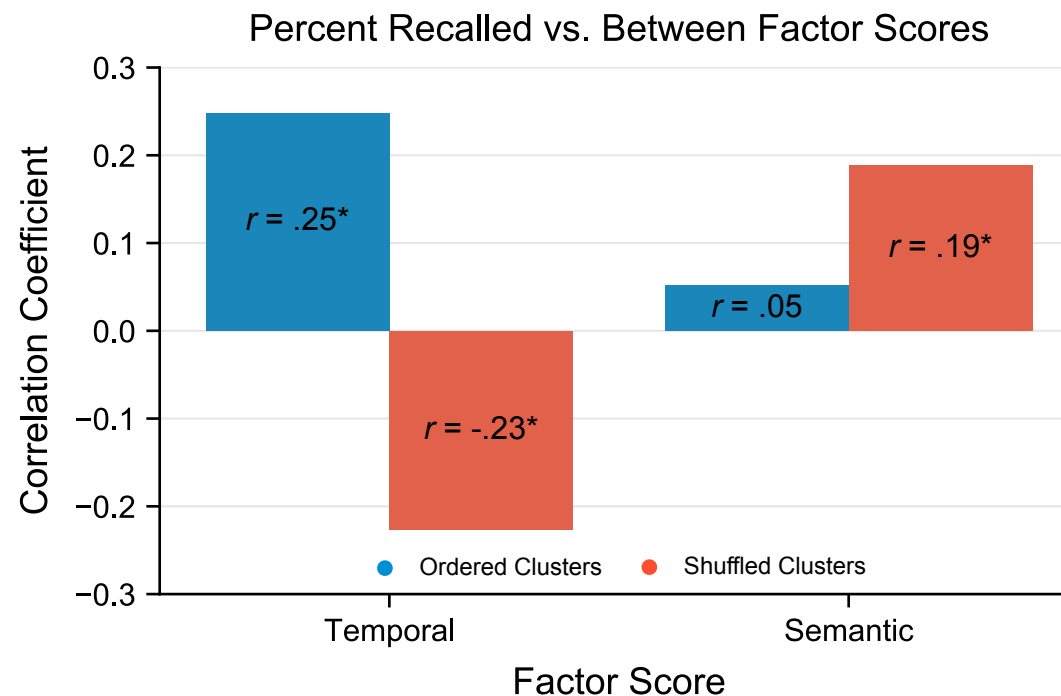
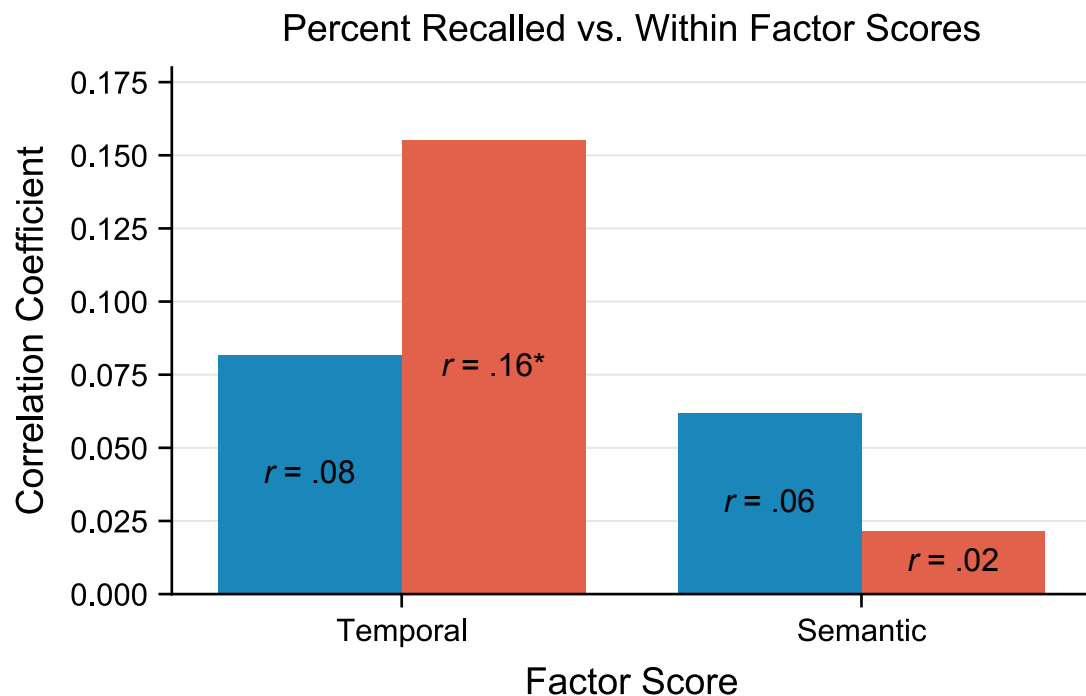
Between Clusters:



