CONSOLIDATING A LASTING MEMORY: THE ROLE OF CREATIVITY IN THE RELATIONSHIP BETWEEN WORKING MEMORY AND LONG-TERM MEMORY

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HOW DO WE FORM LASTING MEMORY REPRESENTATIONS?

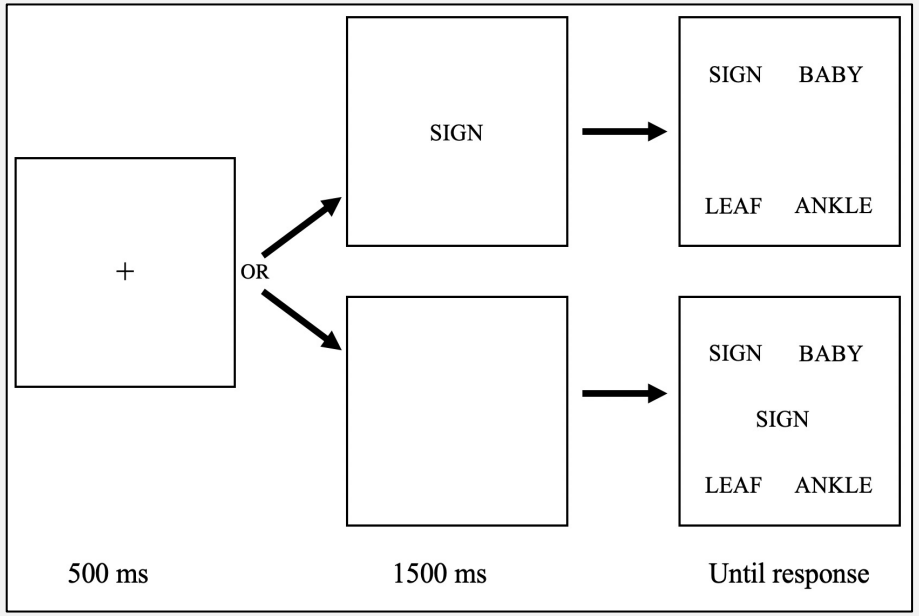
- We frequently encounter large amounts of information only momentarily, but are often able to retain it for long periods of time
- Question 1: Does working memory processing impact long-term retrieval?
- Question 2: What processes underlie the potential relationship between working memory and long-term memory?
- Question 3: Can this ability be improved?
- **Preview of results: Yes, TBD, Not really but maybe in a way**

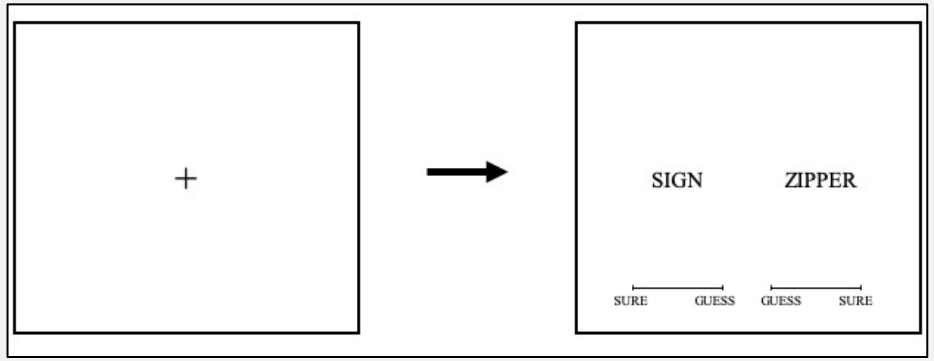
WORKING MEMORY PROCESSING IMPROVES LONG-TERM MEMORY

- **Working memory consolidation:** Process of stabilizing fragile traces into more durable representations (Jolicœur & Dell'Acqua, 1998)
- When an item first enters working memory, features and related concepts in long-term memory are activated
- Consolidation may strengthen the bindings of activated features, stabilizing the representation and making it more likely to be retrieved later
- Consolidating an item into working memory improves delayed recognition performance (Cotton & Ricker, 2020)

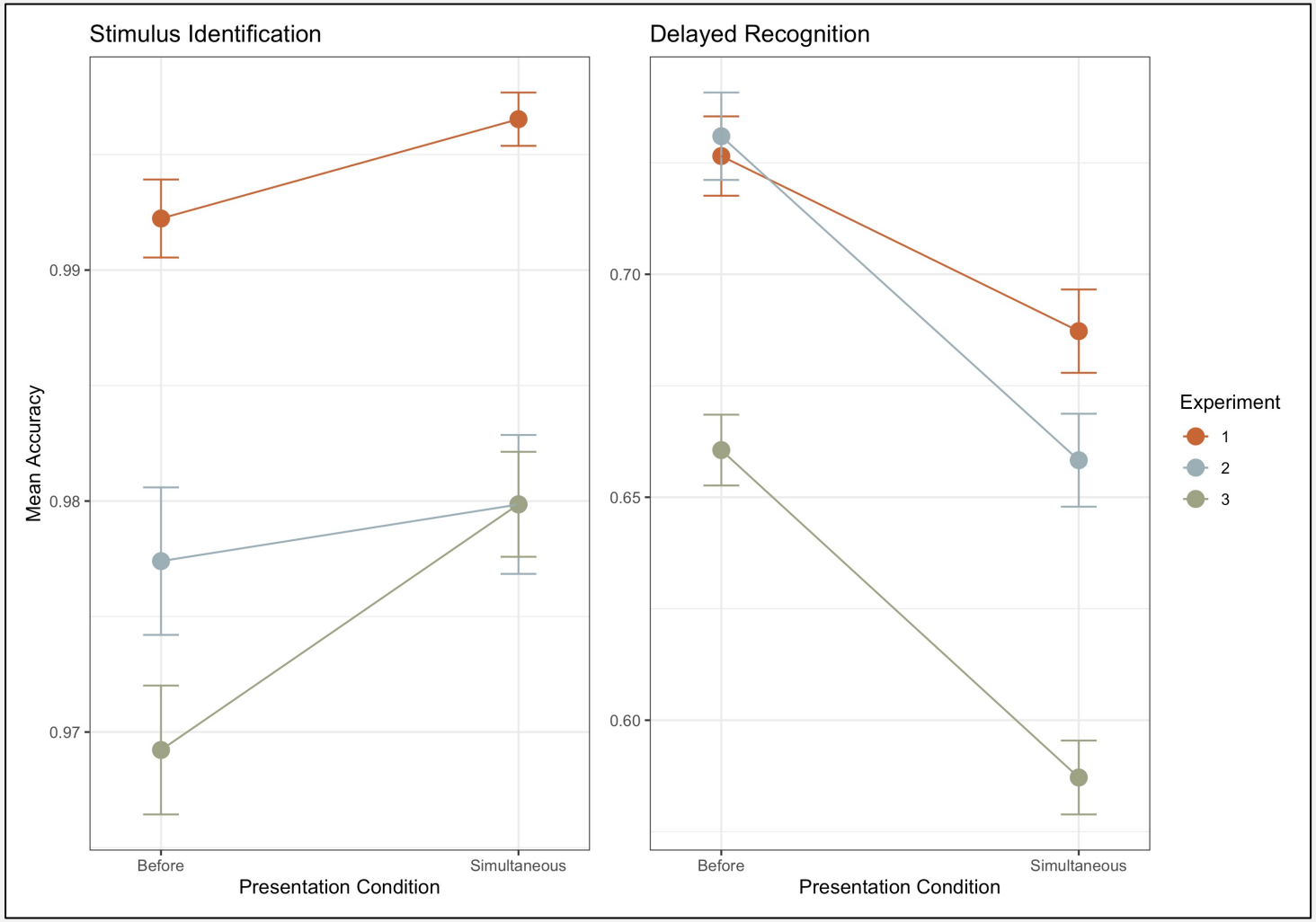
CONSOLIDATING A LONGER-LASTING MEMORY TRACE

- General procedure across all experiments:
  - Based on attribute amnesia paradigm from Chen & Wyble (2016)
  - Stimulus identification
    - Before Presentation = consolidation
    - Simultaneous Presentation = no consolidation
  - Delayed 2AFC with confidence rating





DOES WORKING MEMORY CONSOLIDATION IMPROVE DELAYED RECOGNITION?



Cotton and Ricker (2020)

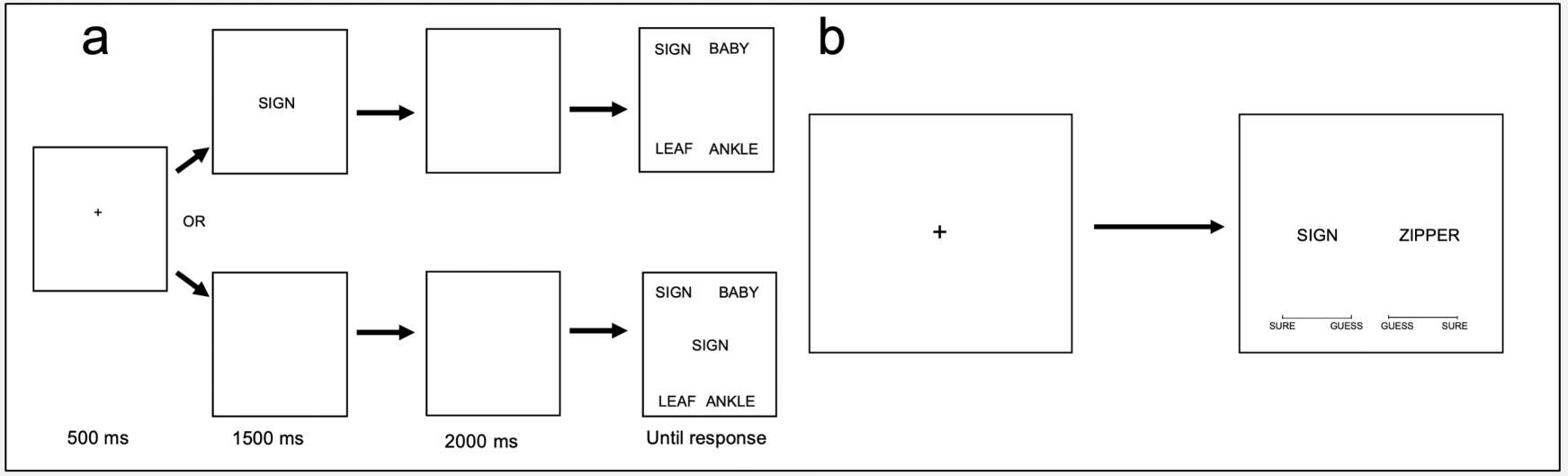
- Items originally presented briefly before being used were more likely to be recognized after a delay (Experiment 1)
- Increasing the response-set onset delay to 2000ms strengthened consolidation effect (Experiment 2)
- Consolidation effect found for both words and non-words (Experiment 3)
- Question 1: Does working memory processing impact long-term retrieval? **Yes, particularly consolidation**

WHAT UNDERLIES THIS CONSOLIDATION EFFECT?

