



# Not all Working Memory Tasks are Created Equal: A Factor Analysis of Memory & Language Tasks across the Lifespan



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## ABSTRACT

Controversy exists over the structure of verbal working memory (WM) tasks. Baddeley and colleagues postulate a phonological loop for storage and a domain-general central executive function for processing. Kane & Engle suggest a domain-general Working Attention plus semi-independent domain-specific WM resources for language and visual processing. Just & Carpenter assert that one unitary WM store supports both storage and processing of verbal information, and advocate the reading span as an appropriate measure of this. MacDonald & Christiansen suggest that WM tasks, particularly the reading span, are merely language tasks by another name. The current study investigated these claims by examining the construct of verbal WM using factor analysis.

A secondary aim was to examine whether a set of common verbal WM tasks tap into the same cognitive resources in both young (YA) and older (OA) adults. This would allow us to identify tasks that were best suited for using when comparing these groups. We were particularly interested in the reading span task and digit ordering in this regard.

### Research Questions

1. Do older and young adults (OA and YA) use the same sets of resources to complete verbal WM tasks?
2. Do complex verbal WM tasks also load on vocabulary measures?
3. Are the 4 complex verbal WM tasks (DSB, DO, Rd.Span, 2-bk) equally good measures of WM for comparing OA and YA?

## METHODS

### Subjects

- 105 Young Adults (YA) age 18-25 ( $M = 20.5$ ,  $SD = 1.6$ )  
—Education 14.4 yrs ( $SD = 1.2$ )
- 100 Older Adults (OA) age 60-89, ( $M = 75.8$ ,  $SD = 7.4$ )  
—Education 16.1 yrs ( $SD = 2.7$ )

### Tasks

- **WAIS-III Vocabulary test** (Max score 70). OA > YA
- **Shipley Vocabulary test** (Max score 40). OA > YA
- **Word Reading** (Max score 100). OA = YA  
—Words from Woodcock-Johnson and WRAT word-reading subtests  
—Computer presented. Scored for accuracy.
- **Digit Span Forward** (DSF; Max score 14). OA < YA
- **Digit Span Backward** (DSB; Max score 14). OA < YA
- **Reading Span** (Max score 5). OA < YA  
—Participants read sets of sentences & recall the last word of each sentence in the set.  
—Score = # words recalled at the level in which 2 (of 3) trials were successful
- **Digit Ordering** (Max score = 24). OA < YA  
—Participants are given increasingly long lists of randomly ordered digits which they must put in canonical order.  
—Participants order 4 lists at each level (2-7 digits/level).  
—Testing is stopped if <3 trials are correct at a given level
- **N-Back (15/100 critical trials; scores: A' range .5 - 1.0)**  
—Computer presented task using Direct-RT (Jarvis, 2004).  
—Display shows one upper case consonant at a time in 48 pt. ARIAL font centered on the computer screen  
—**1-back**: Push the right mouse button if you see two of the same letters in a row; if it doesn't match, push the left mouse button. OA < YA  
—**2-back**: Push the right mouse button if the letter matches the one two screens previously; if it doesn't match, push the left mouse button. OA < YA

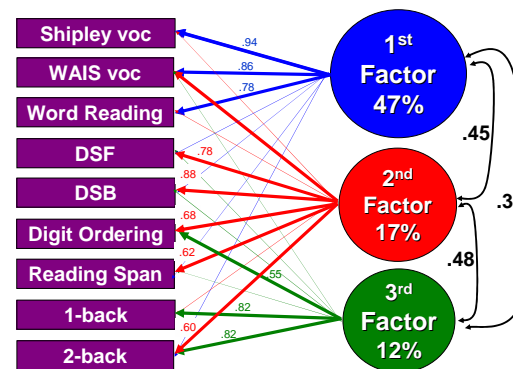
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## RESULTS

- A first attempt to include both groups in the analysis had a poor goodness of fit ( $p < .001$ ), so groups were analyzed separately.
- Maximum Likelihood factor analyses with Direct Oblimin rotation were computed for each group.

