The effect of working memory on testing effect: interaction between capacity and demands

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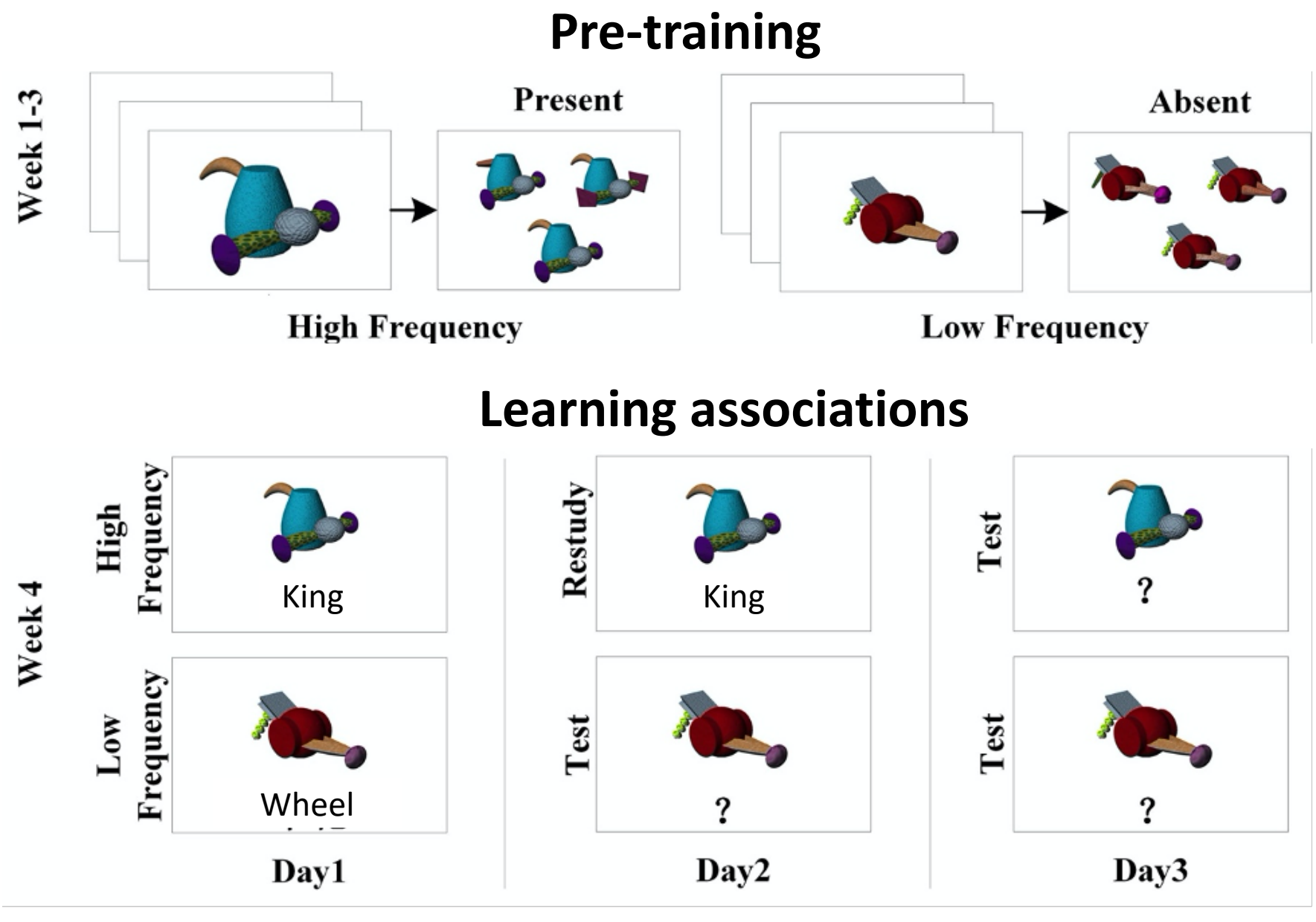
Introduction