- Working memory consolidation strengthens binding between activated features and long-term representations
  - Maybe consolidation supports the formation of novel associations between items, features, and pre-existing representations, leading to easier subsequent memory search
- Previous research suggests that creativity and memory performance may be related (e.g., Dietrich, 2004)
  - Creativity may rely on ability to identify novel associations
- More creative individuals or being in a creative state leads to more efficient consolidation and subsequently better long-term memory

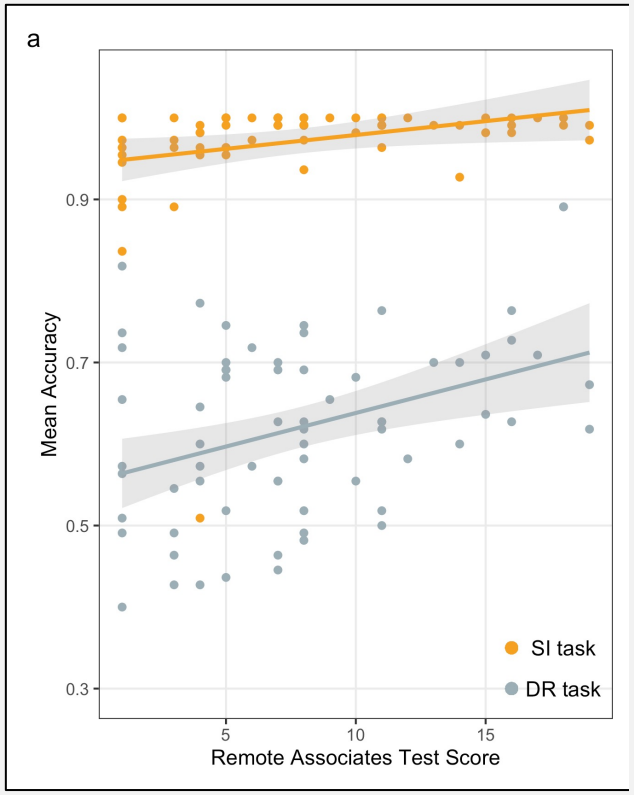
TRAIT-LEVEL CREATIVITY AND MEMORY PERFORMANCE

- *N* = 67 Amazon mTurk participants
- Same general experimental procedure
  - Stimulus identification (a)
  - Delayed recognition (b)
  - Creativity test: 20-item Remote Associates Test
    - Presented items**:** **DEW COMB BEE**
    - Answer: **honey**



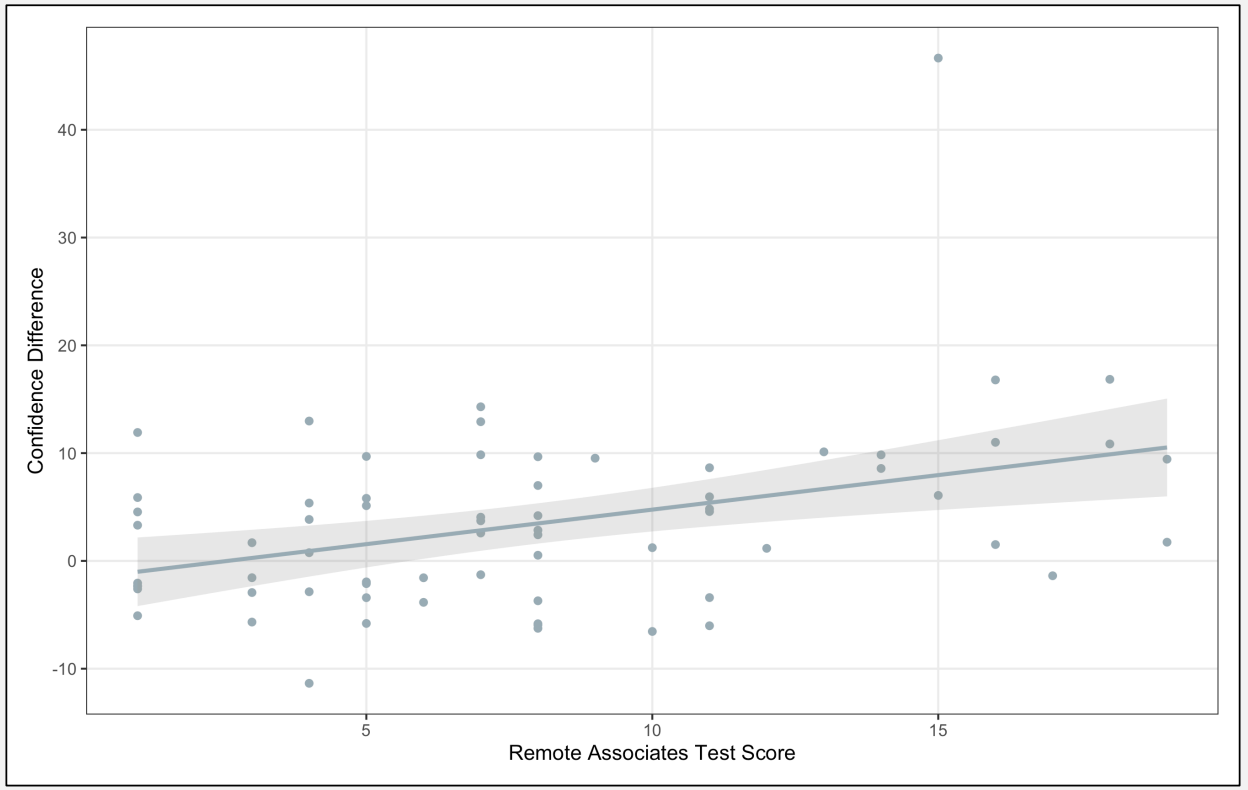
TRAIT-LEVEL CREATIVITY AND MEMORY PERFORMANCE

- **Creativity positively correlated with overall performance in both tasks (a)**
  - SI task: R = .26, BF_{10} **= 2.5;** DR task: R = .38**,** BF_{10} **= 28**
- **No evidence for relationship with the consolidation effect on accuracy (b)**
  - Consolidation effect = Before condition - Simultaneous condition
  - SI task: R = .26, BF_{10} **= 2.5,** DR task: R = .15, BF_{10} **= .6**



TRAIT-LEVEL CREATIVITY AND MEMORY PERFORMANCE

- **Evidence for a positive relationship between creativity and consolidation effect on confidence**
  - DR task: R = .39, BF_{10} = *40*

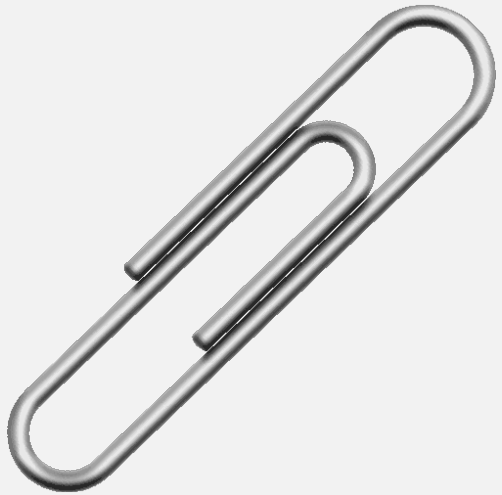


TRAIT-LEVEL CREATIVITY AND MEMORY PERFORMANCE

- Creativity & memory **accuracy**
  - Creativity benefit for general memory performance
  - General difference in task engagement
- Creativity & memory **confidence**
  - Unlikely to reflect a difference in task engagement
  - Potentially demonstrates creativity effect on processes underlying recognition memory

STATE-LEVEL CREATIVITY AND MEMORY PERFORMANCE

- *N* = 126 online undergraduate participants
- Experimental Procedure
  - Same general procedure as previous experiment
  - Problem-solving task:
    - **Math condition:** 60 simple arithmetic problems (e.g., 3 + 4 = ?)
    - **Creative condition:** Alternate Uses test, instructed to generate as many possible uses for a common household items (e.g., a paperclip) for 3 minutes, 5 items total

