Semantic relatedness ameliorates the age-related binding deficit in working memory and episodic memory

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Introduction

- Episodic memory (EM) and Semantic memory (SM) show divergent age trajectories: SM performance increases and EM decreases with age.
- According to the Associative Deficit Hypothesis (Naveh-Benjamin, 2000) the underlying factor of EM deficits in older age is the reduced ability to bind the details associated with the event into a cohesive unit (associative memory). However, memory for single units (item memory) is less impaired with age.
- Working memory (WM) is also constrained in older age. One view considers WM to be responsible for maintaining and updating the content-context bindings (Oberauer, 2005). Accordingly, WM binding deficits may correspond those in EM.
- Schematic support based on prior knowledge and experience has been shown to particularly benefit older adults' memory (Badham & Maylor, 2015). When older adults can rely on their superior SM, their associative memory performance can match that of younger adults (Castel, 2005).

- **The Goal: Examine the link between binding deficits in EM and WM.**
  - Can adapting the semantic relatedness between to-be-remembered items at encoding result in matched binding performance in both WM and EM between younger and older age groups?

Method

Table 1. Sample characteristics.

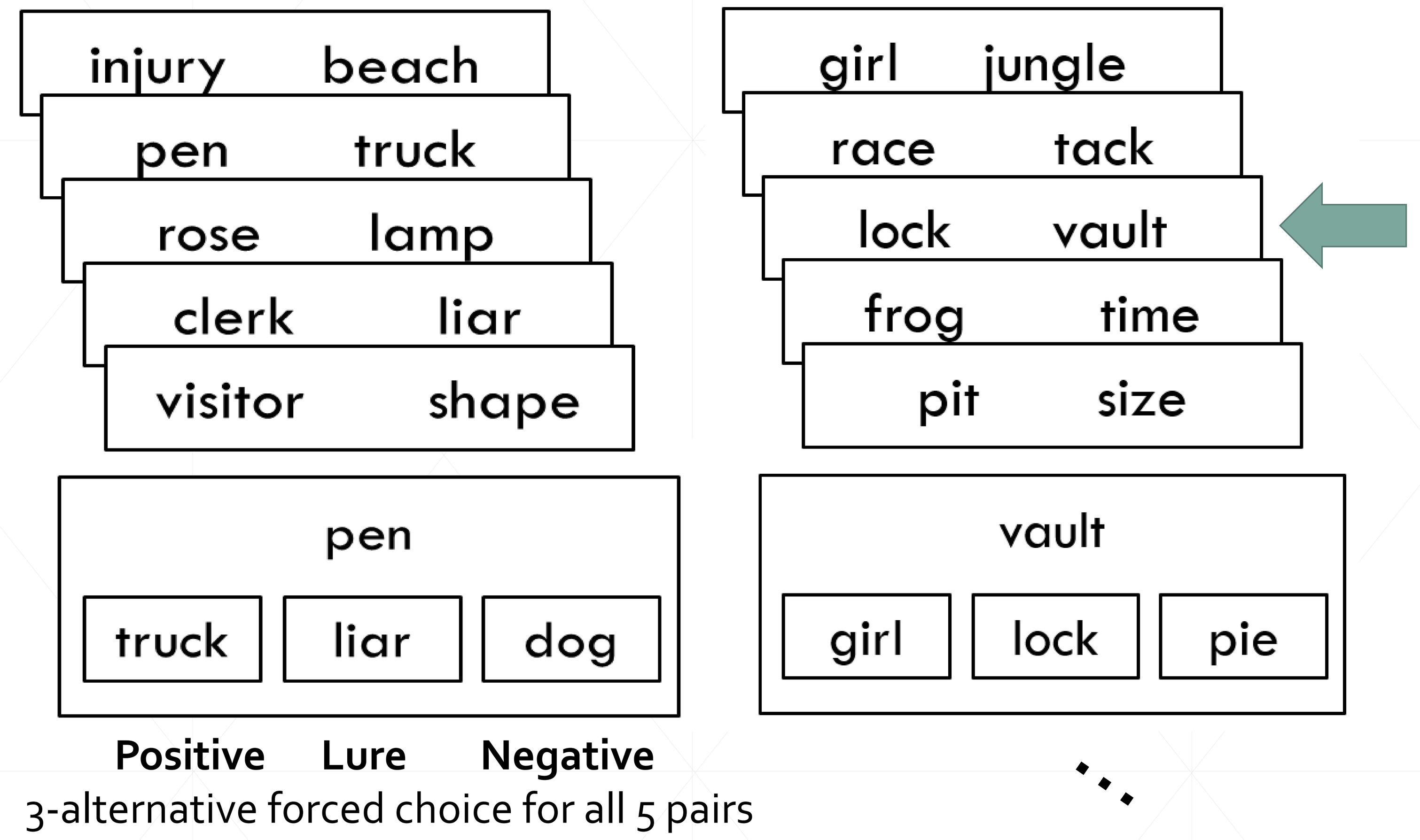
Measure	Younger adults	Older adults	Age Comparison
Age (years)	22.97 (4.69)	70.23 (4.76)	-
Sex (male/female)	12/18	12/18	BF_{10} = 0.31
MMSE	-	29.00 (1.04)	
Years of education	17.07 (2.63)	15.63 (3.20)	BF_{10} = 1.16
Shipley vocabulary (proportion correct)	0.77 (0.10)	0.93 (0.05)	BF_{10} = 2.88e+7
Number of medications	0.53 (0.90)	2.10 (2.32)	BF_{10} = 58
Rated current health (1 - 5, 1 = very good)	1.85 (0.90)	1.77 (0.68)	BF_{10} = 0.03
Rated general health (1 - 5, 1 = very good)	1.87 (0.82)	1.73 (0.64)	BF_{10} = 0.06
Rated restrictions of health (1 - 4, 1 = no restrictions)	1.30 (0.53)	1.67 (0.92)	BF_{10} = 0.12

Note. MMSE = mini mental status examination; BF = Bayes factor.