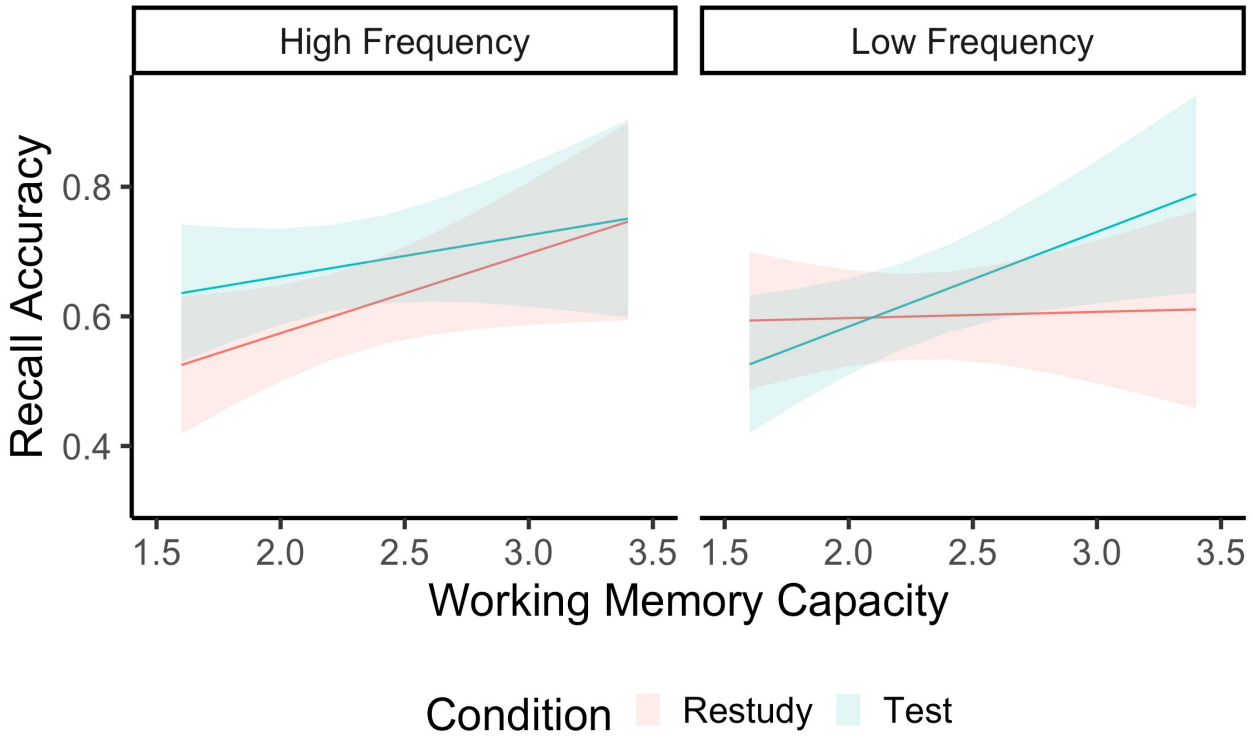
- Testing effect: learned through **testing** outperforms that through additional **study**
- Existing evidence showed inconsistent results regarding the role of working memory capacity (WMC) in the testing benefits (Chan, 2009; Brewer & Unsworth, 2012; Agarwal et al., 2017)
- **Hypothesis: the influence of WMC on the testing effect is modulated by working memory demand (WMD)**
  - WMD can be manipulated by item familiarity. Higher familiarity -> lower WMD, vice versa (Reder et al., 2016; Popov & Reder, 2020)