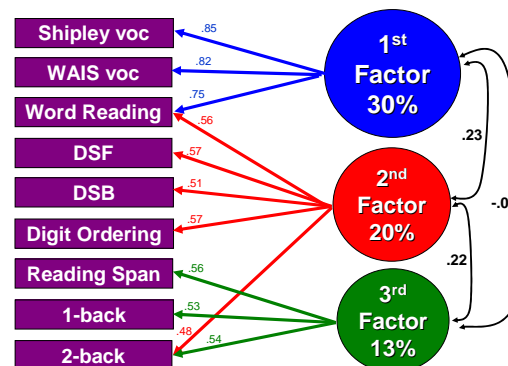
### Older Adults

- 3 factor solution, accounting for 76% of the variance.
- Goodness of fit  $\chi^2(12) = 6.368$ ,  $p > .89$ , (high  $p$  is better)
- 23 factor loadings > .3.
- Narrow lines are loadings between .3 and .4



### Young Adults

- 3 factor solution, accounting for 63.7% of the variance.
- Goodness of fit  $\chi^2(12) = 5.933$ ,  $p > .90$ , (high  $p$  is better)
- 11 factor loadings > .3



## DISCUSSION

These results illustrate that, as argued in Kemper & Sumner (2003), the structure of language and memory abilities may differ between young and older adults. In particular, older adults utilize a combination of semantic, memory, and attention resources to perform most tasks; whereas, young adults appear much more modular in their processing. These data present a good example of the differentiation of memory and language abilities in OA, as shown by the strong correlation between factors and the fact that all tasks loaded on more than one factor.

We found no evidence that complex verbal WM tasks loaded on the vocabulary factor in YA. This suggests that correlations reported in the literature between reading span and complex language tasks (e.g., verbal SAT scores, reading comprehension, ambiguity resolution) are due to the processing demands of these tasks, rather than to the WM task tapping fundamental language (i.e., semantic) representations. In contrast, many verbal WM measures did correlate with the vocabulary factor in OA.

Two complex verbal WM tasks appear to tap different resources in OA and YA: reading span and digit ordering. In OA, reading span on the 2<sup>nd</sup> factor, a memory measure, while in YA, it only loads on the 3<sup>rd</sup> factor, which likely is attention or executive function. Digit ordering loads nearly equally on the memory and attention factors in OA, but in YA it loads solely on the memory factor. Therefore, we caution against using these tasks to compare WM ability across YA and OA. On the other hand, digit span backward loads on the memory factor in both groups, and the 2-back loads on a combination of memory and attention factors in both groups. Thus, we suggest that these 2 tasks would be more suited for comparing these groups. However, many low functioning OA may score at chance on the 2-back. Thus, the digit ordering task might be a better measure for comparing subgroups of OA's, especially impaired populations, because it has a similar factor structure to the 2-back and has been found to be easily understood by both Alzheimer and Parkinson patients.

These results provide no support for theories in which WM is a single undifferentiated faculty. Neither do they support theories asserting that complex WM tasks tap semantic representations. Although these results could be stretched to support Baddeley's theory, the second factor for both groups correlates with performance on most of the complex WM tasks, not simply DSF, suggesting that this factor is not a mere slave system, but also contributes to verbal processing. This is particularly true in the OA group. Indeed, the memory factor may evolve over the lifespan from primarily phonological loop functions to somewhat more complex processing, (e.g., manipulable memory). Consequently, we believe that these findings are most consistent with Kane & Engle's (2002) Working Attention hypothesis which posits a domain-general attention factor and domain-specific memory functions that support ongoing processing in particular modalities (e.g., language and vision).

### References

- Baddeley, (1990). *Human Memory: Theory and Practice*. Boston: Allyn & Bacon.  
 Kane & Engle (2002). The role of prefrontal cortex in working-memory capacity, executive attention, and general fluid intelligence: An individual differences perspective. *Psychonomic Bulletin and Review*, 9, 637-671.  
 Kemper, S. & Sumner, A. (2002). The structure of verbal abilities in young and older adults. *Psychology and Aging*, 16 (2), 312-322.  
 MacDonald, M.C. & Christiansen, M. (2002). Reassessing working memory: Comment on Just & Carpenter (1992) and Waters & Caplan (1996). *Psychological Review*, 109, 35-54.

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