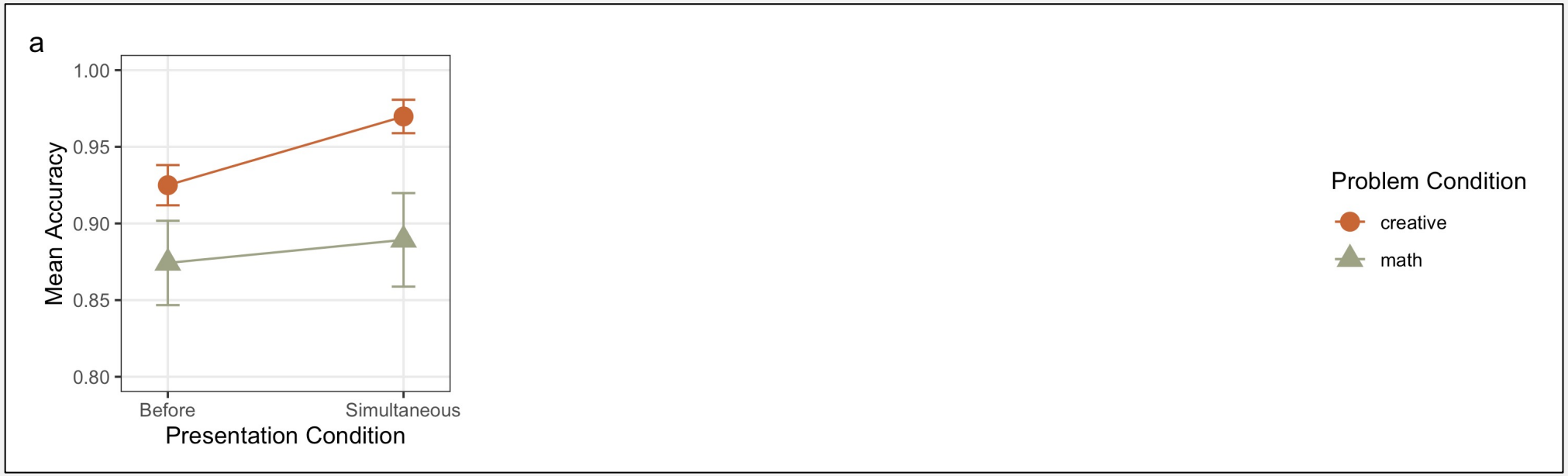


Possible uses for a paperclip

- Keep papers together
- Clean computer keyboard
- Hang Christmas ornaments
- Hold flowers together
- Keep a bag closed
- Mark place in book
- Use to make holes
- Wear as earrings
- …

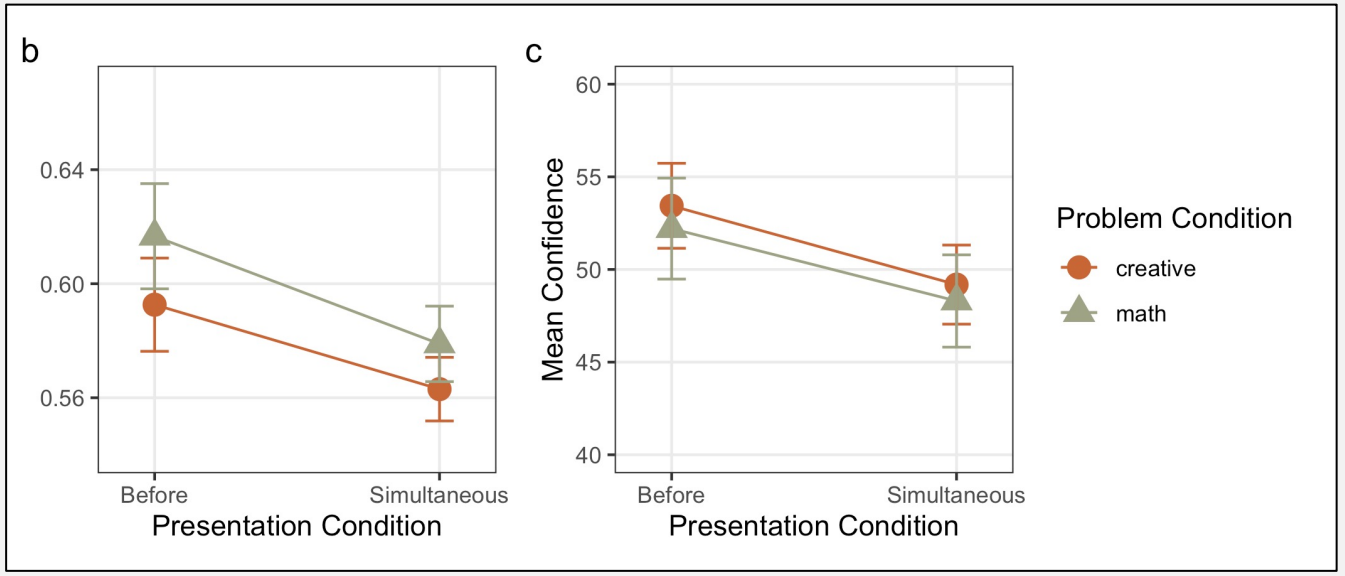
STATE-LEVEL CREATIVITY AND MEMORY PERFORMANCE

- **High performance in both conditions in stimulus identification, no evidence for interaction effect (a)**
  - Creative Before: .93, Creative Simultaneous: .97, Math Before: .87, Math Simultaneous: .89, $BF_{10} = .8$
- **Consolidation effect in both conditions for memory accuracy in delayed recognition, no evidence for interaction effect (b)**
  - Creative Before: .59, Creative Simultaneous: .56, Math Before: .62, Math Simultaneous: .58, $BF_{10} = .2$
- **Consolidation effect in both conditions for memory confidence in delayed recognition, no evidence for interaction effect (c)**
  - Creative Before: 53, Creative Simultaneous: 49, Math Before: 52, Math Simultaneous: 48, $BF_{10} = .2$



STATE-LEVEL CREATIVITY AND MEMORY PERFORMANCE

- No evidence to suggest that inducing a creative state can improve working memory consolidation effect on long-term memory accuracy or confidence
- However, even though participants in Creative condition were generally less accurate in the delayed recognition task compared to participants in Math condition, they were similarly confident in their memory



DOES CREATIVITY INFLUENCE CONSOLIDATION EFFECTS?

- Question 2: What processes underlie the potential relationship between working memory and long-term memory? **TBD but probably not creativity or forming novel associations**
- Question 3: Can this ability be improved? **Not really, although maybe we can affect memory confidence**

OPEN QUESTIONS, FUTURE DIRECTIONS

- How are working memory consolidation and long-term consolidation related?
  - Maybe there is a single shared consolidation process
  - Trying to do a multi-day study but recruitment is slow
- What other factors may affect the relationship between working memory consolidation and long-term memory?
  - Differences across clinical groups (schizophrenia, MS, aging)
  - Effects of stress
- What about memory confidence and creativity?

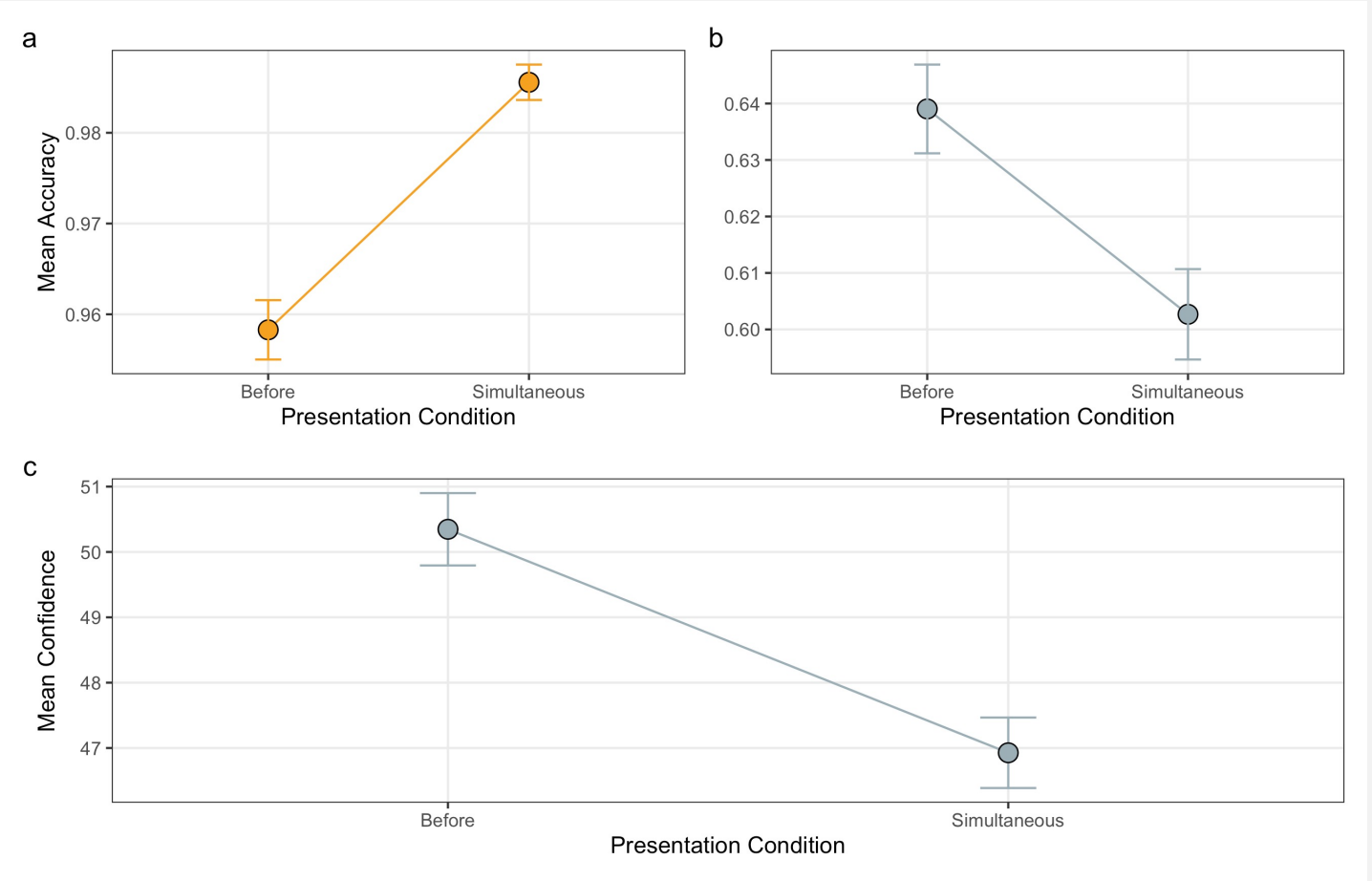
THANK YOU!

