Levels of Processing & Temporal Contiguity in Free Recall

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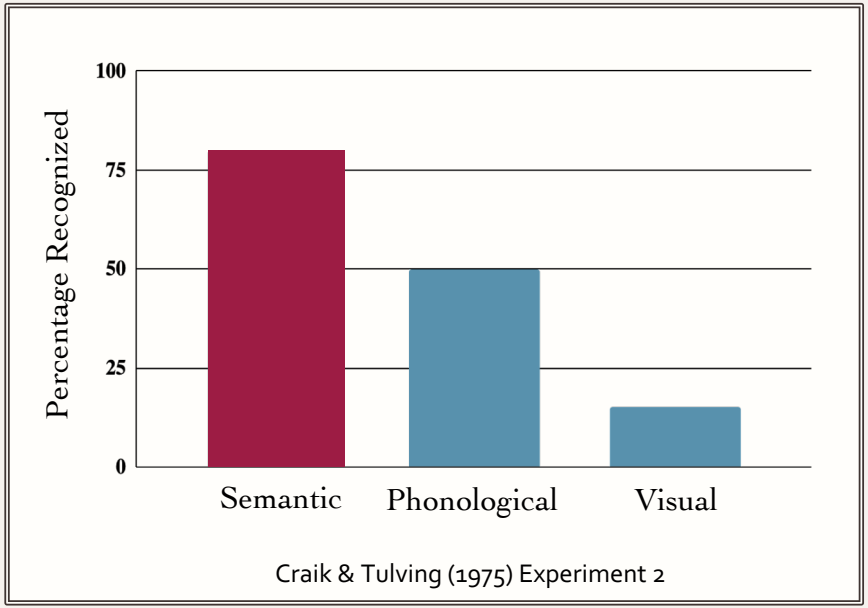
Levels of Processing Effect

Temporal Contiguity Effect

Levels of Processing

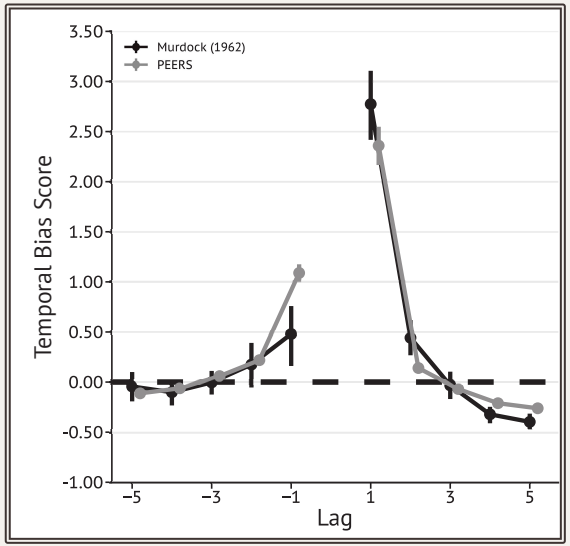
- Levels of Processing Effect: deeper processing results in better memory than shallow processing
- Well-replicated effect
  - Encoding intentionality (Craik & Tulving, 1975; Seiver et al., 2019)
  - Retrieval task (e.g., Craik & Tulving, 1975; Hyde & Jenkins, 1969, Seamon & Murray, 1976)
  - Basic & real-world stimuli (Biggs, 1978; Seiver et al., 2019; Martin et al., 1985; Ovalle-Fresa, Uslu, & Rothen, 2021)
- Influence on theory development
  - LOP Framework (Craik & Lockhart, 1972)
  - Mechanisms still not well understood (Baddeley, 1978; Craik, 2002; Eysenck, 1979)

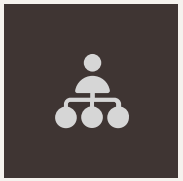


Craik & Tulving (1975) Experiment 2

Temporal Contiguity Effect

- Temporal Contiguity Effect (TCE): recall of one event tends to trigger recall of other events originally experienced nearby in time (Healey, Long, & Kahana, 2019)
  - Correlated with memory performance (Sederberg et al., 2010)
- Well-replicated effect
  - Encoding intentionality (Healey, 2018; Mundorf, Lazarus, Uitvlugt, & Healey, 2021)
  - Retrieval task (e.g., Howard & Kahana, 2000; Schwartz et al., 2005; Davis et al., 2008)
  - Basic & real-world stimuli (Diamond & Levine, 2020; Moreton & Ward, 2010; Uitvlugt & Healey, 2019)
- Influence on theory development
  - Specific TCE-generating mechanisms