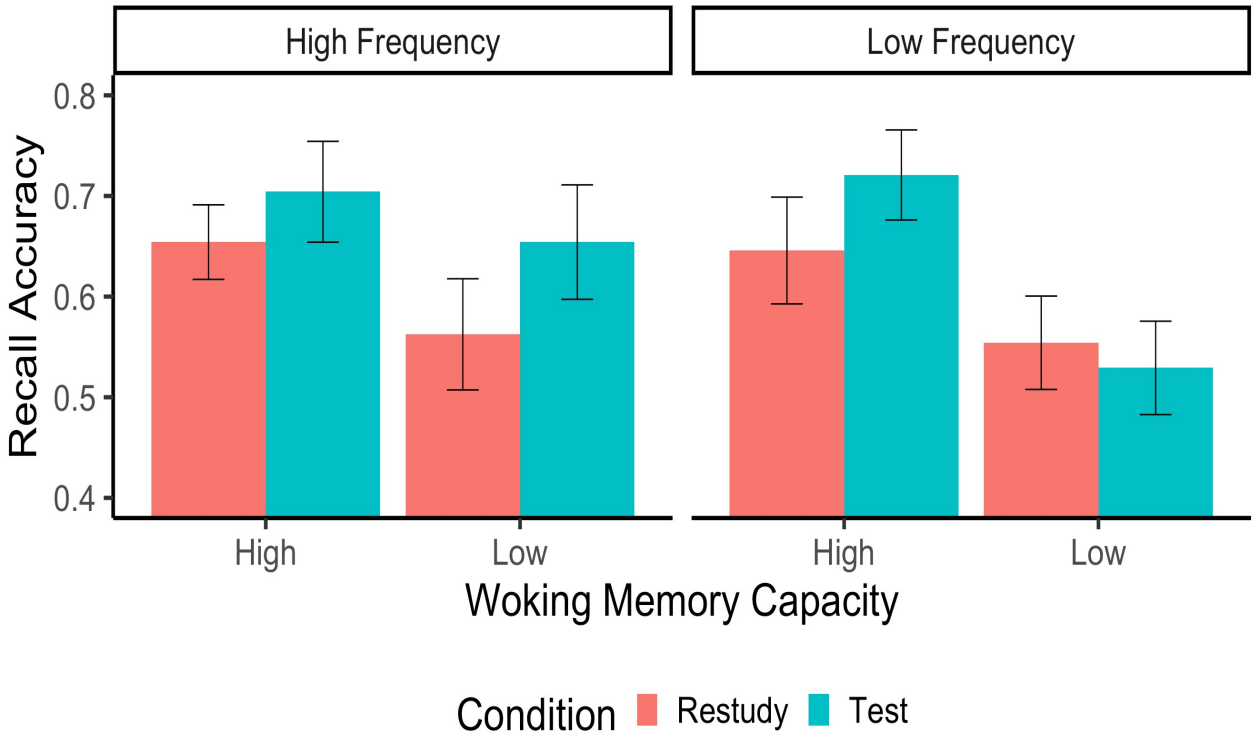
Procedure



- Week 1-3:
  - Frequency of novel objects (Fribble by Barry et al., 2014) in pre-training HF:LF = 15:1
  - 3 one-hour sessions per week × 3 weeks training
  - After the 3rd, 6th and 9th sessions, N-back tests on HF & LF stimuli
- Week 4:
  - Day1: Study Fribble-word pairs to the same criteria - correctly recalling twice in a row
  - Day2: Restudy or test half of the pairs
  - Day3: Final test on all pairs