Kelly Cotton

Questions? kcotton@gradcenter.cuny.edu

EXTRA STUFF

- Creativity Exp 1 results
- SI Accuracy (A)
  - Before = .96
  - Simultaneous = .99
  - BF_{10} = 1972
- DR Accuracy (B)
  - Before = .64
  - Simultaneous = .60
  - BF_{10} = 3.6
- DR Confidence (C)
  - Before = 50
  - Simultaneous = 47
  - BF_{10} = 23

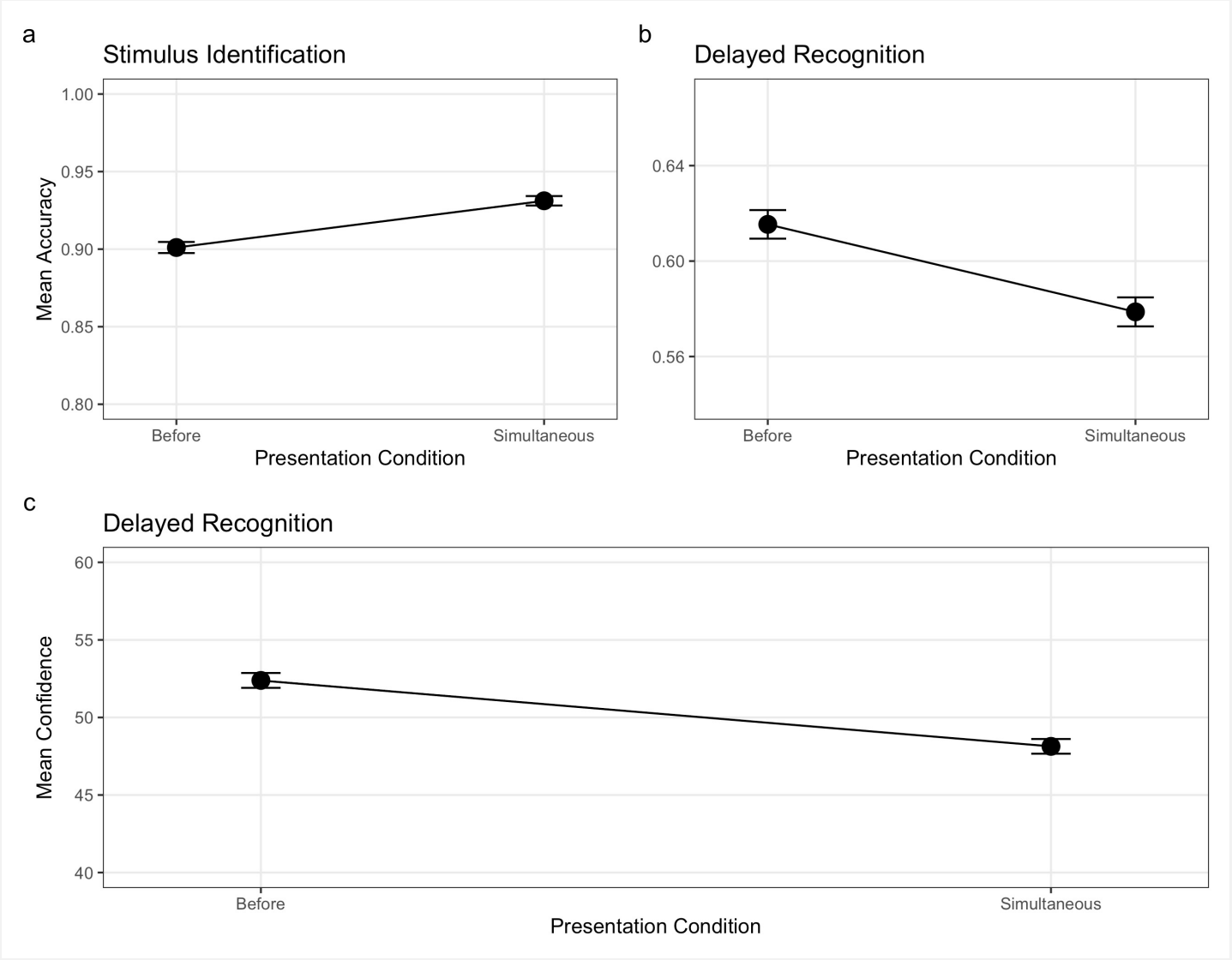


EXTRA STUFF

Measure ~ Creativity Score	R	R BF_{10}	R^2	R^2 BF_{10}
SI Mean Accuracy	0.26	2.5	0.07	2
DR Mean Accuracy	0.38	28.3	0.14	21.2
DR Mean Confidence	0.13	0.5	0.02	0.4
SI Accuracy Difference	0.26	2.5	0.07	2
DR Accuracy Difference	0.15	0.6	0.02	0.5
DR Confidence Difference	0.39	40.4	0.15	30

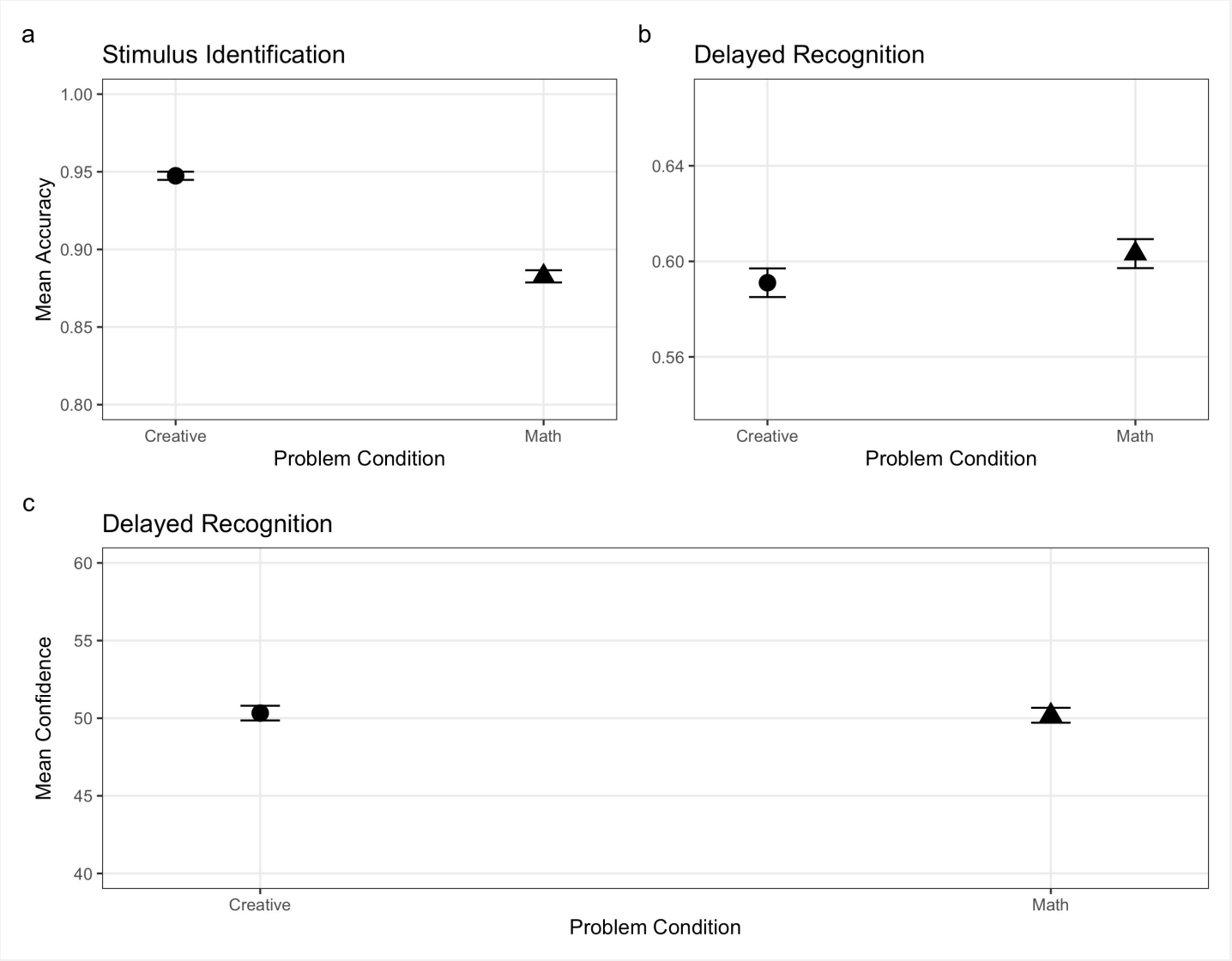
EXTRA STUFF

- Creativity Exp 2 results
- SI Accuracy (A)
  - Before = .90
  - Simultaneous = .93
  - BF_{10} = 32
- DR Accuracy (B)
  - Before = .60
  - Simultaneous = .57
  - BF_{10} = 42
- DR Confidence (C)
  - Before = 53
  - Simultaneous = 49
  - BF_{10} = 29010



