Individual differences in verbal working memory impacts prediction performance during sentence comprehension

Yu Lu, Simon Fischer-Baum, Randi Martin

Rice University, Houston, TX, USA

Introduction: Language comprehension is a rapid and efficient process, in part facilitated by our ability to quickly generate predictions about the upcoming content [1,2]. The current study took an individual differences approach with older adults to investigate the cognitive factors mediating predictive performance, focusing on the role of working memory (WM). Previous work has shown that semantic WM – the ability to temporarily maintain word meaning information - plays a greater role than phonological WM – the ability to temporarily maintain word sound information - in supporting sentence comprehension and production [3,4,5]. Therefore, we hypothesized that semantic WM, but not phonological WM, would relate to prediction performance.

Methods: The participants were 60 cognitive healthy individuals, native English speakers aged 50 or older. Prediction performance was assessed through a sentence completion task, where participants predicted the final word for auditorily presented sentences. The task included four types of sentences with increasing WM demands: (a) short, highly predictable sentences [6], "I could not remember his (name)." (b) preceding clause changing prediction, "I wanted to give him a phone call, but I could not remember his (number)." (c) irrelevant initial clause, "When I was at work yesterday, I wanted to give him a phone call, but I could not remember his (number)," (d) irrelevant intervening clause, "I wanted to give him a phone call, when I was at work yesterday, but I could not remember his (number)." Participants completed three semantic WM tasks (category probe, conceptual span, and synonym probe), four phonological WM tasks (digit matching span, digit span, rhyme probe, nonword repetition), and a speeded picture naming task, used as a control variable reflecting their ability to quickly retrieve stored word information from memory.

Results: Key measures of prediction performance were the proportion of expected responses, coded as "match"; then, "switch" errors including the proportion of responses predicted by just the final clause for b,c,d sentences ("local" switch), or for (a) sentences the proportion of responses should be predicted by the paired multi-clause sentences ("global" switch). Three contrasts were examined in all analyses: 1) the global conditions vs. the local condition (b,c,d vs. a), 2) longer vs. shorter global conditions (c,d. vs. b), and 3) intervening vs. non-intervening additional clause in global conditions (d vs. c). For the mean match and switch responses, using Helmert coding, all comparisons yielded significant results (see Figure 1). To address the influence of different types of WM, we first affirmed the existence of separate semantic and phonological factors using a principal components analysis. Then, mean performance on the more difficult condition(s) was regressed on the easier condition for all three contrasts, with composite semantic and phonological WM scores (computed by averaging z-scores) and mean naming accuracy as predictors. As shown in Table 1 (Match responses) and Table 2 (Switch responses), a significant independent contribution of semantic WM was found for the global conditions vs. the local conditions. For the longer vs. shorter global conditions, the independent contribution of semantic WM was marginally significant for the match responses and significant for the switch responses. Phonological WM failed to reach significance in any contrast. The control variable of naming accuracy was significant for all match contrasts but was non-significant for switch contrasts.

Conclusions: The sentence completion results first indicate that in healthy older adults, prediction performance diminishes with longer sentences and when there is increased separation between the key content clause and the prediction response, supporting a role for WM in prediction. With respect to type of WM involved, regression results showed an influence of semantic WM, but not phonological WM. The results are thus consistent with previous findings supporting a greater role of semantic than phonological WM in language comprehension and production and extending its role to supporting prediction.

References

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Figure 1. Mean sentence completion results.

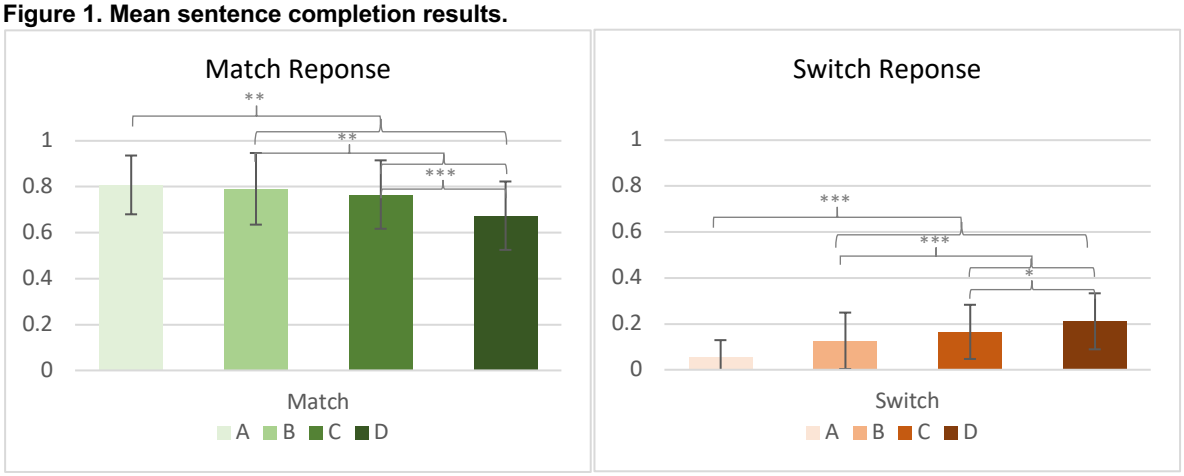

Table 1. *Multiple Regression Results for Match Reponses with WM Composites and Naming Predictors showing unstandardized coefficients and significance levels*

Dependent measure	Predictors					
	Semantic WM Composite	Phonological WM Composite	Picture Naming Proportion Correct	A Match	B Match	C Match
BCD Match Mean	**B = .205** ***p = .044***	B = .01 *p = .92*	**B = 3.33** ***p = .002***	B = -.17 *p = .75*	--	
CD Match Mean	B = .26 *p = .08*	B = -.03 *p = .83*	**B = 3.997** ***p = .012***	--	**B = -1.95** ***p = .005***	--
D Match	B = .007 *p = .82*	B = .014 *p = .63*	**B = .746** ***p = .013***	--	--	B = .198 *p = .123*

Table 2. *Multiple Regression Results for Switch Reponses with WM Composites and Naming Predictors showing unstandardized coefficients and significance levels*

Dependent measure	Predictors					
	Semantic WM Composite	Phonological WM Composite	Picture Naming Proportion Correct	A Switch	B Switch	C Switch
BCD Switch Mean	**B = -.3** ***p = .005***	B = .107 *p = .32*	B = -1.81 *p = .096*	B = -1 *p = .29*	--	
CD Switch Mean	**B = -.36** ***p = .02***	B = .15 *p = .32*	B = -2.42 *p = .1*	--	B = -1.54 *p = .05*	--
D Switch	B = -.016 *p = .55*	B = .005 *p = .86*	B = -.34 *p = .18*	--	--	B = .12 *p = .4*