INTELLIGENCE

A latent variable analysis of working memory capacity, short-term memory capacity, processing speed, and general fluid intelligence

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Abstract

Significant relationships exist between general fluid intelligence and each of the following constructs: short-term memory capacity, working memory capacity (WMC), and processing speed. However, the interrelationship among all four constructs has not been investigated. Multiple measures of each of these constructs were obtained from 120 healthy young adults. Structural equation modeling was then performed to determine which construct served as the best predictor of general fluid intelligence. The results suggest that WMC, but not short-term memory capacity or processing speed, is a good predictor of general fluid intelligence in young adults. Possible mechanisms underlying the link between WMC and general fluid intelligence are discussed. © 2002 Elsevier Science Inc. All rights reserved.

1. Introduction

A decade has passed since Kyllonen and Christal (1990) inquisitively exclaimed "Reasoning ability is (little more than) working memory capacity?!". Despite an impressive

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series of projects demonstrating correlations between working memory capacity (WMC) and reasoning ability in the range of .80–.88 (Kyllonen & Christal, 1990), the leap to the notion that WMC is the basis of Spearman's *g* (Kyllonen, 1996) has not yet been universally embraced. The most notable challenges have been the claims that processing speed accounts for the relationship between WMC and fluid abilities (Fry & Hale, 1996; Jensen, 1998; Kail & Salthouse, 1994; Salthouse, 1996) and that WMC may not be a unitary resource, but rather, can be divided into separate resource pools for spatial and verbal processing (Shah & Miyake, 1997). In contrast, recent work that has clarified the distinction between WMC and short-term memory capacity (Cowan 1995; Engle, Tuholski, Laughlin, & Conway, 1999) has supported the notion that WMC is strongly linked to fluid abilities (Engle, Tuholski, et al., 1999). With this new information in hand, we explore the four-way relationship between WMC, short-term memory capacity, processing speed, and fluid intelligence.

It is clear from previous research that significant intercorrelations exist between measures of short-term memory capacity, WMC, processing speed, and fluid intelligence. However, investigations of these constructs typically involve only two-way relationships, such as the relationship between processing speed and fluid intelligence (for reviews, see Neisser et al., 1996; Vernon, 1987), or between short-term memory capacity and fluid intelligence (Bachelder & Denny, 1977a, 1977b), while some have examined different three-way relationships (Engle, Tuholski, et al., 1999; Fry & Hale, 1996; Kyllonen & Christal, 1990). In the current project, we explore the complex relationship that exists between these constructs in order to identify the primary contributor to individual differences in fluid intelligence. This is particularly necessary because some theorists posit that processing speed accounts for the relationship between WMC and fluid intelligence (Fry & Hale, 1996; Jensen, 1998; Kail & Salthouse, 1994; Salthouse, 1996), while others posit that WMC is the primary predictor of fluid intelligence (Carpenter, Just, & Shell, 1990; Engle, Tuholski, et al., 1999; Kyllonen, 1996; Kyllonen & Christal, 1990). This approach is also useful in that it has the potential to clarify the subtle distinction between the short-term memory and working memory constructs and to illustrate how these constructs relate to fluid abilities (Engle, Tuholski, et al., 1999).

Before exploring this complex relationship, it is important to clearly define each construct. First, we propose a distinction between working memory and short-term memory (Cowan, 1995; Engle, Tuholski, et al., 1999). We view short-term memory as a simple storage buffer, the capacity of which is determined by practiced skills and strategies, such as rehearsal and chunking. In contrast, working memory is more complex in that it consists of a storage component as well as an attention component. The function of working memory is to maintain memory representations in the face of concurrent processing, distraction, and/or attention shifts (Baddeley & Hitch, 1974; Engle, Tuholski, et al., 1999; Miyake & Shah, 1999). Therefore, the extent to which a task demands WMC is determined by the extent to which it requires the maintenance of activation to memory representations that could otherwise be lost from the focus of attention due to interference or decay. We view this capacity as a general resource, which contributes to cognitive performance in any domain which demands this type of controlled processing (Cowan, 1995; Engle, Tuholski, et al., 1999; Lovett, Reder, & Lebiere, 1999).