Levels of Processing Effect

Temporal Contiguity Effect

1

Retrieved Context Models

2

Item-Order Account

3

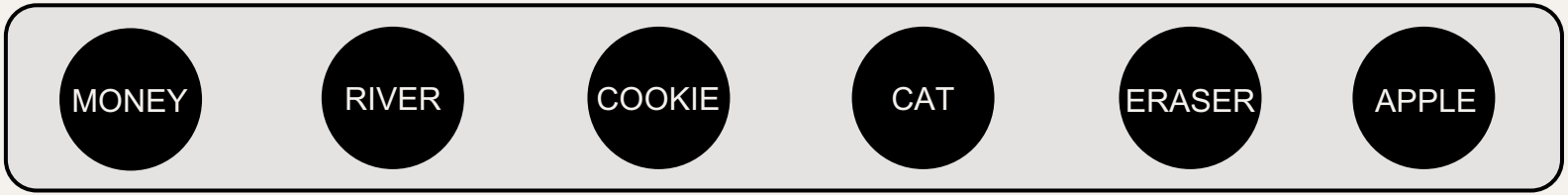
Strategic Control Processes

Theoretical Accounts

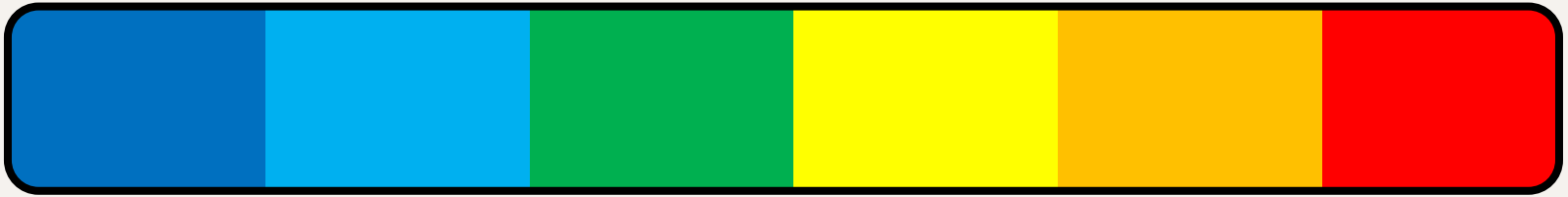
Retrieved Context Models

- During encoding, item & current mental context form associations

Item

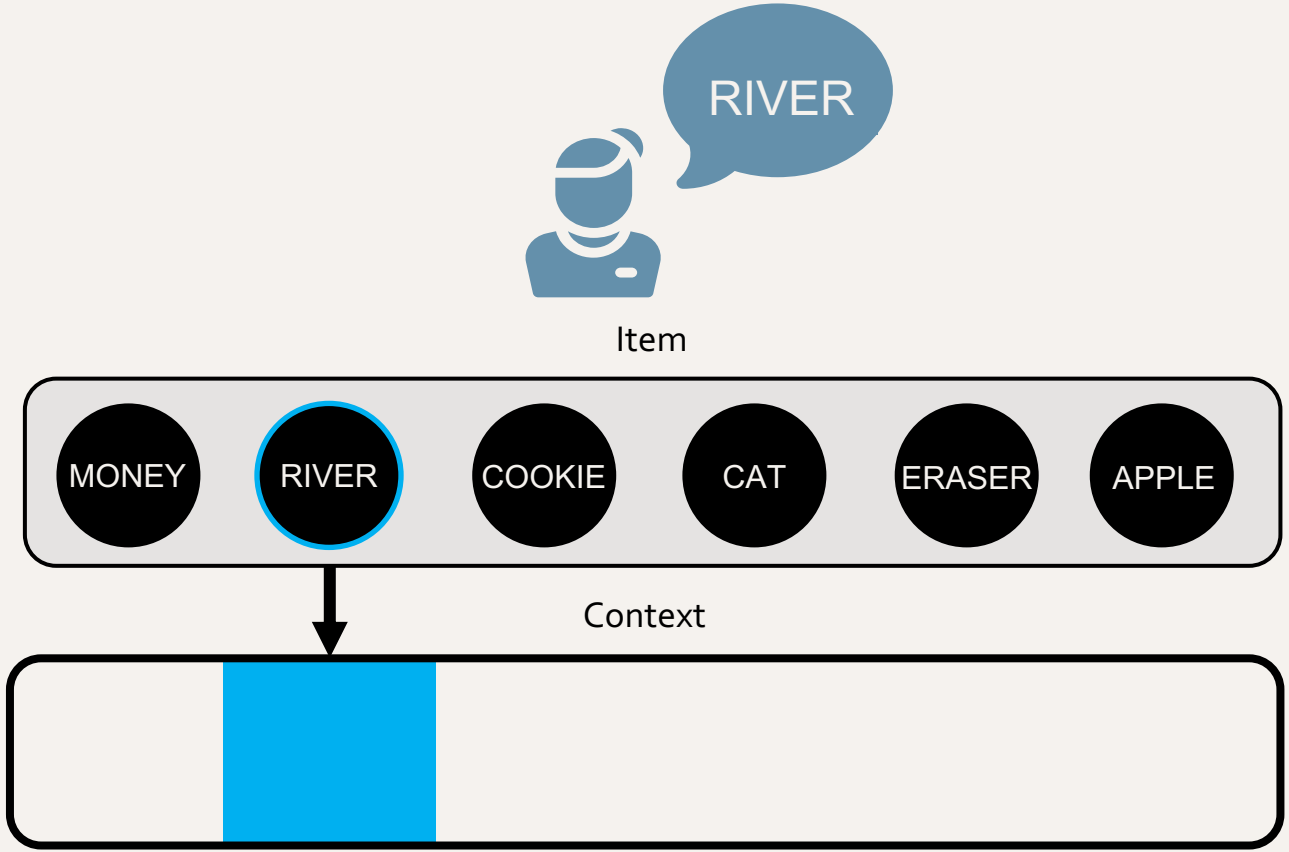


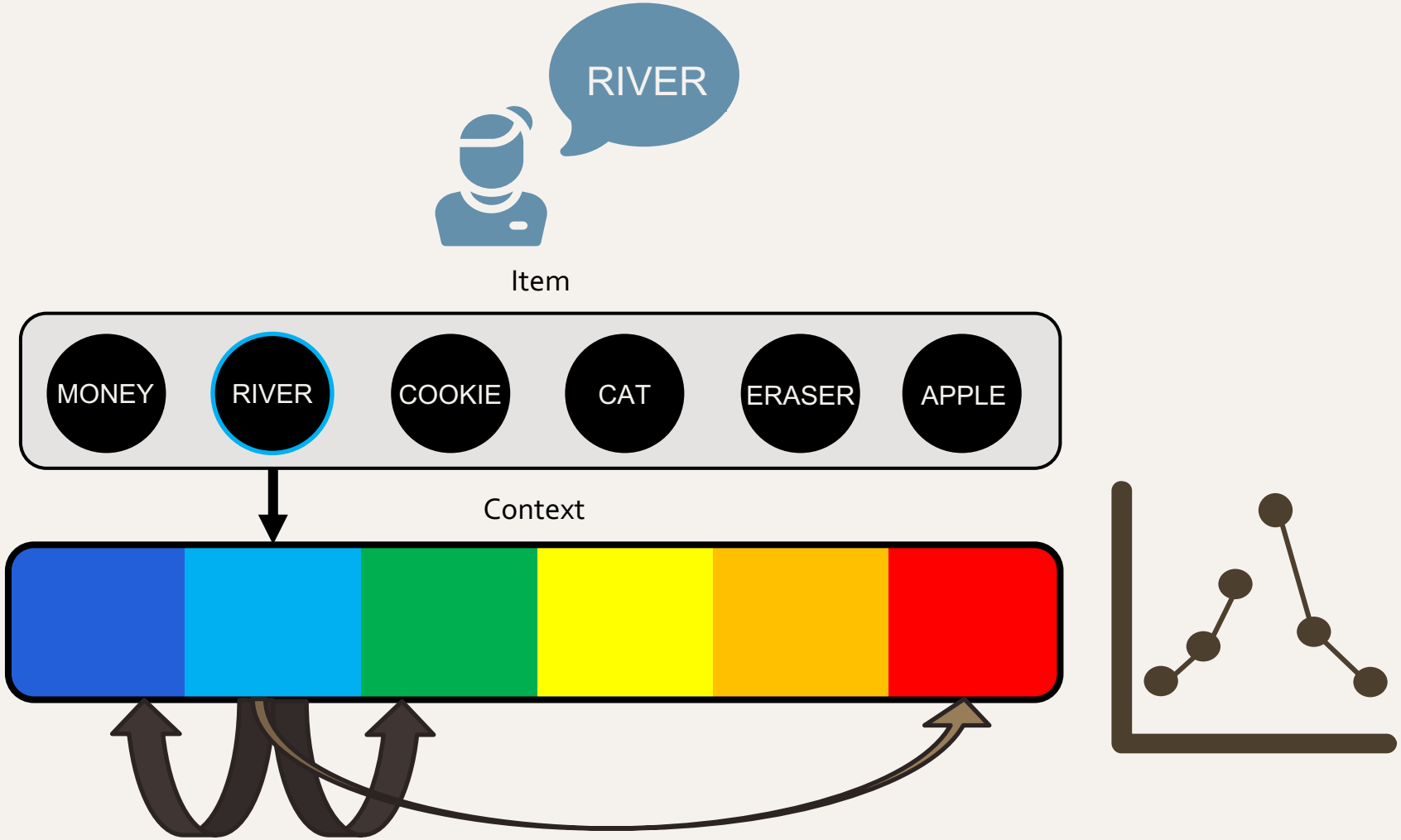
Context



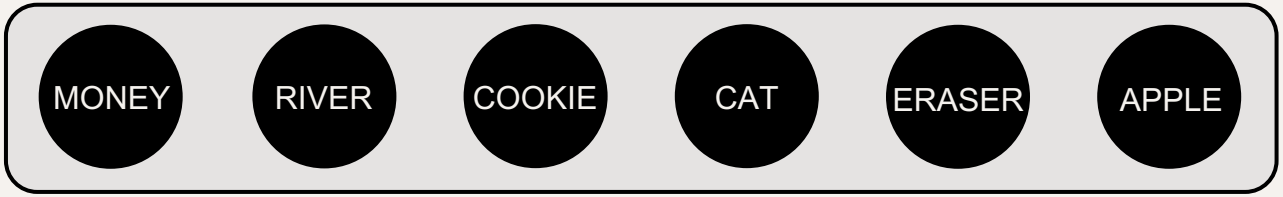
Retrieved Context Models

- During encoding, item & current mental context form associations
- Recalling an item brings to mind its associated context
    - Context serves as a cue for recalling the next item

