

A Matter of Memory?

Age-Invariant Relative Clause Disambiguation and Memory Interference

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Introduction

- Language, Aging, Memory



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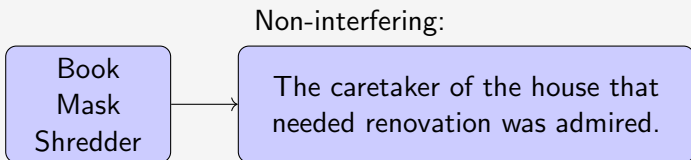
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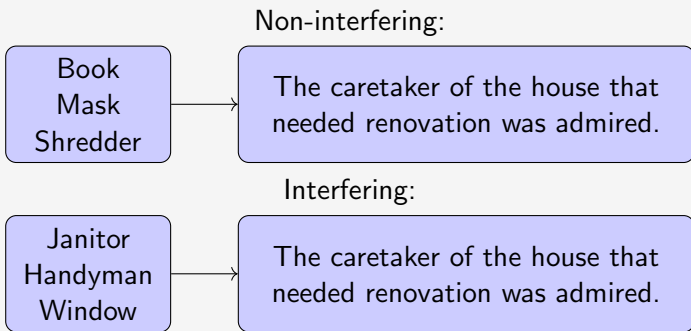
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 - Fundamental to linguistic behaviour!

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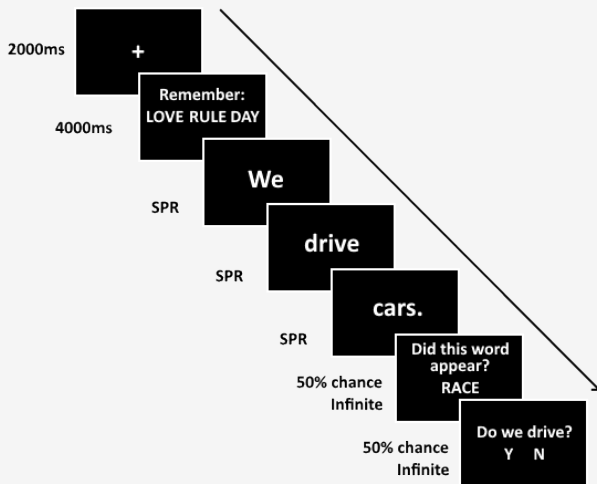
(Non-matching)

OHNQPNS

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(Matching)

Procedure



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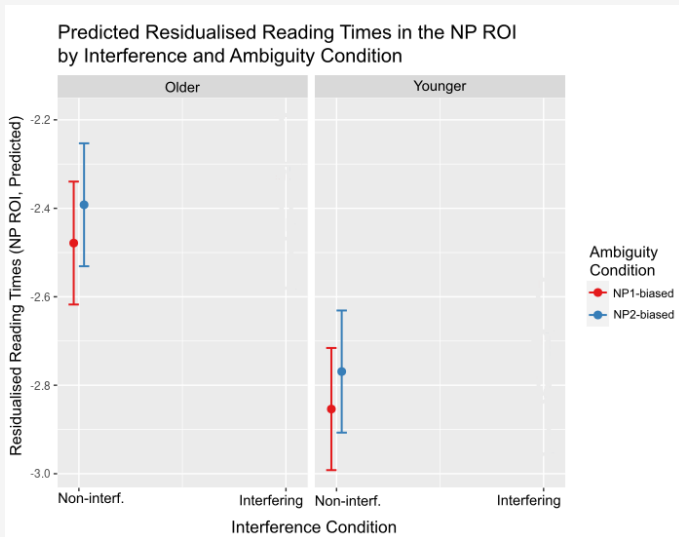
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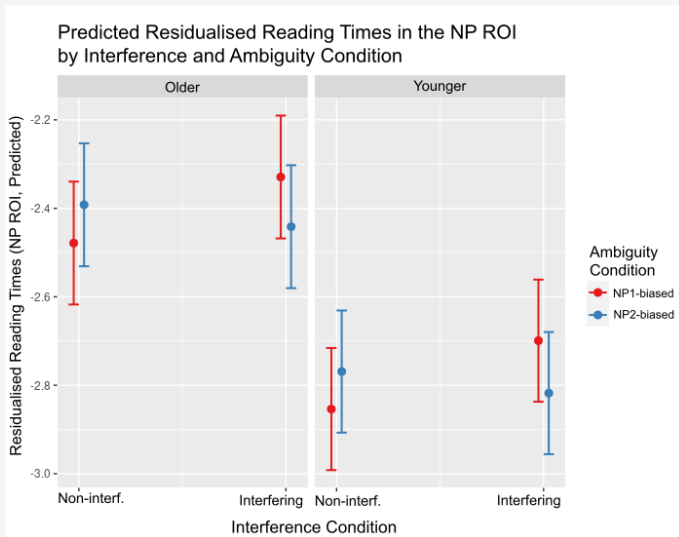
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- 3 Older adults might show different attachment preferences.