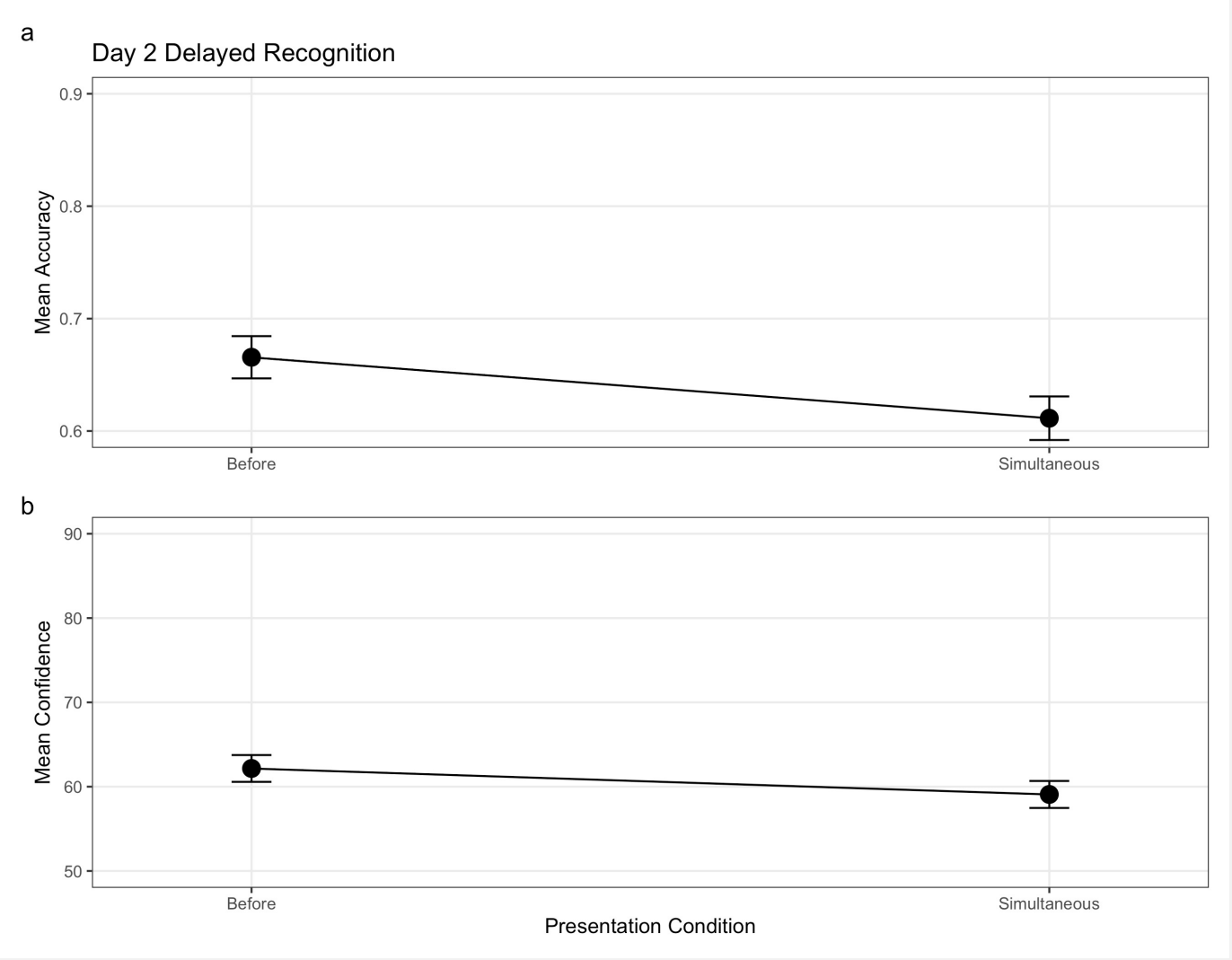
EXTRA STUFF

- Creativity Exp 2 results
- SI Accuracy (A)
  - Creative = .95
  - Math = .88
  - BF_{10} = 2.8 x 10^{39}
- DR Accuracy (B)
  - Creative = .59
  - Math = .60
  - BF_{10} = .05
- DR Confidence (C)
  - Creative = 50
  - Math = 50
  - BF_{10} = .02



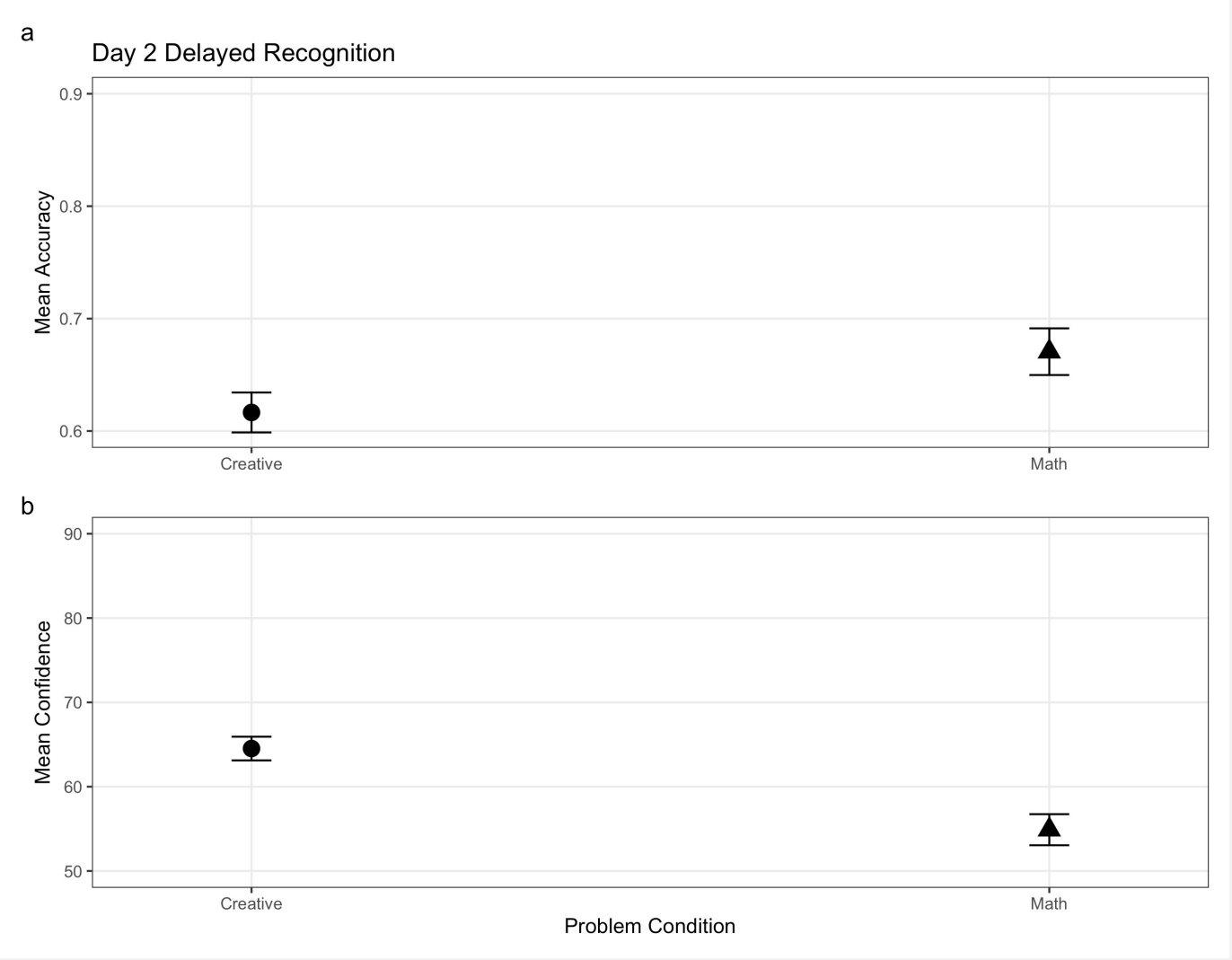
EXTRA STUFF

- Creativity Exp 2 Day 2 results
- *N* = 12
- DR Accuracy
  - Before = .67
  - Simultaneous = .61
  - BF_{10} = .46
- DR Confidence
  - Before = 62
  - Simultaneous = 59
  - BF_{10} = .16