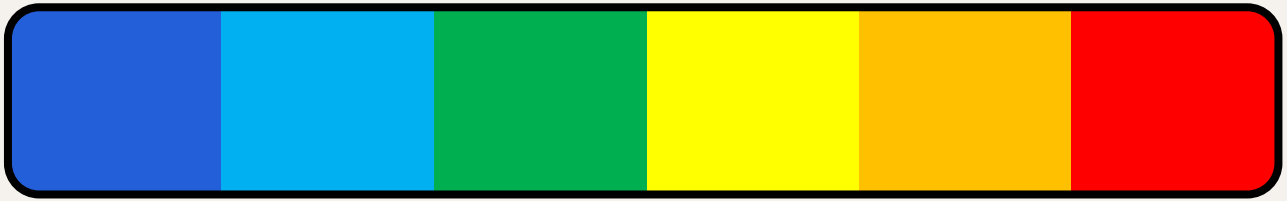

RIVER
Item
MONEY
RIVER
COOKIE
CAT
ERASER
APPLE
Context

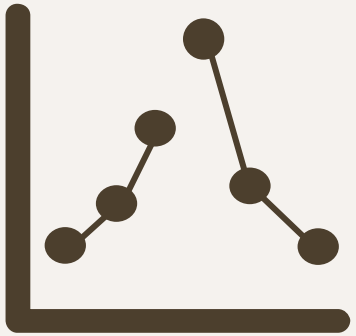

RIVER
Item
MONEY
RIVER
COOKIE
CAT
ERASER
APPLE
Context

Item

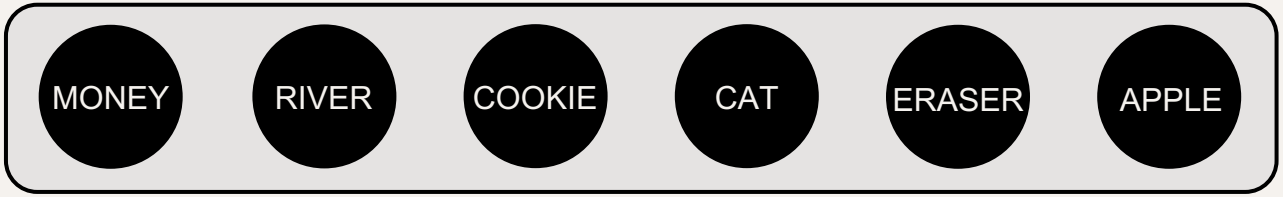


Context

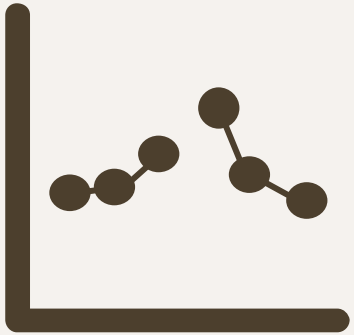




Item



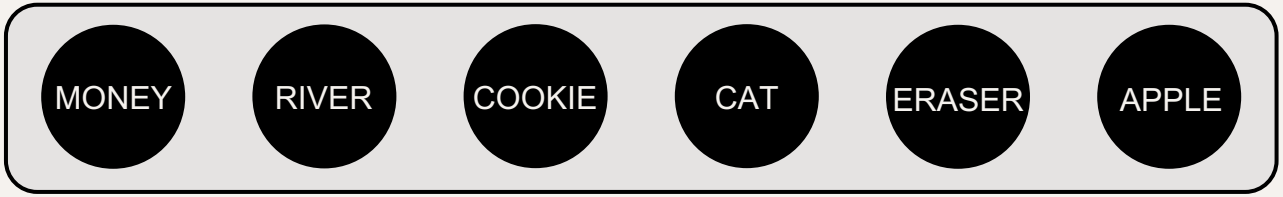
Context



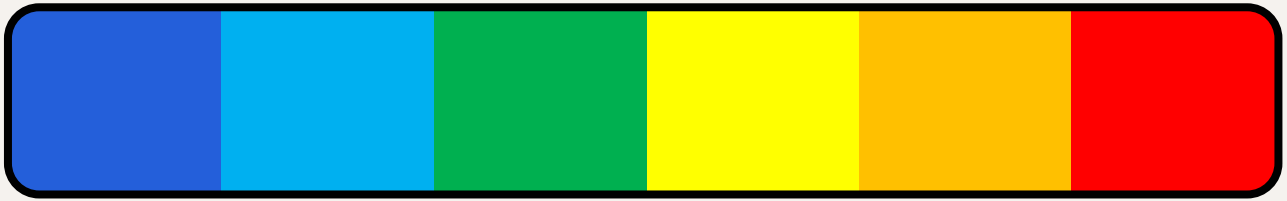
Retrieved Context Models

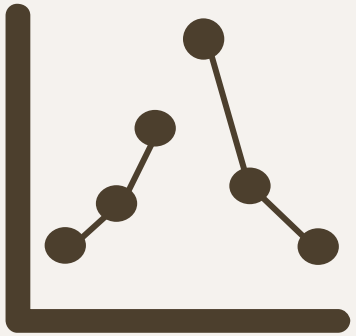
- Changes in context are driven by **items**
  - Greater activation of items' existing associations causes greater change in context
- **If deep processing causes greater changes in context with each item**, the TCE will be greater in deep than shallow processing (Healey & Kahana, 2016)

Item

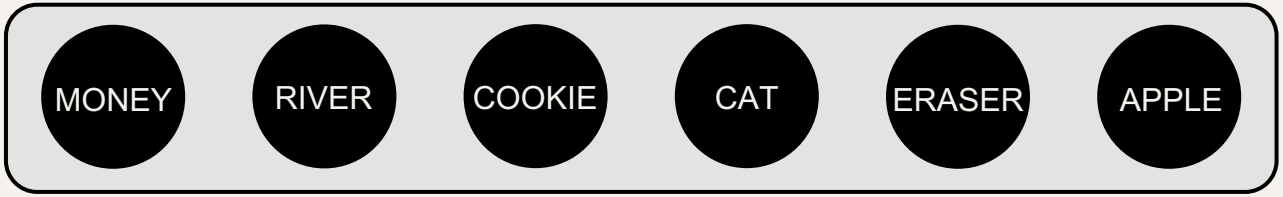


Context

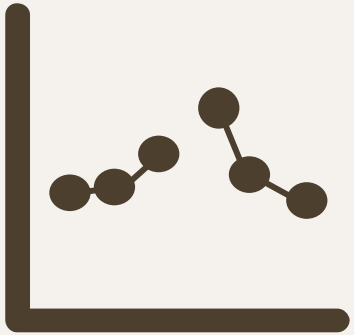




Item

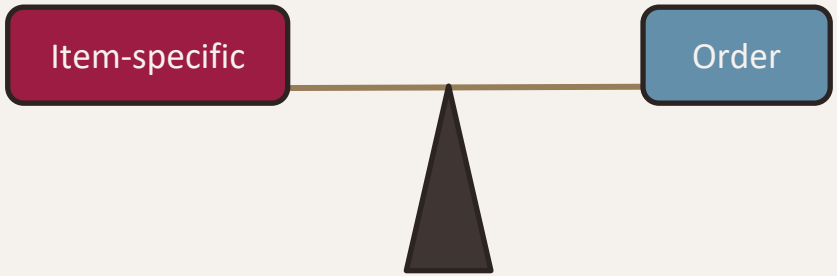


Context



Item-Order Account

- Anything that encourages item-specific processing should reduce encoding of relational order information (McDaniel & Bugg, 2008)



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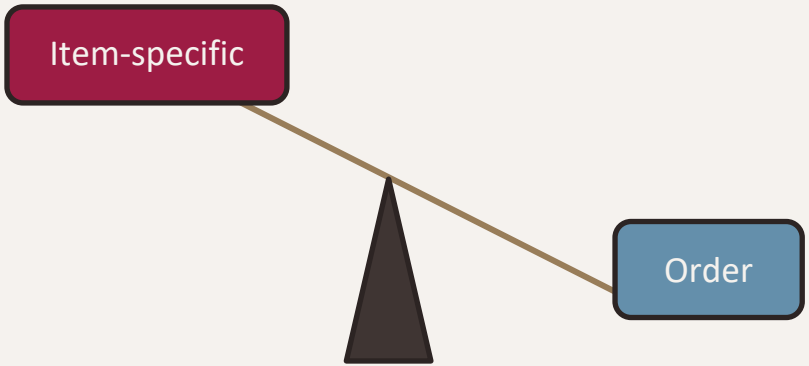
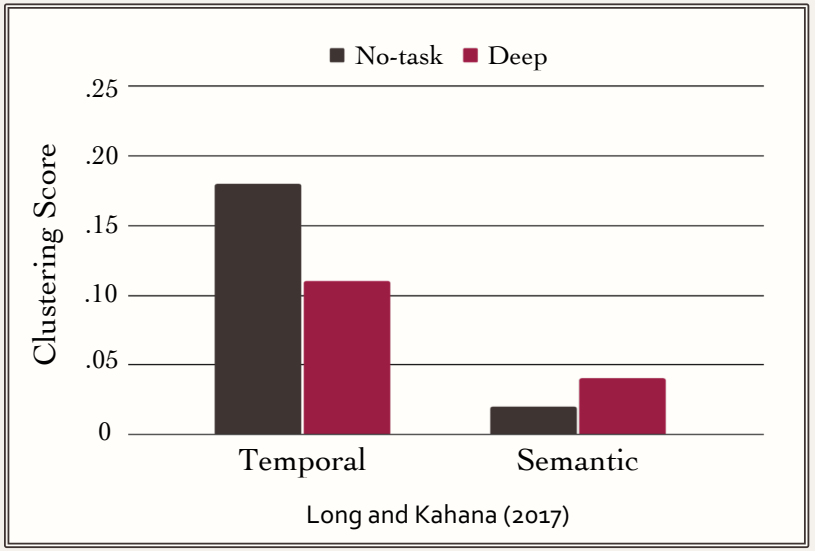