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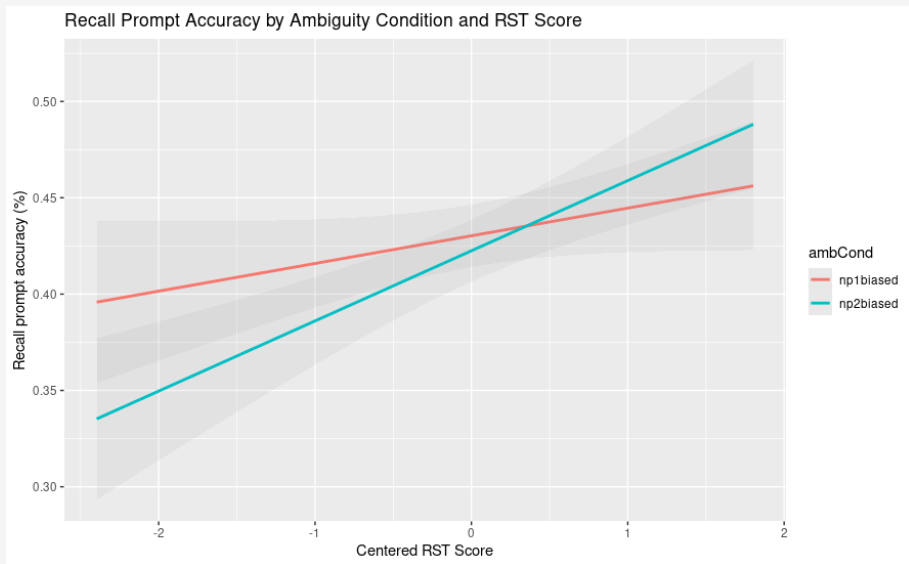
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 - How about those recall prompts?

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- No evidence for declining language processing with age;
- No WM / PS role in *implicit* language processing;
- Interaction of syntax / memory / semantic abilities is key.

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 - Tailoring interference to either NP;
- Integrate with linguistic prediction.

Thank you for your attention!

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References

- Chang, F., Janciauskas, M., & Fitz, H. (2012). Language adaptation and learning: Getting explicit about implicit learning. *Language and Linguistics Compass*, 6(5), 259-278.
- Felser, C., Marinis, T., & Clahsen, H. (2003). Children's Processing of Ambiguous Sentences: A Study of Relative Clause Attachment. *Language Acquisition*, 11(3):127-163.
- Fu, L., Wang, Y., & He, L. (2020). Factors Associated with Healthy Ageing, Healthy Status and Community Nursing Needs among the Rural Elderly in an Empty Nest Family: Results from the China Health and Retirement Longitudinal Study. *Healthcare*, 8(3) p. 317.
- Gordon, P. C., Hendrick, R., & Levine, W. H. (2002). Memory-load Interference in Syntactic Processing. *Psychological Science*, 13(5):425-430.
- Hardy, S. M., Messenger, K., & Maylor, E. A. (2017). Aging and syntactic representations: Evidence of preserved syntactic priming and lexical boost. *Psychology and Aging*, 32(6), 588.
- Hardy, S. M., Segaert, K., & Wheeldon, L. (2020). Healthy aging and sentence production: Disrupted lexical access in the context of intact syntactic planning. *Frontiers in Psychology*, 11, 257.
- Howard Jr, J. H., & Howard, D. V. (2013). Aging mind and brain: is implicit learning spared in healthy aging? *Frontiers in Psychology*, 4, 817.
- Keefover, R. W. (1998). Aging and cognition. *Neurologic clinics*, 16(3), 635-648.
- Mather, M. (2010). Aging and cognition. *Wiley Interdisciplinary Reviews: Cognitive Science*, 1(3), 346-362.
- Norman, S., Kemper, S., & Kynette, D. (1992). Adults' reading comprehension: Effects of syntactic complexity and working memory. *Journal of Gerontology*, 47(4), P258-P265.
- Payne, B. R., Grison, S., Gao, X., Christianson, K., Morrow, D. G., & Stine-Morrow, E. A. (2014). Aging and Individual Differences in Binding During Sentence Understanding: Evidence from Temporary and Global Syntactic Attachment Ambiguities. *Cognition*, 130(2):157-173.
- Peelle, J. E. (2019). Language and aging. *The Oxford handbook of neurolinguistics*, 295-216.

References (2)

- Poulisse, C., Wheeldon, L., & Segaert, K. (2019). Evidence against preserved syntactic comprehension in healthy aging. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 45(12), 2290.
- Ramscar, M., Hendrix, P., Shaoul, C., Milin, P., & Baayen, H. (2014). The myth of cognitive decline: Non-linear dynamics of lifelong learning. *Topics in Cognitive Science*, 6(1), 5-42.
- Rieckmann, A., & Bäckman, L. (2009). Implicit learning in aging: extant patterns and new directions. *Neuropsychology review*, 19(4), 490-503.
- Salthouse, T. A. (2004). What and when of cognitive aging. *Current directions in psychological science*, 13(4), 140-144.
- Schaie, K. W. (1989). The hazards of cognitive aging. *The Gerontologist*, 29(4), 484-493.
- Siegel, L. S. (1994). Working memory and reading: A life-span perspective. *International journal of behavioral development*, 17(1), 109-124.
- Van Dyke, J. A. & McElree, B. (2006). Retrieval Interference in Sentence Comprehension. *Journal of Memory and Language*, 55(2):157-166.
- Verhaeghen, P. (2003). Aging and vocabulary score: A meta-analysis. *Psychology and aging*, 18(2), 332.