- Contiguity is seen even when we look at transitions within a cluster and between clusters

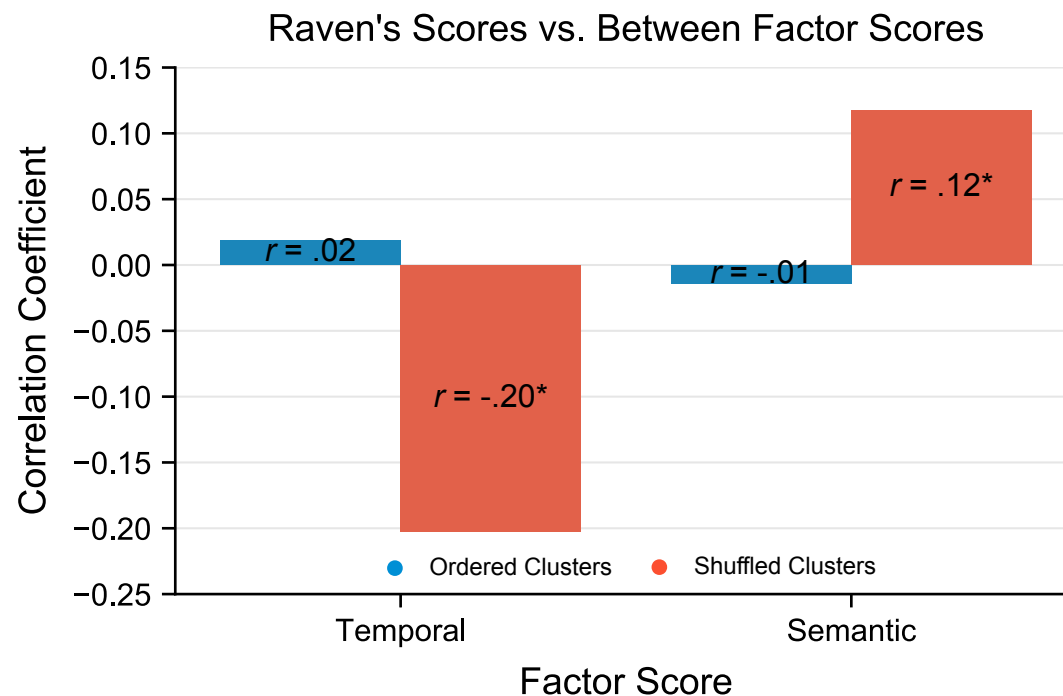
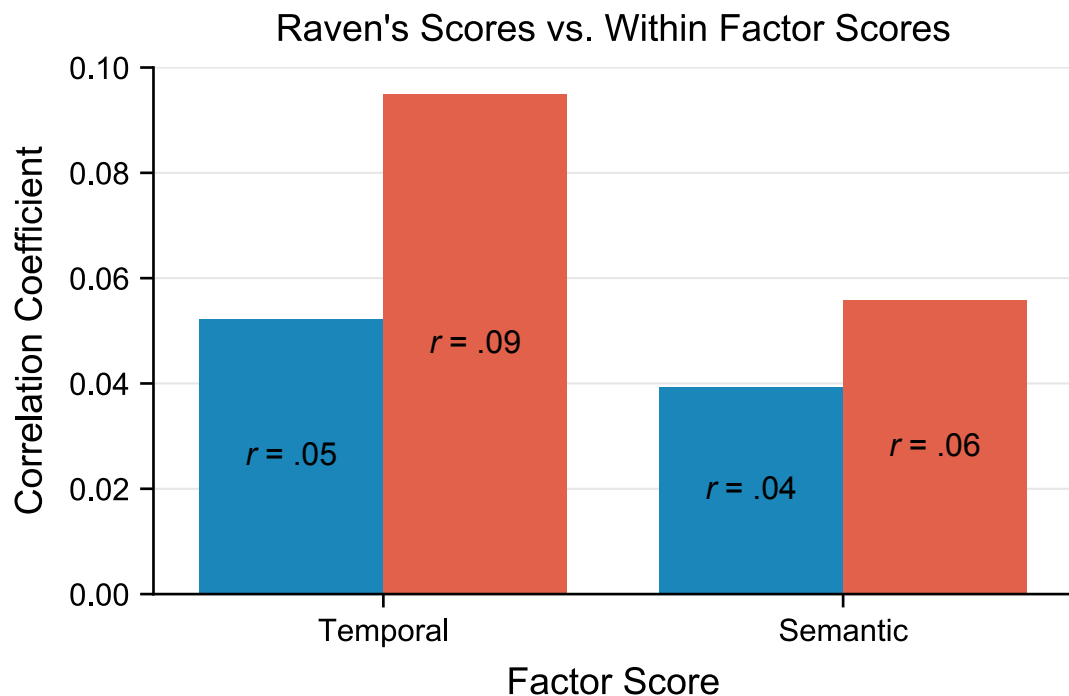