Experiment Results – Final Test Performance

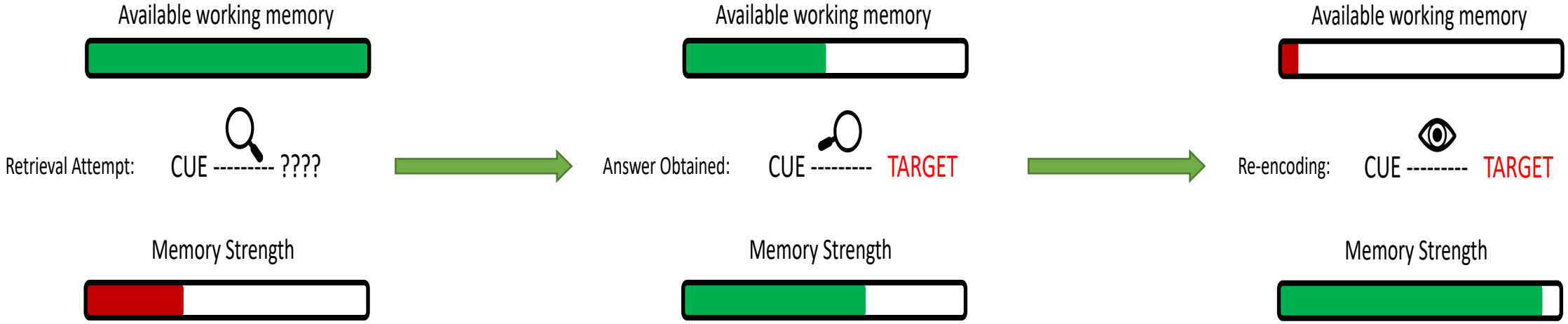




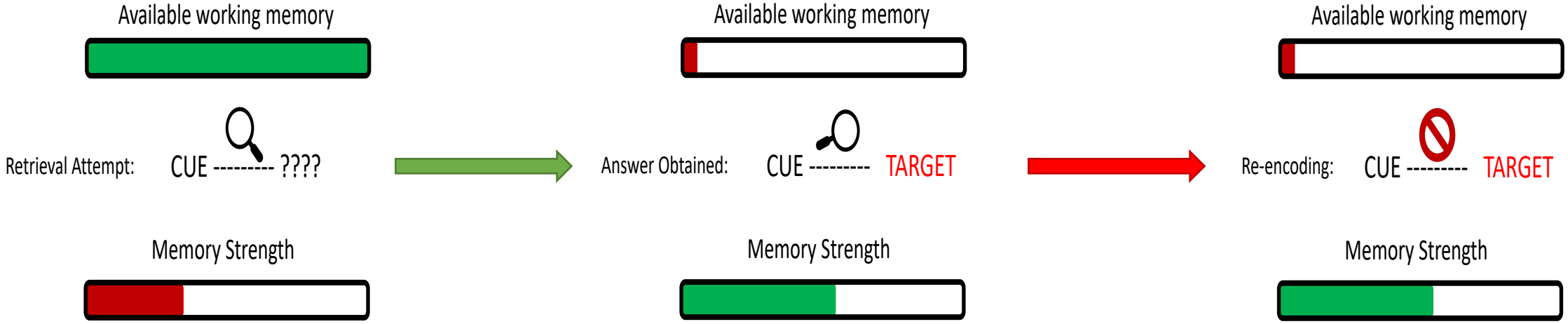
Modeling

- Source of Activation Confusion (SAC) model (Reder et al, 2007; Popov & Reder, 2020)
  - Memory is represented as a set of nodes in an associative network
  - Nodes vary in strength: strength increases through practice and decays with time (e.g., **familiar nodes have higher strength than unfamiliar nodes**)
  - The formation of new associations between nodes depletes a limited pool of working memory (WM) resources: **stronger nodes require less WM to encode and bind.**
- SAC was adapted to account for the testing effect:
  - Two processes (retrieval attempt & re-encoding) are involved in retrieval (Liu & Reder, 2016; Liu et al., 2018).
  - Both processes consume WM and strengthen memory
  - Stronger nodes require less WM to **retrieval.**