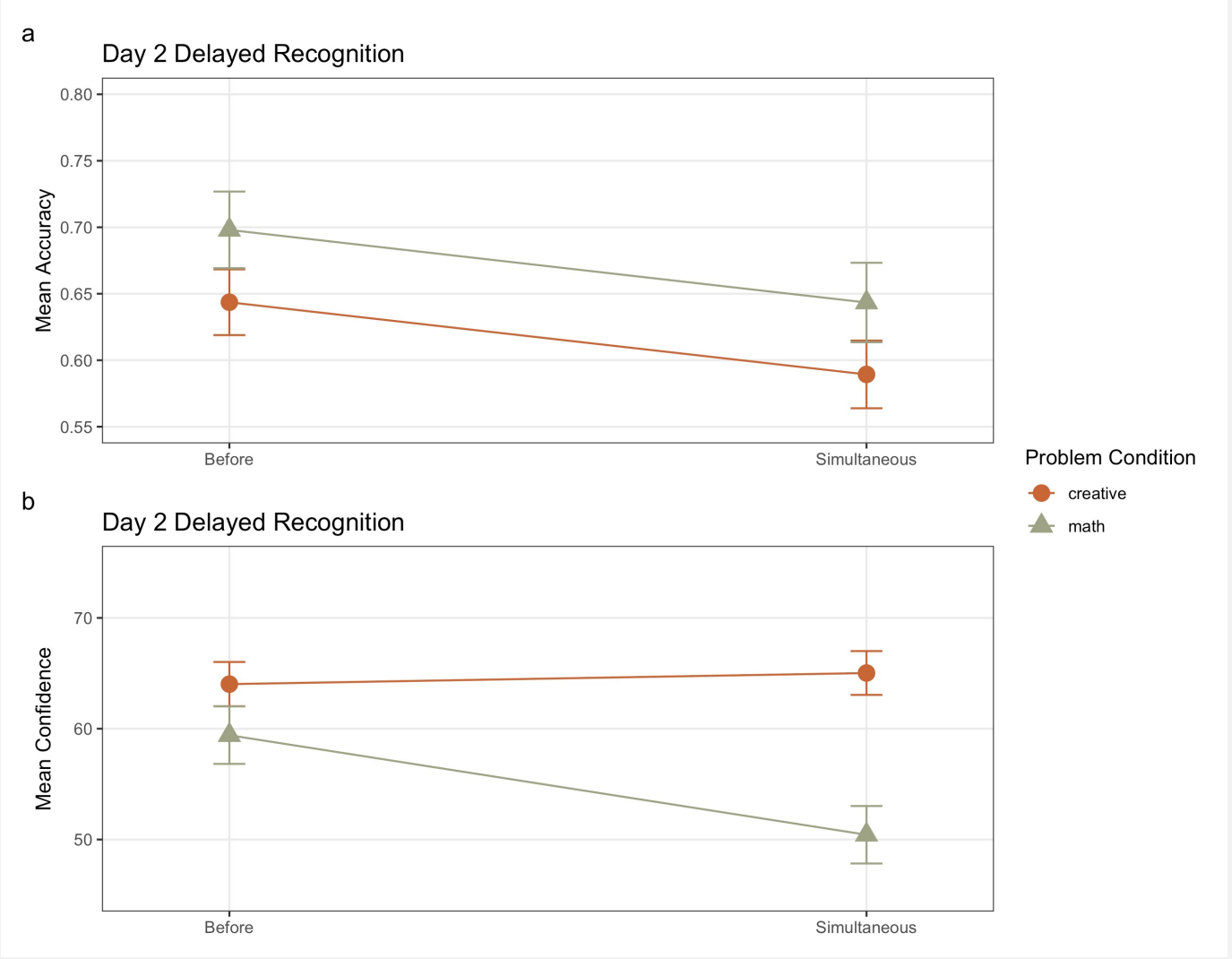
EXTRA STUFF

- Creativity Exp 2 Day 2 results
- *N* = 12
- DR Accuracy
  - Creative = .62
  - Math = .67
  - BF_{10} = .43
- DR Confidence
  - Creative = 65
  - Math = 55
  - BF_{10} = 398



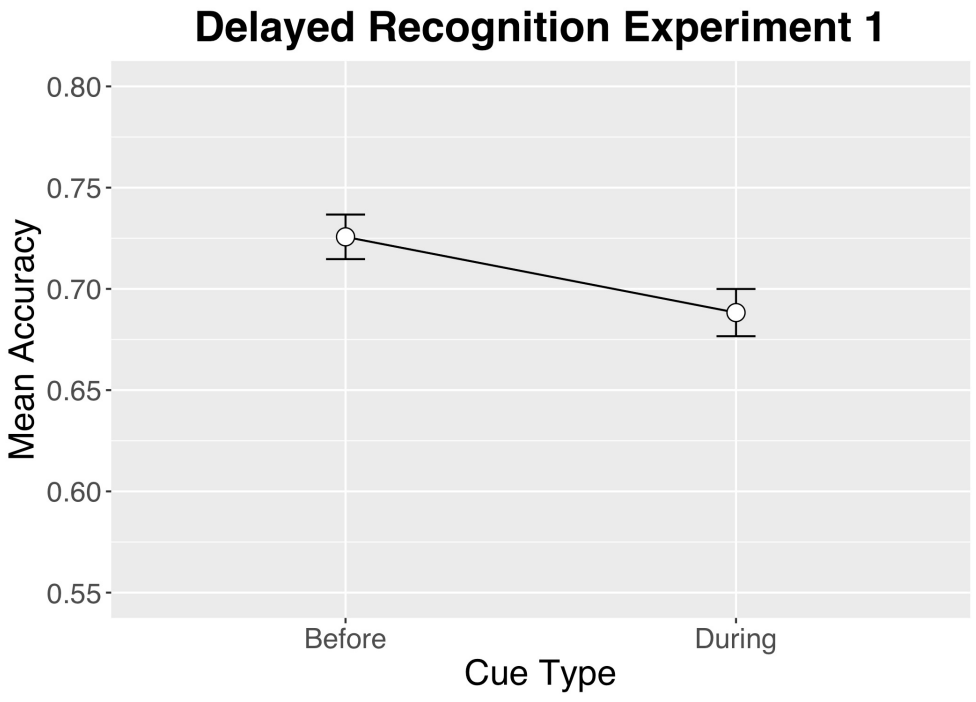
EXTRA STUFF

- Creativity Exp 2 Day 2 results
- *N* = 12
- DR Accuracy
  - Creative Before = .64
  - Creative Simultaneous = .59
  - Math Before = .70
  - Math Simultaneous = .64
  - BF_{10} = .09
- DR Confidence
  - Creative Before = 64
  - Creative Simultaneous = 65
  - Math Before = 59
  - Math Simultaneous = 51
  - BF_{10} = 1.2



EXTRA STUFF

- Full results from Cotton and Ricker (2020)



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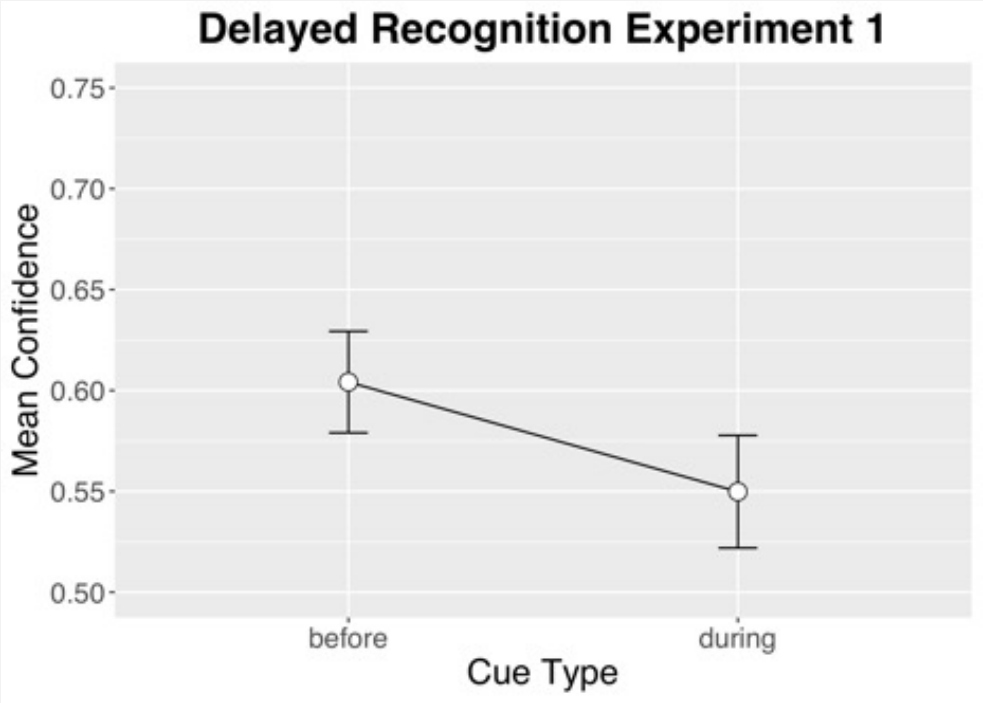

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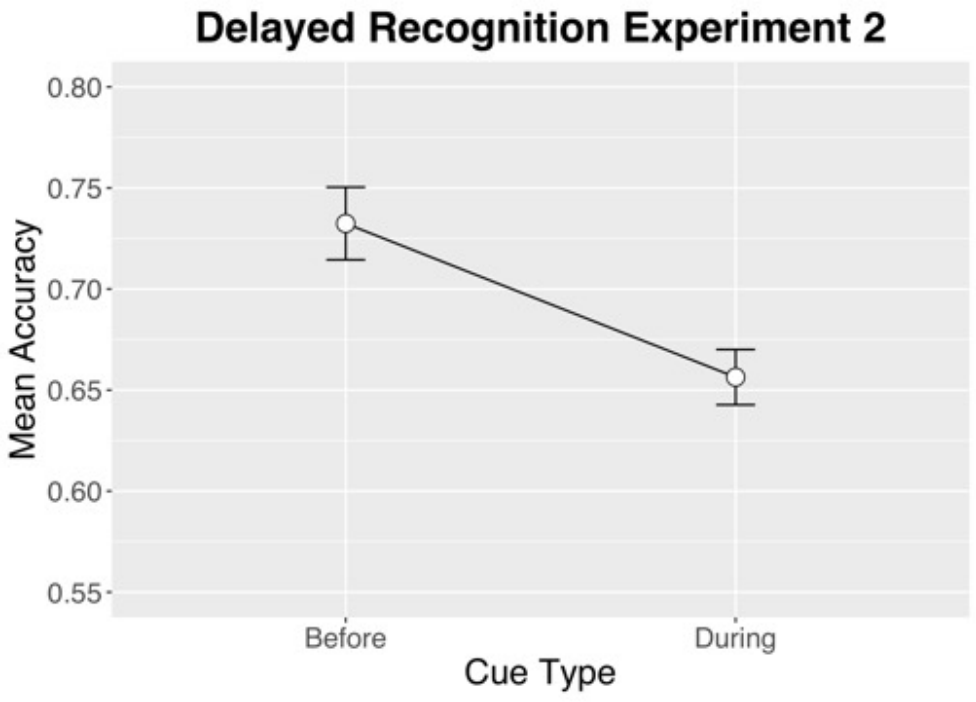