Item-Order Account

- Anything that encourages item-specific processing should reduce encoding of relational order information (McDaniel & Bugg, 2008)
- Deep processing may encourage item-specific processing (Gallo, Meadow, Johnson & Foster, 2008)
- **A deep processing task should reduce the TCE relative to shallow processing**

Strategic Control Processes

- Assigning a task may change encoding strategies
- In free recall lists, participants often adopt order-based strategies
    - Method of loci, creating a story (Delaney & Knowles, 2005; Unsworth, 2016)
    - Strategies contribute to the TCE (Bouffard et al., 2018)
- Any assigned task interferes with these strategies, reducing both recall and the TCE (Hagen, Meacham, & Mesibov, 1970; Mazuryk & Lockhart, 1974; Long & Kahana, 2017)
- **Any assigned task will reduce the TCE**



Long and Kahana (2017)

1

Retrieved Context Models

Higher recall & TCE
in deep than shallow processing

2

Item-Order Account

Higher recall but smaller TCE
in deep than shallow processing

3

Strategic Control Processes

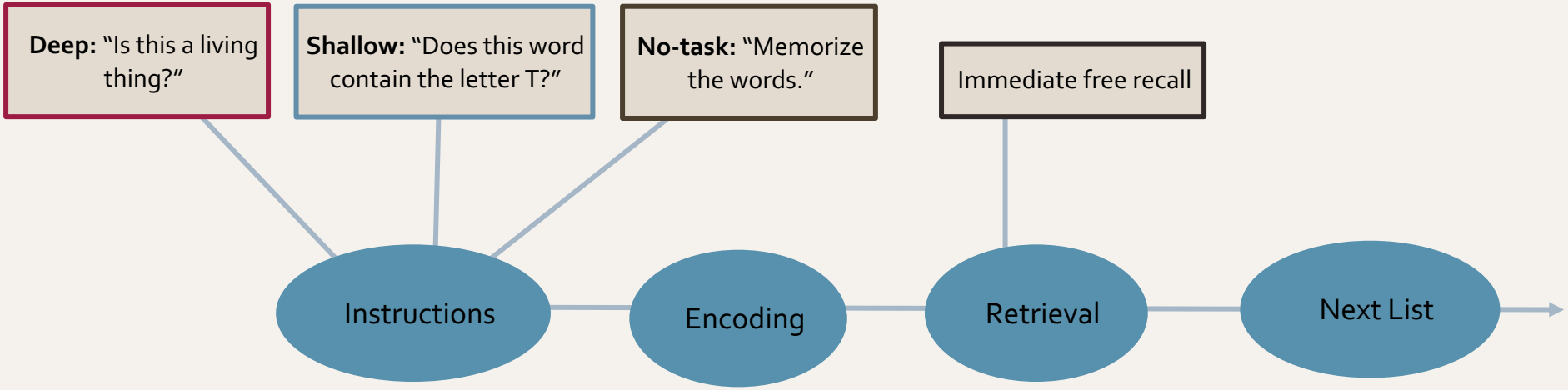
Higher recall & TCE
for no-task than deep or shallow processing

Methods

Participants & Materials

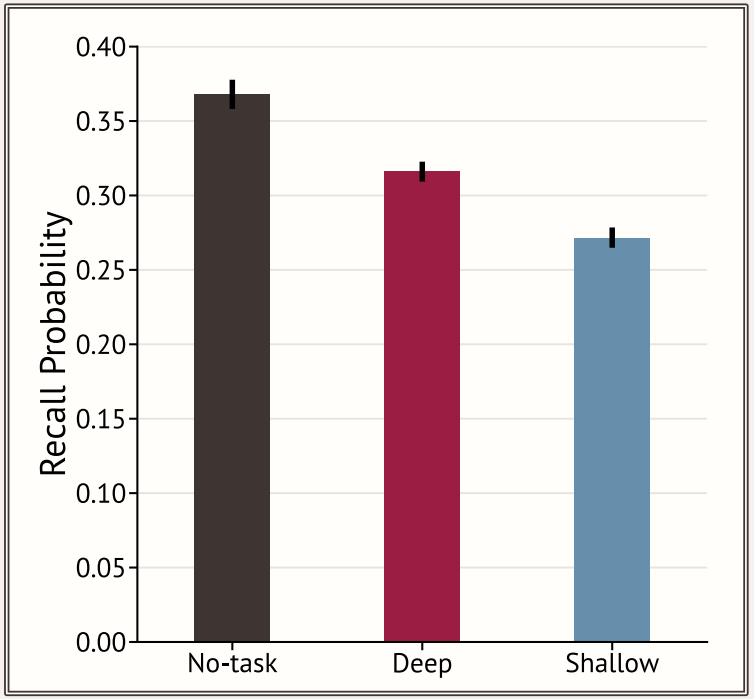
- 680 participants recruited from MSU undergraduate subject pool (online)
- Each participant studied 30 lists of 16 items
  - 10 lists with a shallow task
  - 10 lists with a deep task
  - 10 lists with no task
- List order shuffled

Procedure


Deep: "Is this a living thing?"
Shallow: "Does this word contain the letter T?"
No-task: "Memorize the words."
Immediate free recall
Instructions
Encoding
Retrieval
Next List

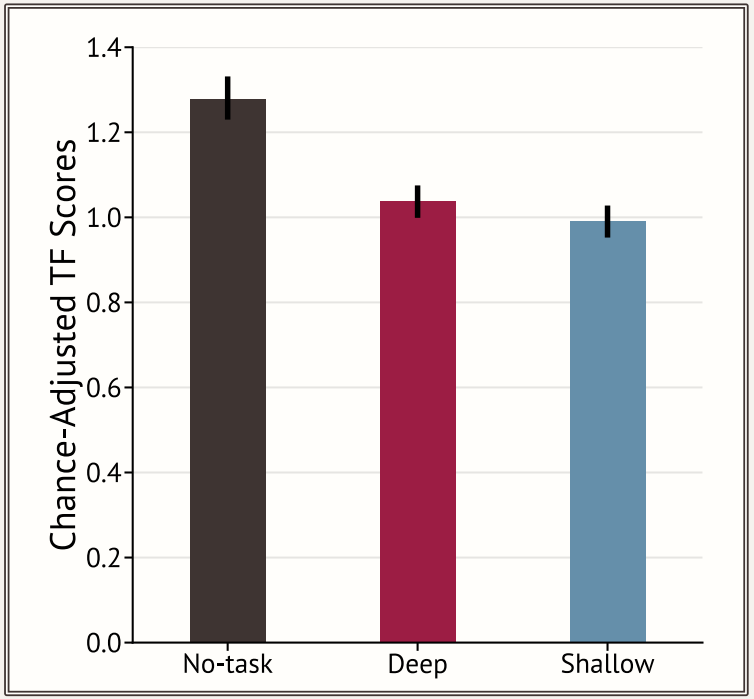
Results

Recall



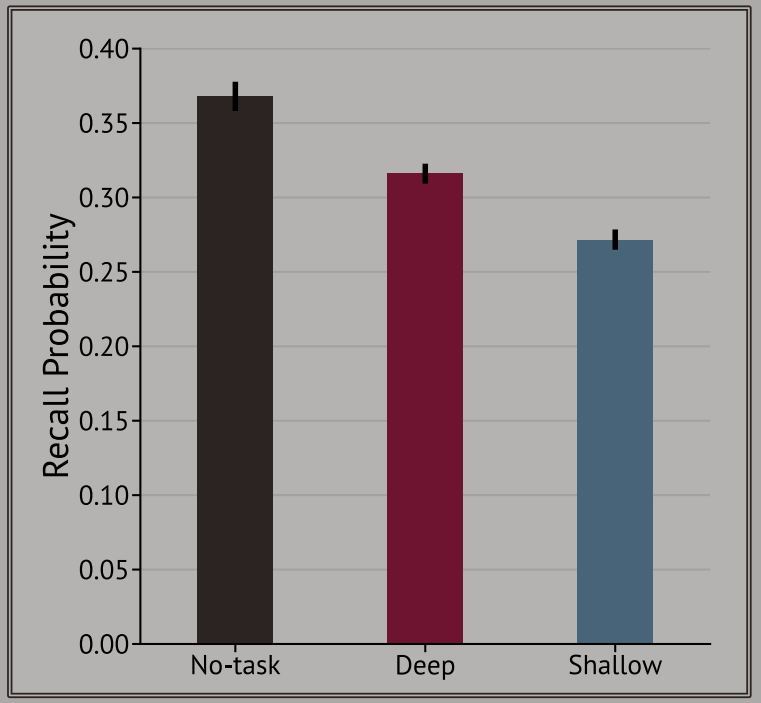
No-task > deep (*d*=.579)*
Deep > shallow processing (*d*=0.937)*