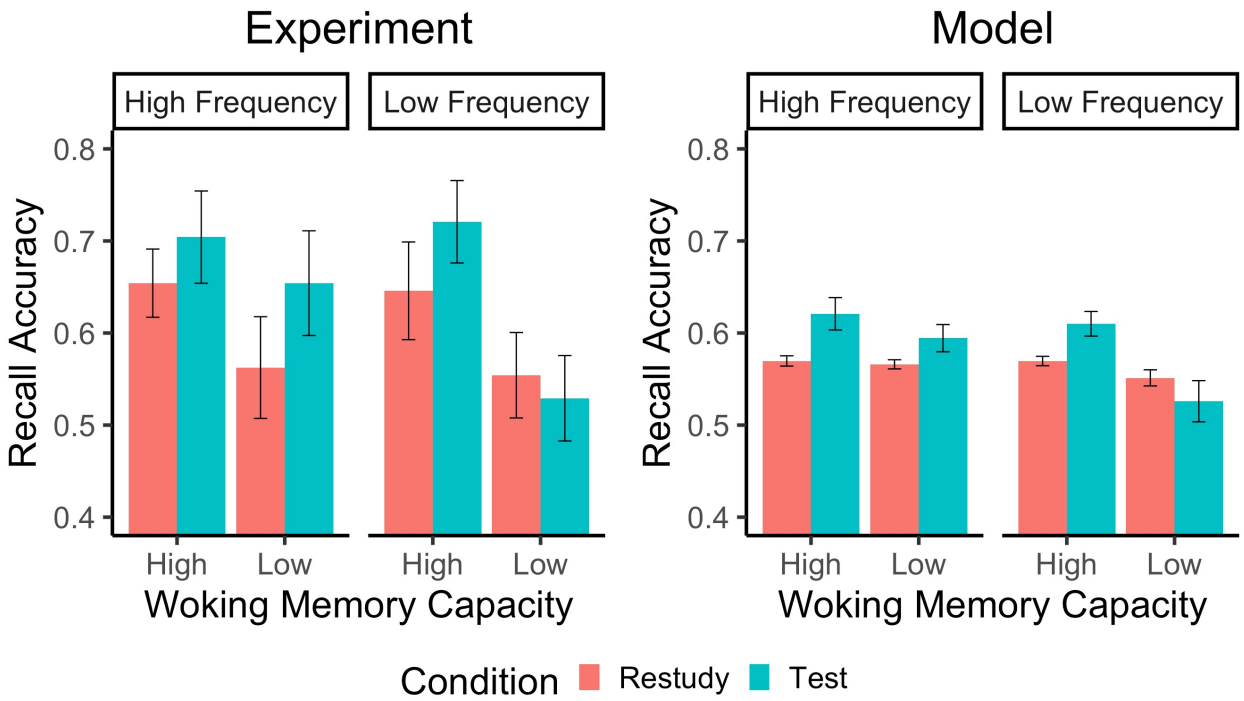
When WM is adequate

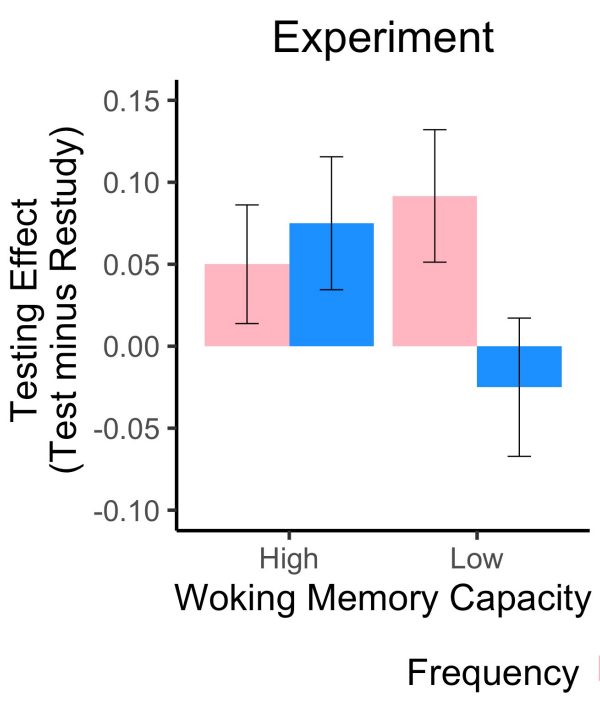


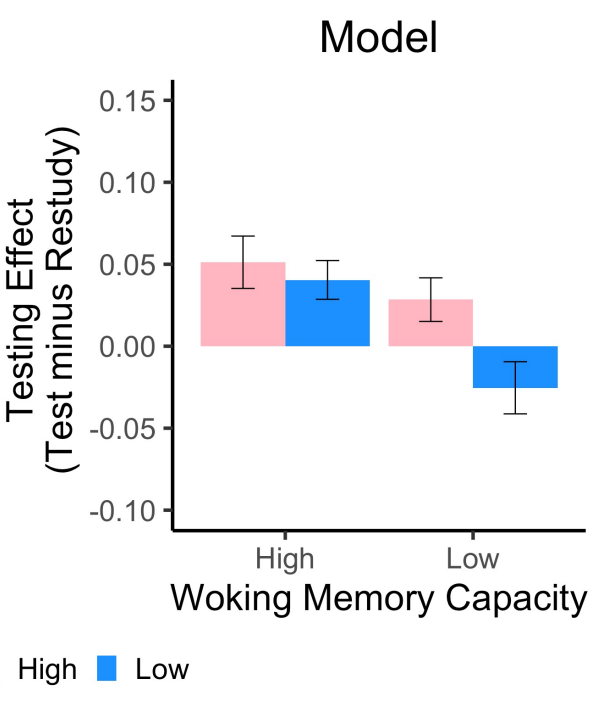
When WM is limited



Modeling Results







Conclusion

- The testing effect only emerges when WM resources are adequate
- The current results support a dual-process working memory dependent model of the testing effect.

Citations

- Chan, J. C. (2009). When does retrieval induce forgetting and when does it induce facilitation? Implications for retrieval inhibition, testing effect, and text processing. *Journal of Memory and Language*, *61*(2), 153-170.

- Brewer, G. A., & Unsworth, N. (2012). Individual differences in the effects of retrieval from long-term memory. *Journal of Memory and Language*, *66*(3), 407-415.

- Agarwal, P. K., Finley, J. R., Rose, N. S., & Roediger III, H. L. (2017). Benefits from retrieval practice are greater for students with lower working memory capacity. *Memory*, *25*(6), 764-771.

- Reder, L. M., Liu, X. L., Keinath, A., & Popov, V. (2016). Building knowledge requires bricks, not sand: The critical role of familiar constituents in learning. *Psychonomic bulletin & review*, *23*(1), 271-277.

- Popov, V., & Reder, L. M. (2020). Frequency effects on memory: A resource-limited theory. *Psychological review*, *127*(1), 1.

- Barry, T. J., Griffith, J. W., De Rossi, S., & Hermans, D. (2014). Meet the Fribbles: novel stimuli for use within behavioural research. *Frontiers in Psychology*, *5*, 103.