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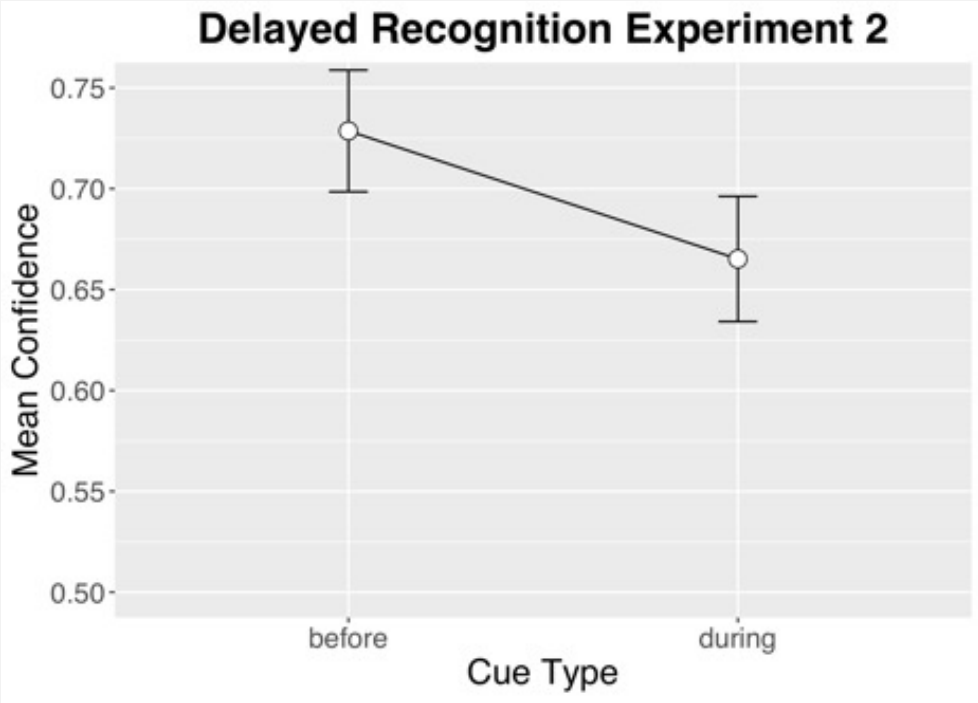

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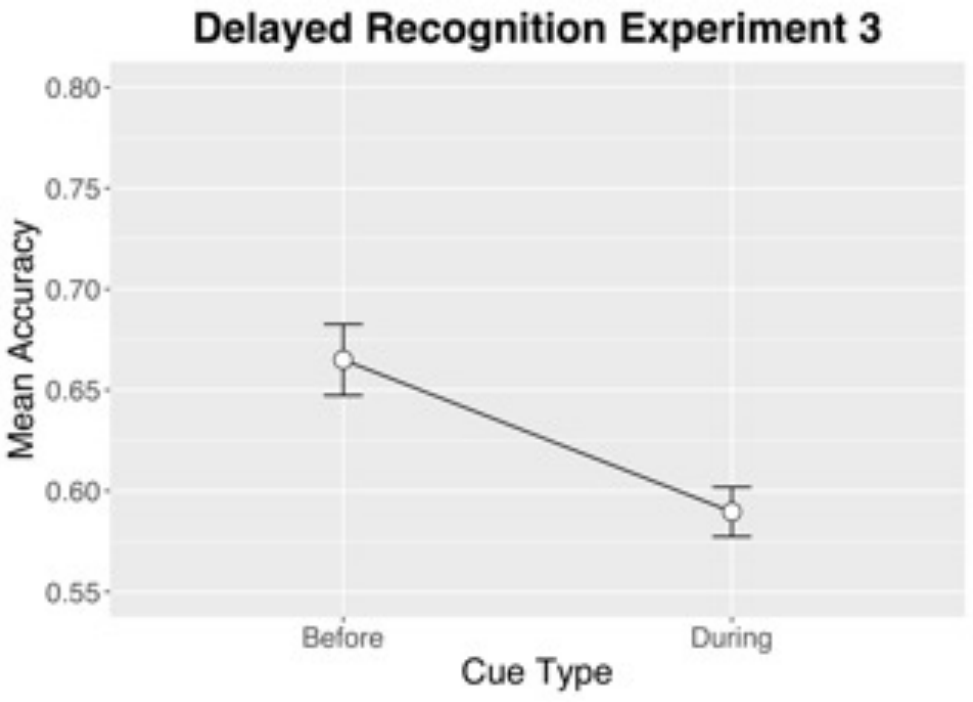

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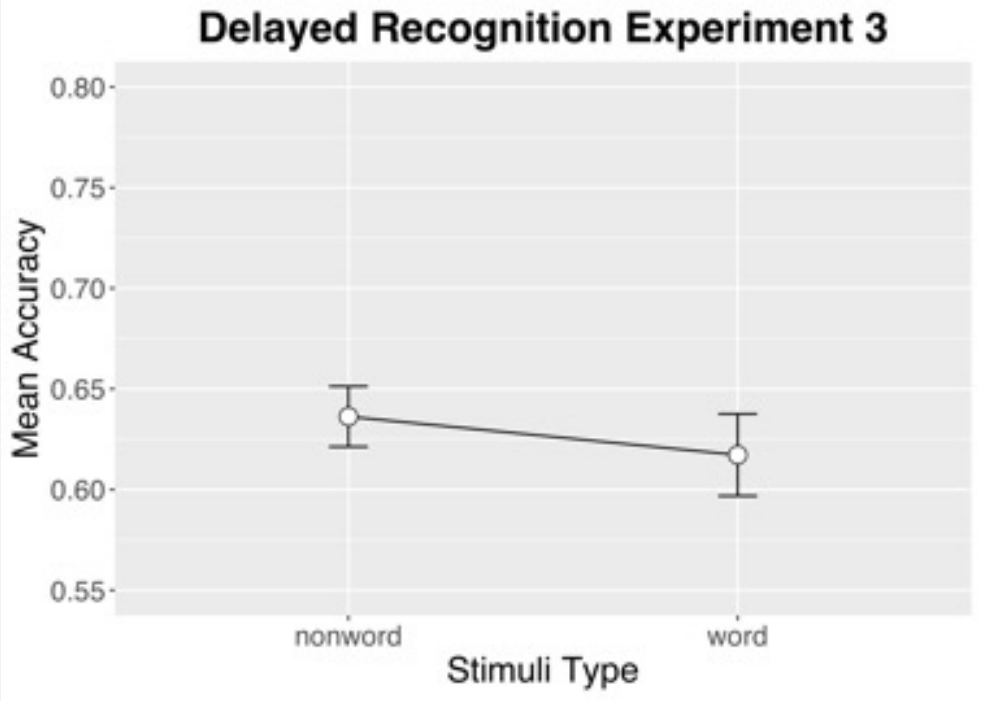

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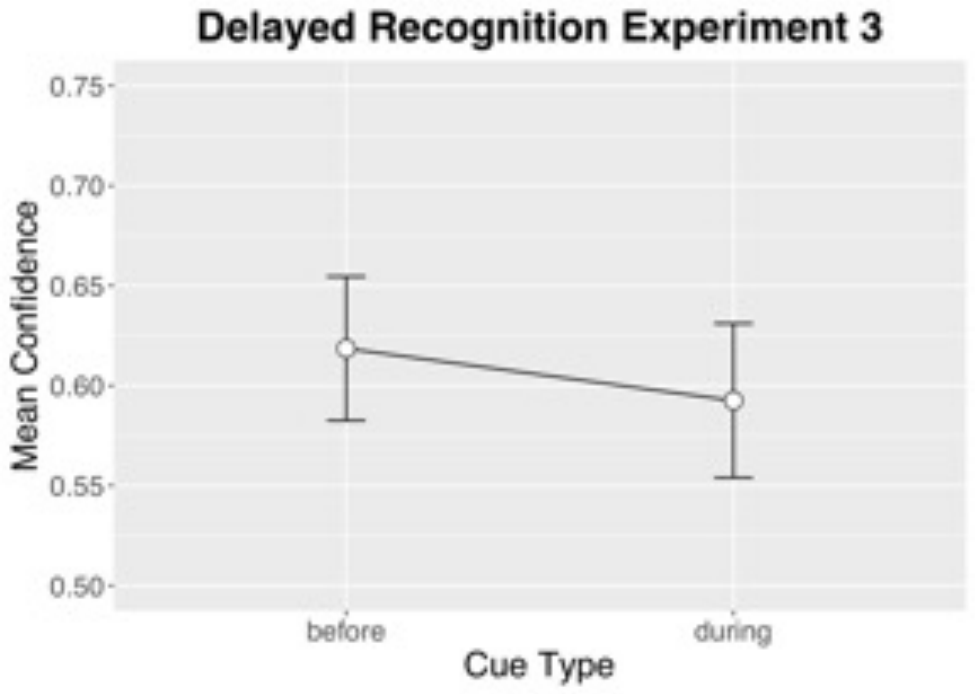