Temporal Contiguity



No-task > deep (*d* = .419)*
Deep > shallow processing (*d*=0.110)*

Recall



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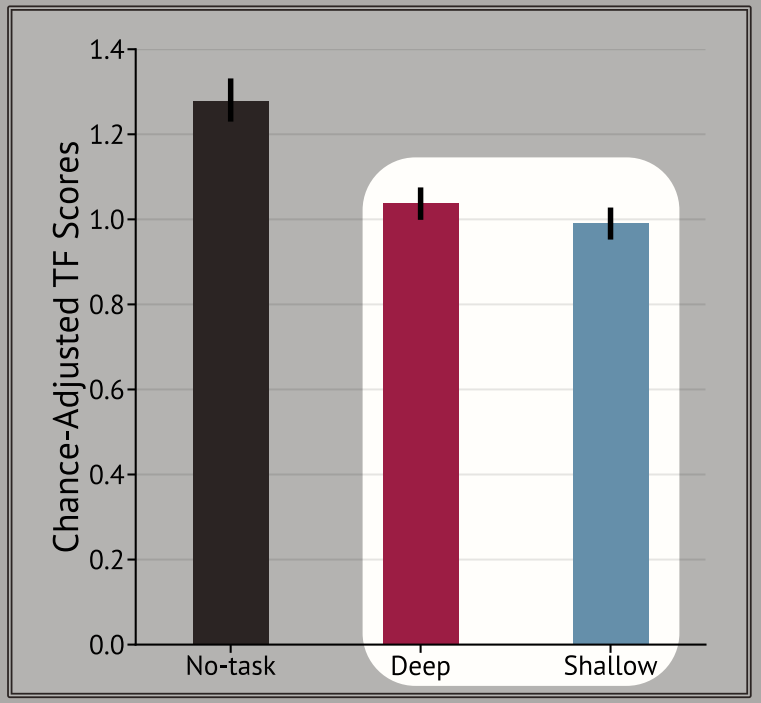

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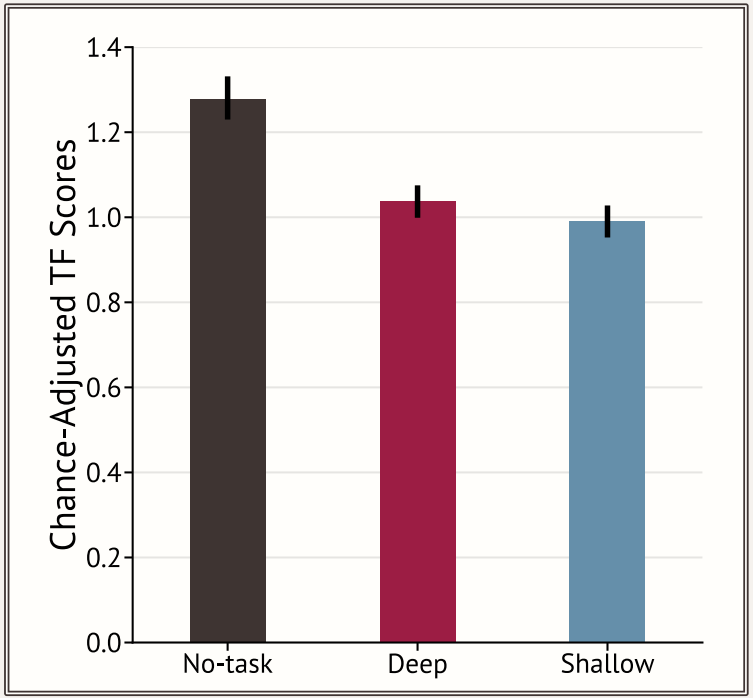
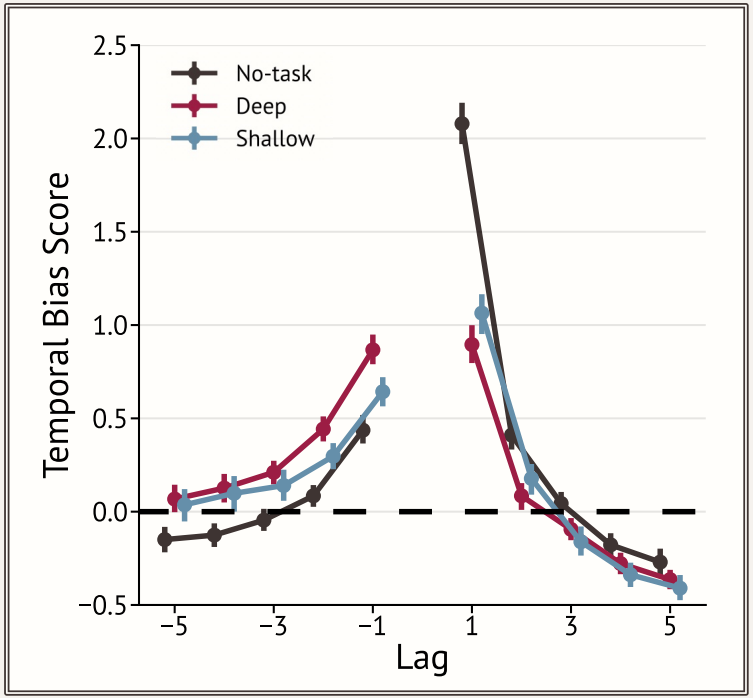
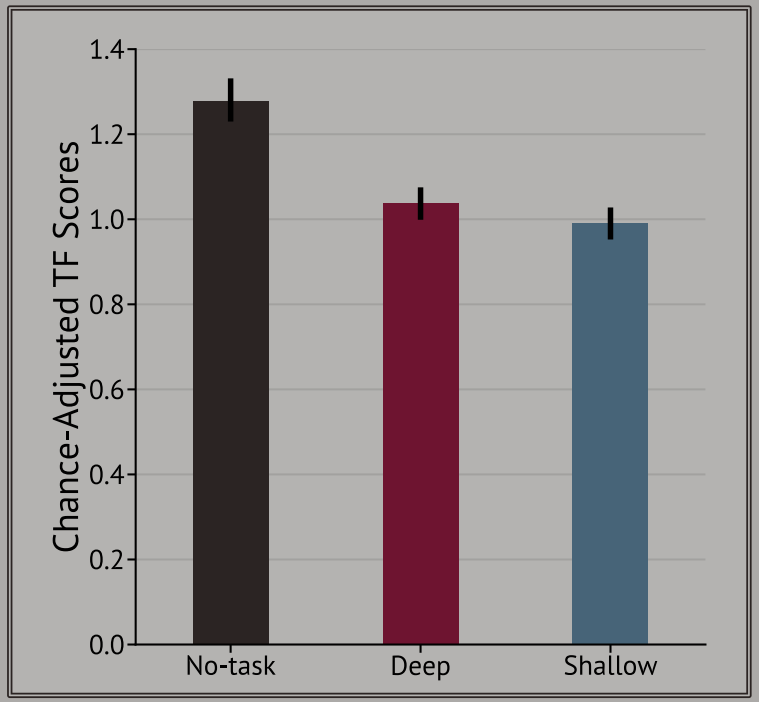
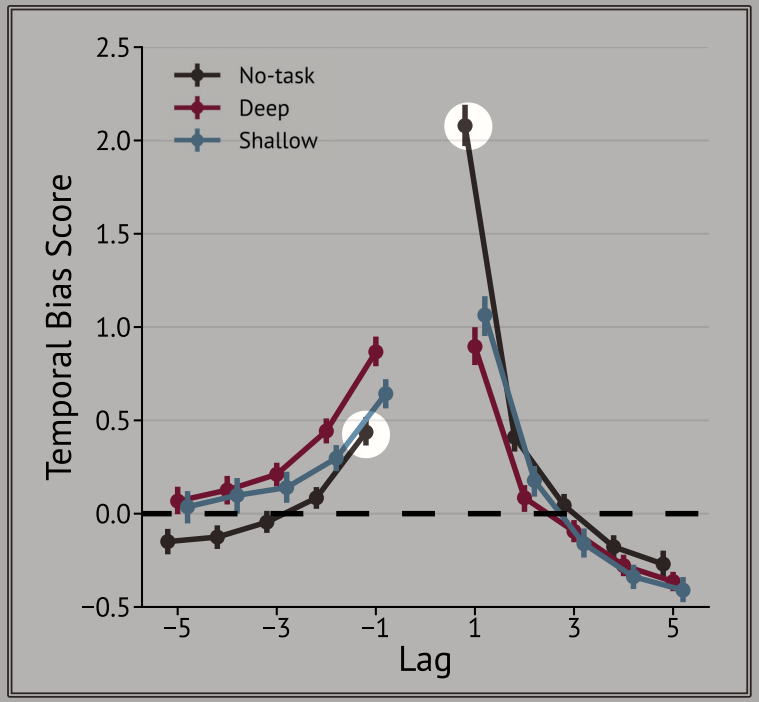
Temporal Contiguity