Within / Between Cluster Correlations





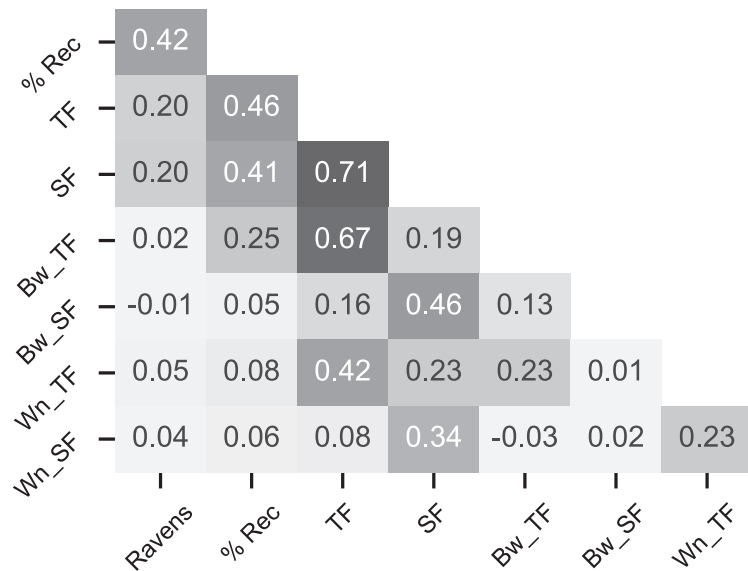
Within / Between Cluster Correlations



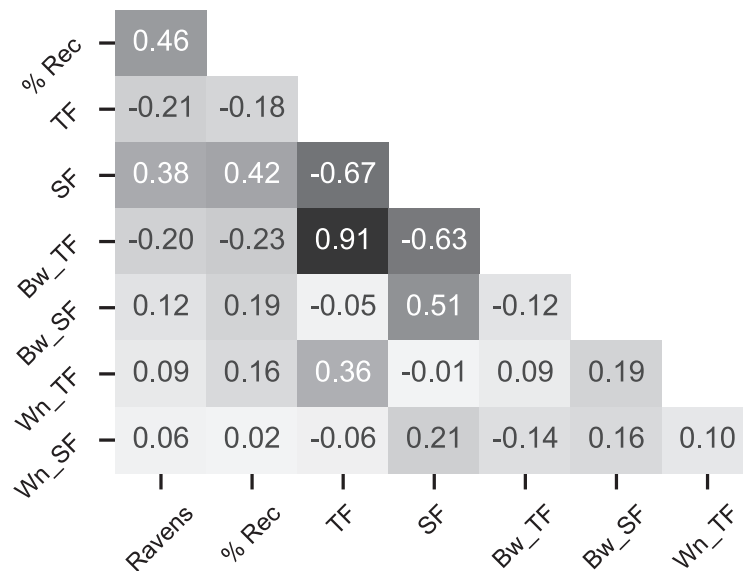


All Correlations

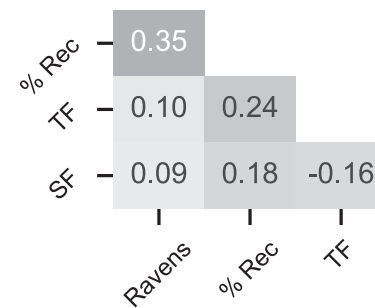
Ordered Clusters:



Shuffled Clusters:



Unrelated:



Correlation Coefficient