Materials and Procedure

- Five blocks of WM trials, each followed by a delayed EM test. For each block:
  - Five WM trials of five pairs of nouns | distracter | EM test of previous 25 WM pairs
- Two main scores: binding (strict; positive only) score and item (lenient; positive or lure) score
- Adaptive algorithm: aiming to achieve 70% accuracy in WM in both age groups
  - Ongoing accuracy of the previous 10 trials was calculated after each trial
  - A related pair (FSG = .02 - .04) was introduced or removed based on ongoing accuracy

Figure 1. Example WM trial sequence.



Adaptive algorithm based on ongoing accuracy:
If binding score < 60% (younger) or 67% (older), introduce a related pair
If exceeded, remove a related pair

Results

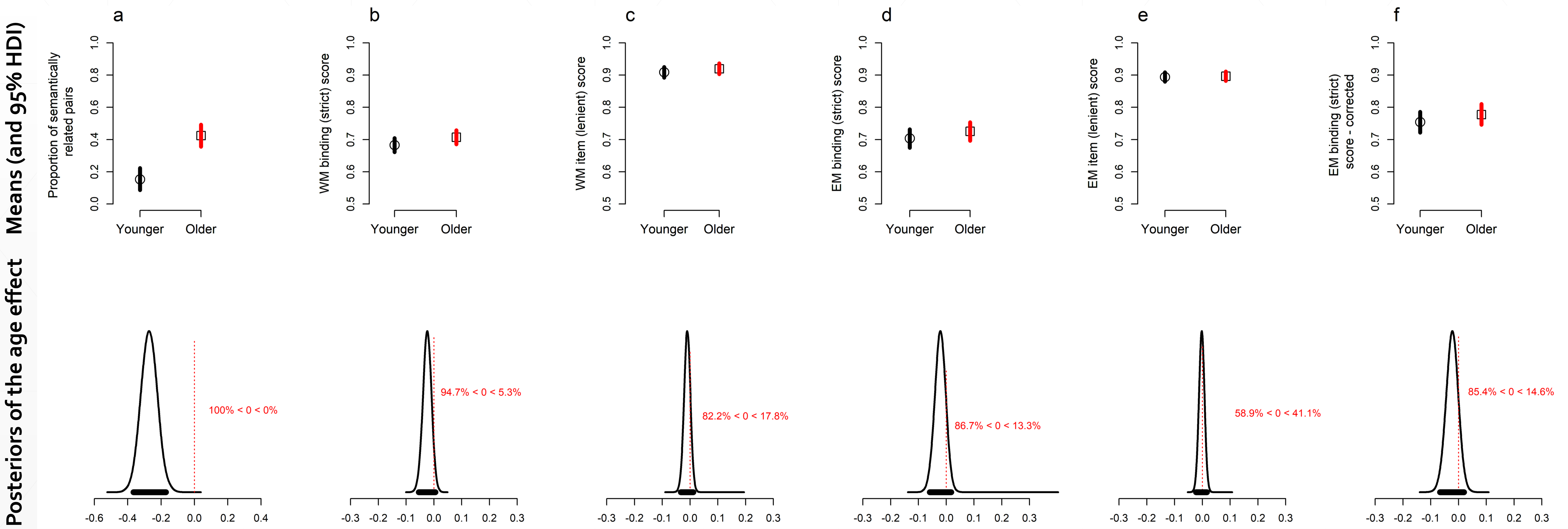


Figure 2. Mean performance (and 95% HDIs; top row) and posteriors of the age effects (bottom row) for each critical measure of the study. *Note*: For the posteriors (bottom row), the red dotted line at 0 indicates no age differences, and the percentages indicate how much the estimated effect's posterior distribution lies above/below 0. Values below 0 indicate greater performance in older adults, whereas values above 0 indicate greater performance for younger adults.

Younger and older adults were matched in their WM performance for both the binding (strict) score (BF_{10} = 0.99) and item (lenient) score (BF_{10} = 0.40). Importantly, the older adults required a greater proportion of the pairs to be semantically related to achieve similar performance to the younger adults (BF_{10} = 79,973).

Furthermore, younger and older adults retained their similar EM performance, both in terms of the binding (strict) score (BF_{10} = 0.49) and item (lenient) score (BF_{10} = 0.27). We also ensured the pattern was the same even when correcting for initial recall of the correct pairings in WM (BF_{10} = 0.46).

Discussion

- The results demonstrated matched binding and item memory performance in WM and EM between the younger and older age groups. Importantly, older adults required stronger semantic support (i.e., greater semantic relatedness) in order to achieve similar WM and EM performance to younger adults.
- The results are consistent with research indicating that the support provided by superior SM in older age can improve associative memory to the point of performing as well as younger adults (e.g., Castel, 2005).
- Introducing semantic support at encoding during WM trials benefits both WM and the later EM performance. This result indicates that binding deficits seen in WM are either a direct cause of EM binding deficits, or both processes are directly affected by a common cause, e.g., inefficient encoding in older age (Bartsch et al., under review).

- **Future research:** Examine the link between the binding deficits in WM and EM to answer the following: Do WM deficits cause EM deficits? Is the link unidirectional? Or is there a common binding impairment which affects encoding regardless of whether WM or EM is tested?

References

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