Temporal Contiguity





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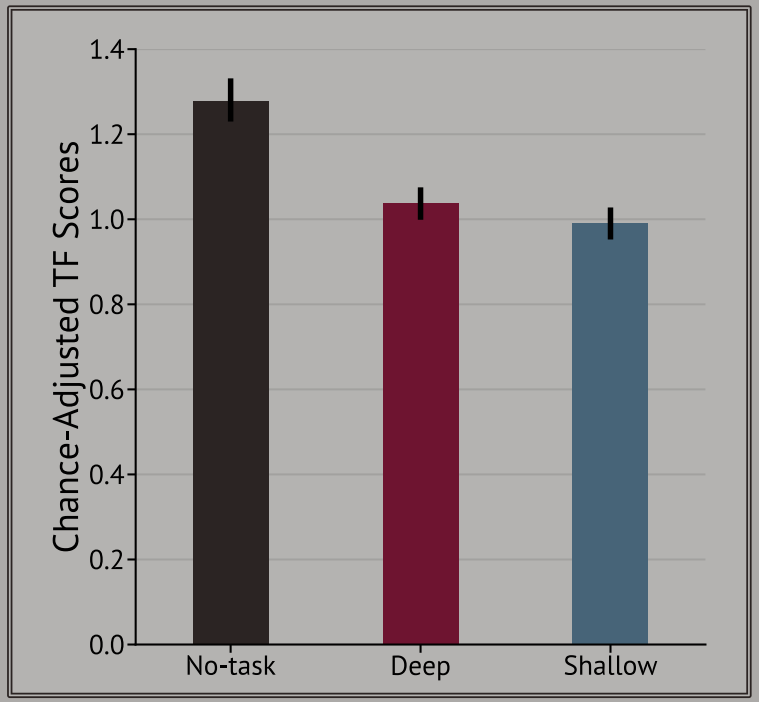
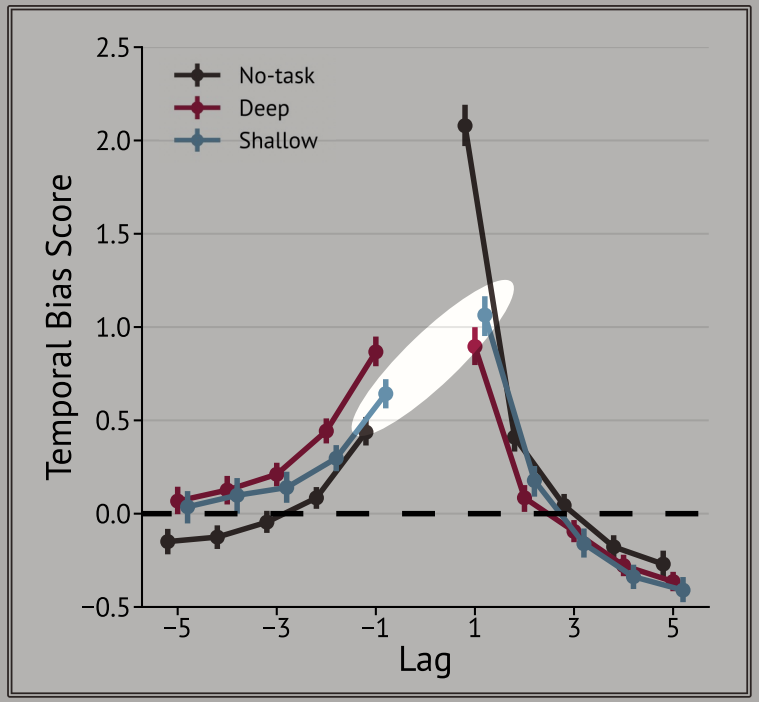
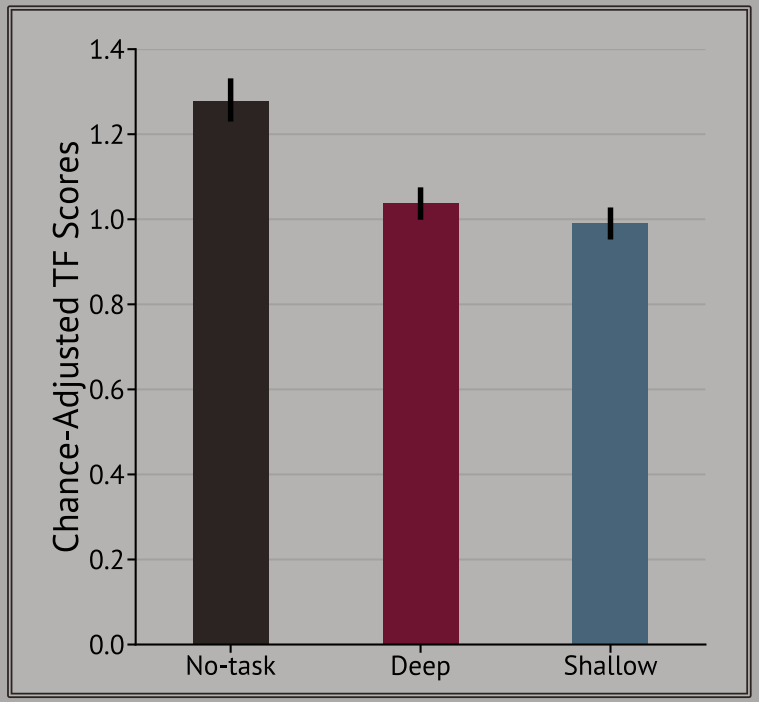
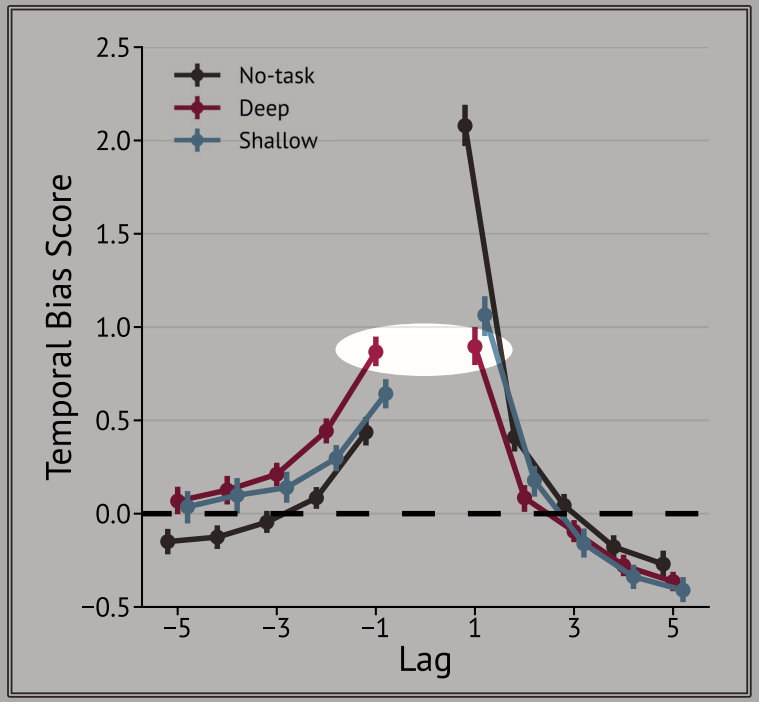




