Working memory capacity and fluid abilities: Examining the correlation between Operation Span and Raven

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Abstract

The correlation between a measure of working memory capacity (WMC) (Operation Span) and a measure of fluid abilities (Raven Advanced Progressive Matrices) was examined. Specifically, performance on Raven problems was decomposed by difficulty, memory load, and rule type. The results suggest that the relation between Operation Span and Raven is fairly constant across levels of difficulty, memory load, and rule type. Thus, it appears something other than the number of things that can be held memory is important for the shared variance between these two tasks. The results are discussed in terms of the importance of attention control as a possible link between working memory capacity and fluid abilities.
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A large body of evidence has accumulated over the last decade supporting a substantial relationship between working memory capacity (WMC) and general fluid intelligence (gF; Ackerman, Beier, & Boyle, 2002; Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Engle, Tuholski, Laughlin, & Conway, 1999; Kyllonen & Christal, 1990). The exact cause of this relationship, however, remains a mystery. The goal of the present study was to better determine the relationship between these two constructs by attempting to identify what variables are important for the relationship. In this regard, we utilized a post-hoc decomposition of the Raven Advanced Progressive Matrices (Raven; Raven, Raven,

& Court, 1998) and examined the relation between these decomposed variables with Operation Span (Ospan; Turner & Engle, 1989).

1. Working memory capacity and fluid abilities

Although we realize that no task is a pure reflection of the construct of interest, we examined the relation between Ospan and Raven for several reasons. Across several studies, the correlation between working memory (WM) span measures, such as reading and counting span, with Raven is typically around 0.30 (Conway et al., 2002; Engle et al., 1999; Kane et al., 2004). In these same studies, Ospan tends to correlate with Raven at about 0.34 (i.e., 12% shared variance). Furthermore, factor analyses demonstrate that Ospan loads highly on a WM factor and Raven loads highly on a gF factor, with the path coefficient between the two hovering around 0.60 (Conway et al., 2002; Engle et al., 1999; Kane et al., 2004). Thus, although a moderate first order correlation exists between the two measures, a substantial amount of variance seems to be shared between the two constructs. We hoped to shed light on this shared variance by examining what variables are important for the relationship between putative measures of each construct (i.e., Ospan and Raven).

With this goal in mind, several different research strategies can be used. One strategy is to manipulate a theoretically important aspect of one of the tasks (e.g., the difficulty of processing on the WM span task) and see how that manipulation affects the correlation between the two. Finding that equating participants on the processing component does not affect the correlation between WM span and higher-order cognition would suggest that processing efficiency does not account for the shared variance (Conway & Engle, 1996).

Another strategy that has become popular in determining the relationship between WMC and gF is the use of CFA and SEM techniques. Here, a set of latent variables are defined by a set of tasks thought to reflect those constructs. After the latent variables are defined, several theoretically plausible models are tested to see which model best fits the data. Here, researchers can test the role of short-term memory in the WM–gF relationship (Engle et al., 1999) or test for the possible role of processing speed in the relationship (e.g., Ackerman et al., 2002).

A third strategy, and the one employed in the current paper, is to examine the simple correlation between two tasks by examining different aspects of performance on one of the tasks and seeing how the correlation changes. For instance, Salthouse (1993, Experiment 1) examined the correlation between each item on Raven with both age and WMC. Salthouse (1993) found that the correlation between solution accuracy for each problem and a composite measure of WM was fairly constant across all problems. The same pattern of results held true for the correlations involving age. However, once the WM composite was partialled out of the analysis, the age correlations dropped to near zero. These findings are striking, particularly in light of the fact that Raven problems are arranged systematically such that the easiest items (highest average solution accuracy) are presented first and the most difficult items (lowest average solution accuracy) are presented last. Based on this evidence, it would seem that item variation in terms of difficulty is not a major factor in the WM-Raven correlation. Although, Salthouse (2000) has subsequently found that more difficult items do share some unique variance with age. In this study, Salthouse grouped items into quartiles based on solution accuracy and examined the effects of each quartile after controlling for the earlier quartiles. Each successive quartile accounted for a