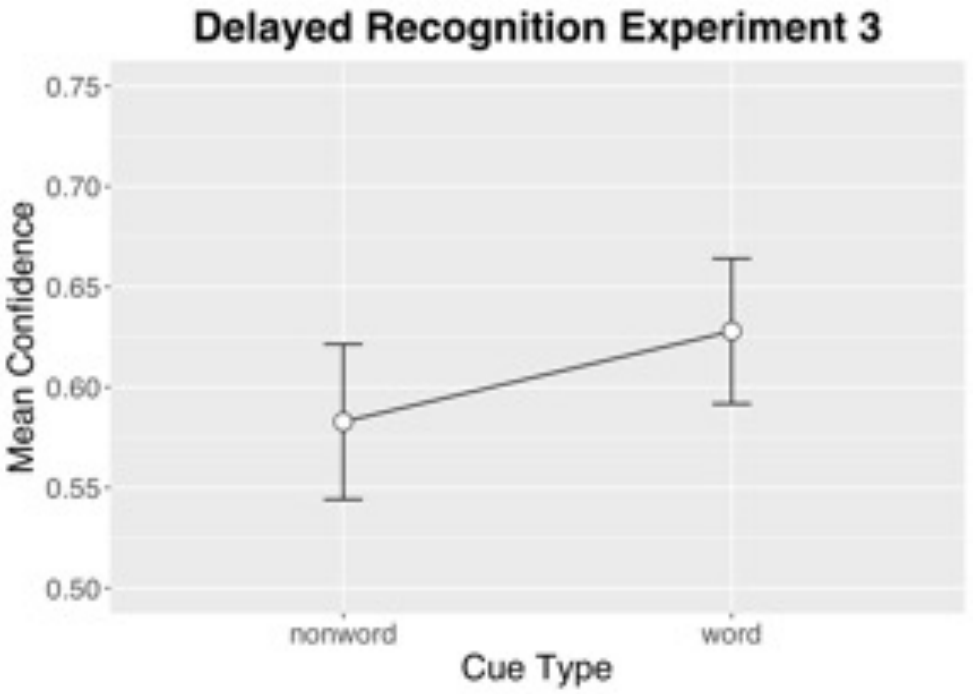

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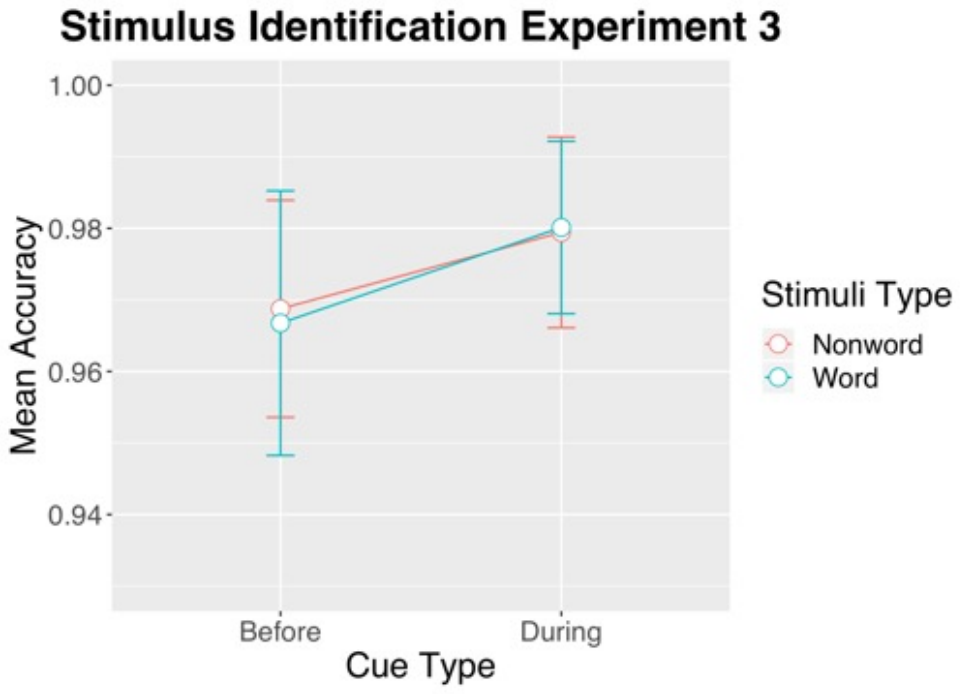

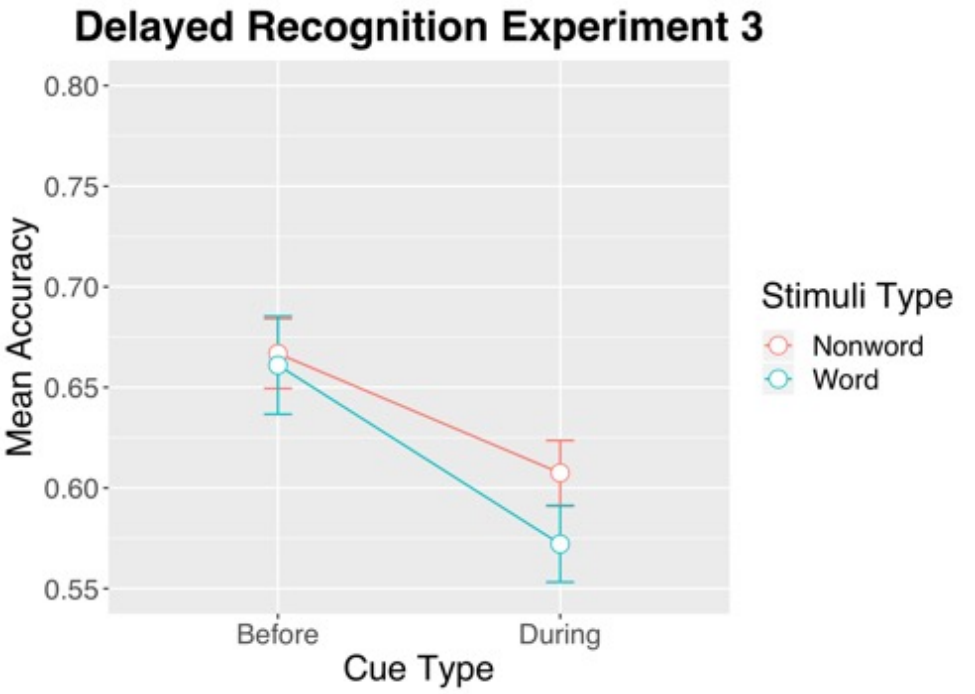

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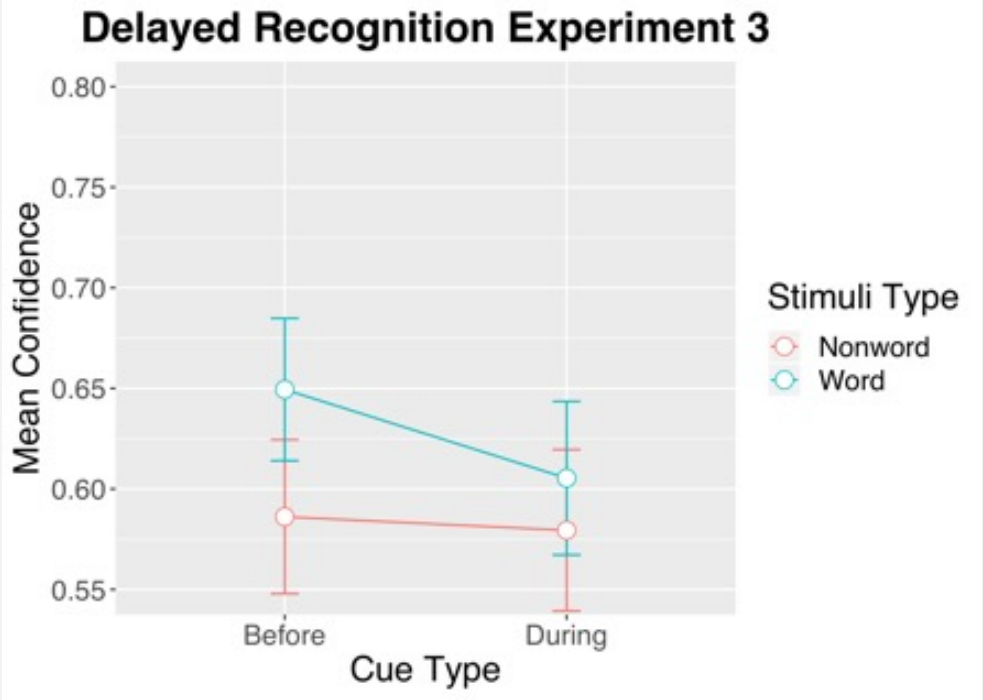

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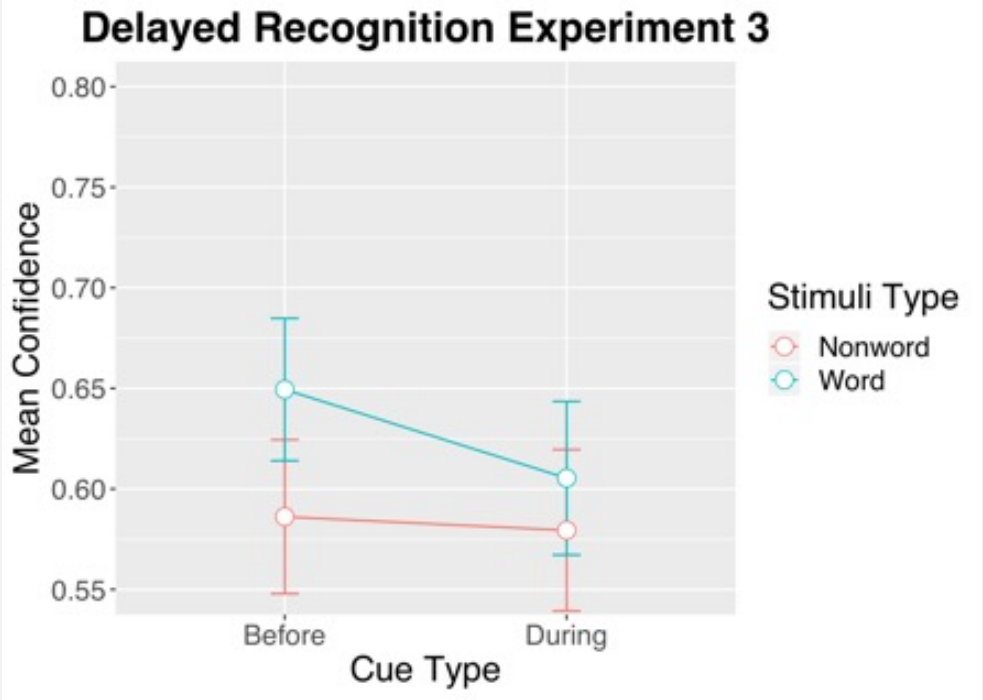
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