Temporal Contiguity

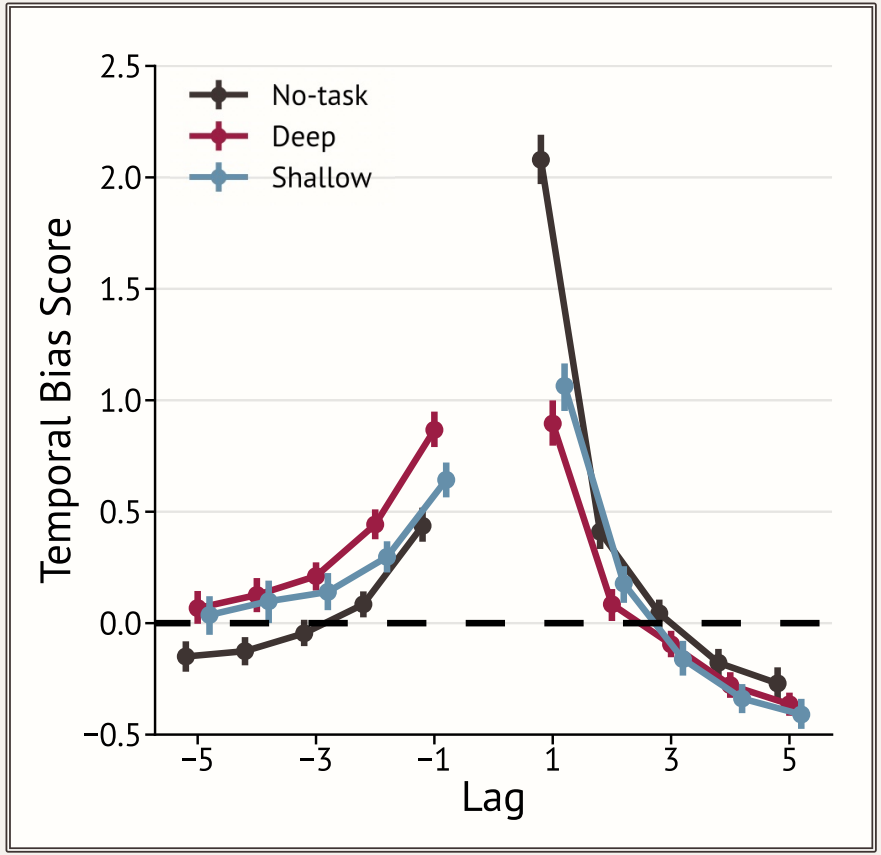




Discussion

Discussion

Account	Prediction for Recall		Prediction for Temporal Contiguity	
Retrieved Context Models	Deep > Shallow	✓	Deep > Shallow	✓
Item-Order Account	Deep > Shallow	✓	Shallow > Deep	✗
Strategic Control Processes	No-task > Deep or Shallow	✓	No-task > Deep or Shallow	✓


No-task
Deep
Shallow
Temporal Bias Score
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−5
−3
−1
1
3
5
Lag

Conclusions

- When left to their own devices, participants utilize order information
  - At least when temporal information is useful
- Temporal contiguity is a piece of the levels of processing puzzle
- Results support **retrieved context models** & **accounts based on strategic control processes**
  - Both perspectives should be considered in future theory development

Acknowledgements

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- Linh Lazarus
- Carter Brown & Kaitlin Ifkovits

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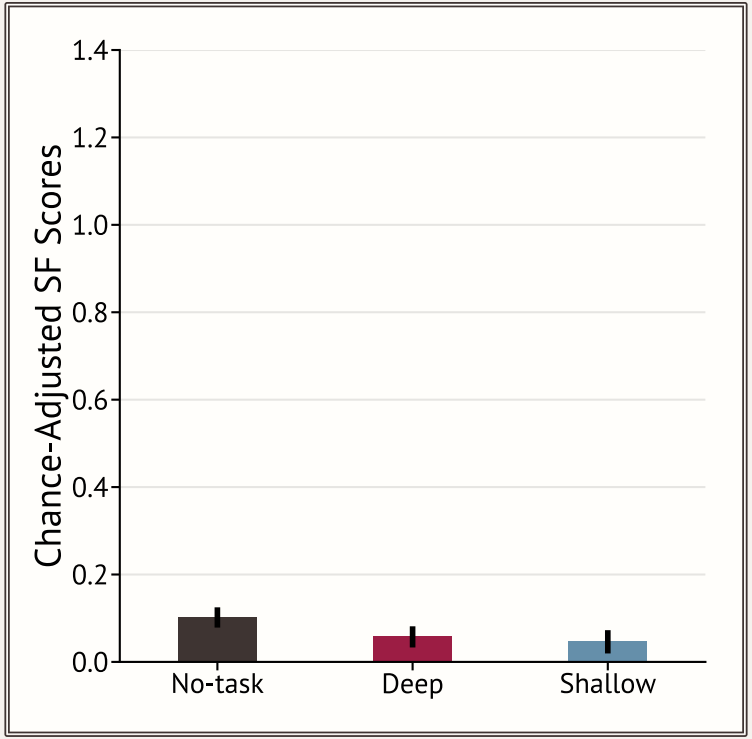
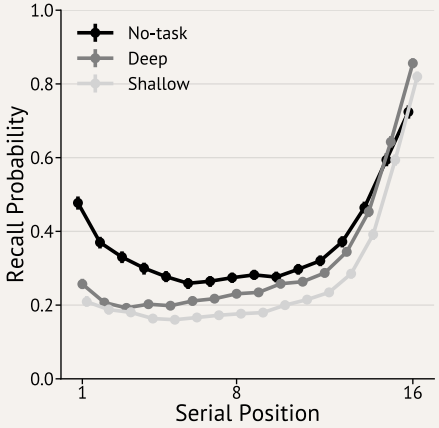
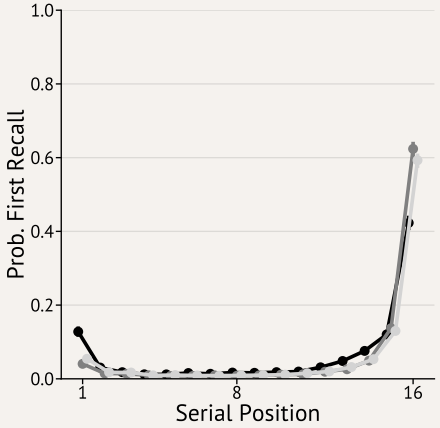
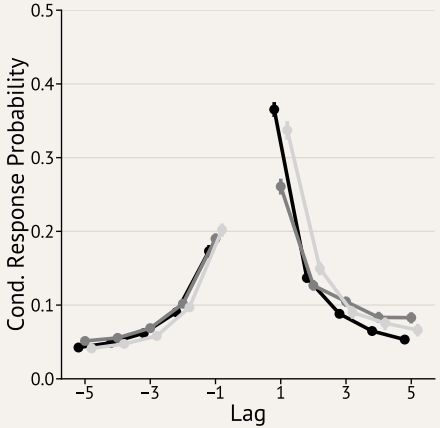
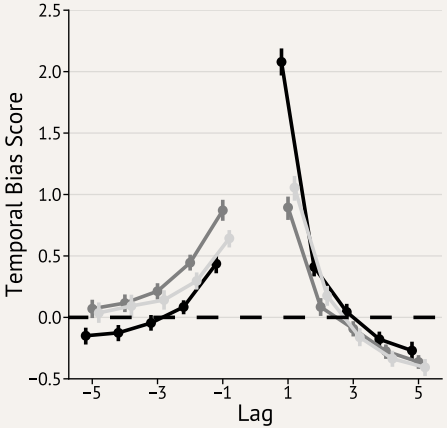
Semantic Contiguity

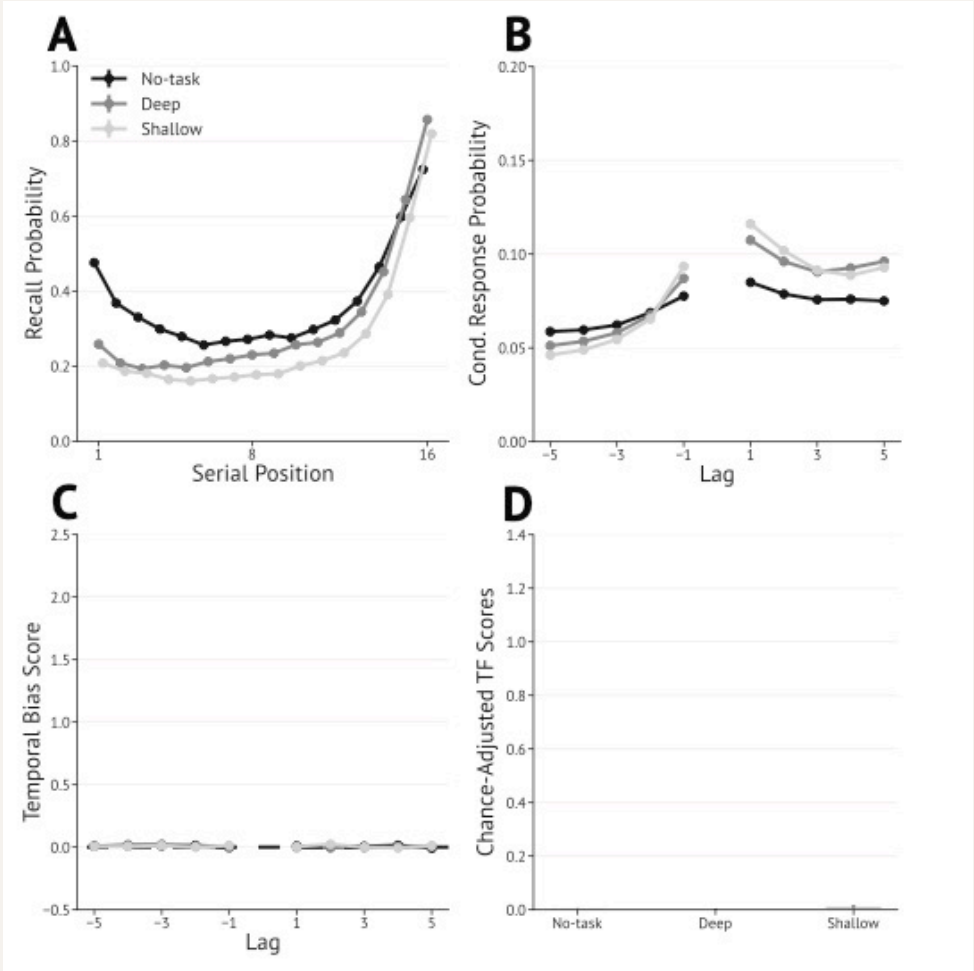


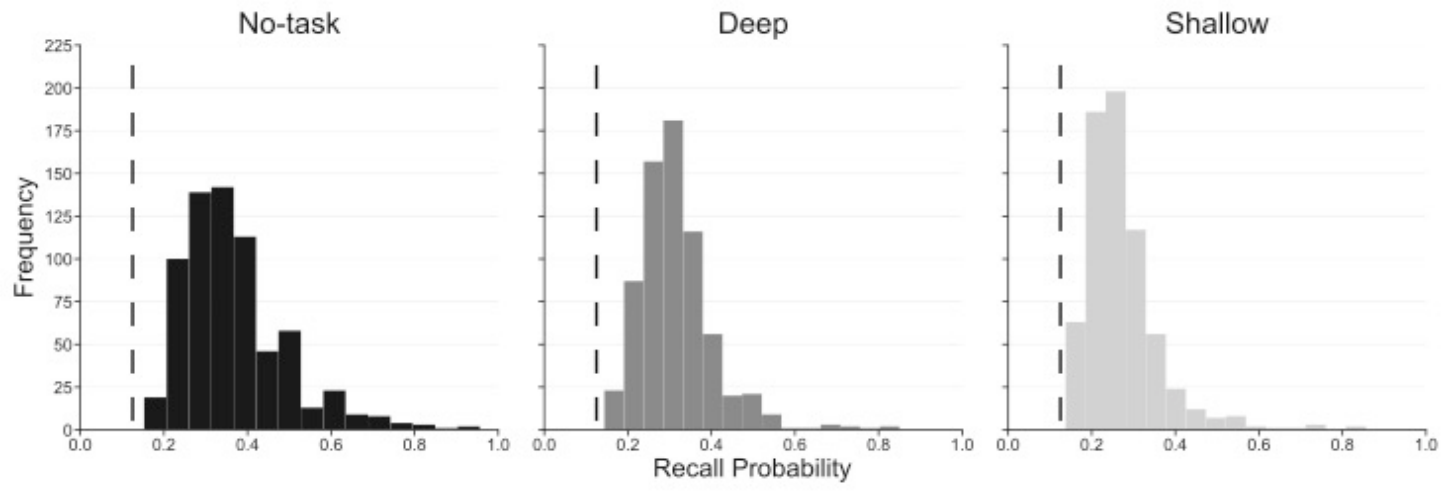

No-task
Deep
Shallow
Recall Probability
Serial Position
1.0
0.8
0.6
0.4
0.2
0.0
1
8
16

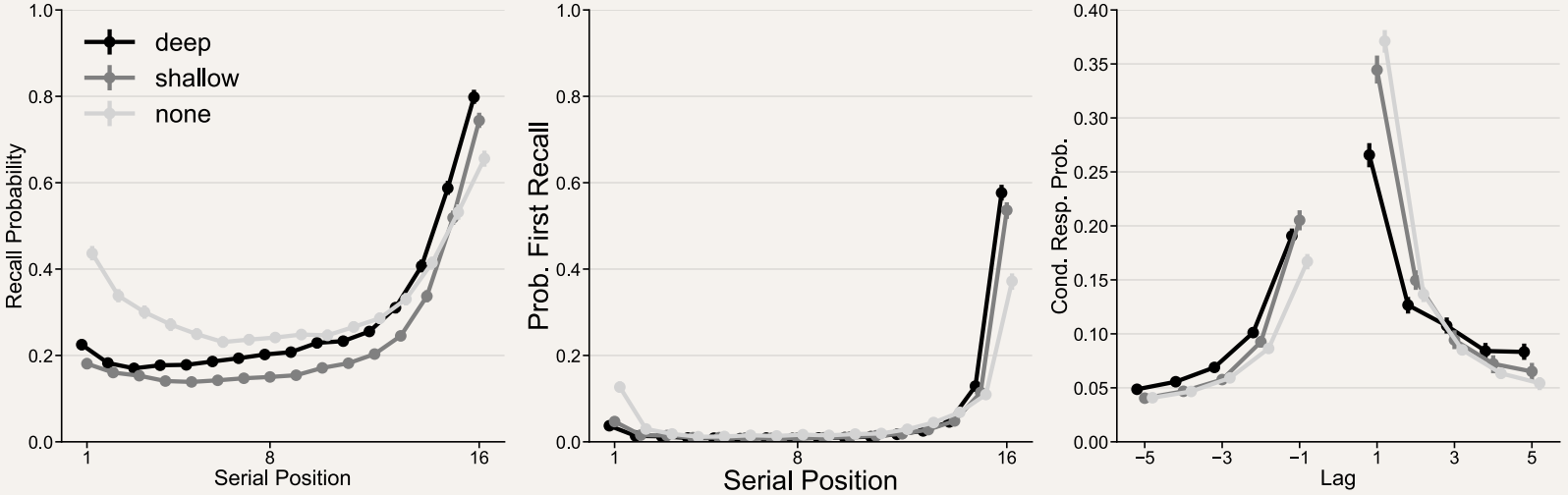

Prob. First Recall
Serial Position
1.0
0.8
0.6
0.4
0.2
0.0
1
8
16


Cond. Response Probability
Lag
0.5
0.4
0.3
0.2
0.1
0.0
−5
−3
−1
1
3
5


Temporal Bias Score
Lag
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−5
−3
−1
1
3
5


A
No-task
Deep
Shallow
Recall Probability
Serial Position
B
Cond. Response Probability
Lag
C
Temporal Bias Score
Lag
D
Chance-Adjusted TF Scores
No-task
Deep
Shallow


No-task
Deep
Shallow
Frequency
Recall Probability
0
25
50
75
100
125
150
175
200
225
0.0
0.2
0.4
0.6
0.8
1.0


deep
shallow
none
Recall Probability
Serial Position
Prob. First Recall
Serial Position
Cond. Resp. Prob.
Lag

Individual differences: Correlations between TCE and recall

- TCE was positively correlated with recall in no-task ($r(678) = .76$, $p < .001$),
- deep ($r(678) = .65$, $p < .001$),
- and shallow ($r(678) = .72$, $p < .001$) lists with a Bonferroni adjusted $\alpha = .006$

Condition	Prob. recall	Chance-adjusted TF scores	Chance-adjusted SF scores
No-task	0.923	0.759	0.072
Deep	0.892	0.628	-0.013
Shallow	0.897	0.671	0.058