Available online at www.sciencedirect.com
ScienceDirect
Intelligence 35 (2007) 83 – 92
INTELLIGENCE

Predicting academic achievement with cognitive ability

Treena Eileen Rohde *, Lee Anne Thompson

Case Western Reserve University, Department of Psychology, 10900 Euclid Avenue Cleveland, Ohio 44106-7123, United States

Received 25 October 2005; received in revised form 15 February 2006; accepted 27 May 2006
Available online 10 July 2006

Abstract

The purpose of the present study is to explain variation in academic achievement with general cognitive ability and specific cognitive abilities. Grade point average, Wide Range Achievement Test III scores, and SAT scores represented academic achievement. The specific cognitive abilities of interest were: working memory, processing speed, and spatial ability. General cognitive ability was measured with the Raven's Advanced Progressive Matrices and the Mill Hill Vocabulary Scales. When controlling for working memory, processing speed, and spatial ability, in a sample of 71 young adults (29 males), measures of general cognitive ability continued to add to the prediction of academic achievement, but none of the specific cognitive abilities accounted for additional variance in academic achievement after controlling for general cognitive ability. However, processing speed and spatial ability continued to account for a significant amount of additional variance when predicting scores for the mathematical portion of the SAT while holding general cognitive ability constant.

Keywords: Intelligence; Spatial ability; Academic achievement

Academic achievement scores of high school students correlate between .50 and .70 with IQ scores (Jensen, 1998), and performance on standardized measures of academic achievement can be used to accurately estimate IQ scores (Frey & Detterman, 2004). While there is empirical evidence for a strong association between general cognitive ability and academic achievement, there is still anywhere from 51% to 75% of the variance in academic achievement that is unaccounted for by measures of general cognitive ability alone. Moreover, understanding the nature of the relationship between general cognitive ability and academic achievement has widespread implications for both practice and theory.

Several specific cognitive abilities have the potential to further an understanding of the components of general cognitive ability. Recent research focused on delineating the structure of general cognitive ability has attempted to identify separable constructs to explain individual differences in psychometric 'g'. These same constructs may also be relevant for understanding academic achievement. As an example, information processing theory suggests that overall mental efficiency can account for a large portion of the individual differences in 'g' (Vernon, 1983). Processing speed and working memory are two cognitive processes that have each been used to explain what drives mental efficiency and thus general cognitive ability.

Jensen (1992) was able to account for 40% of the variance associated with 'g' using Reaction Time (RT) variables — the intraindividual median (RTmd) and the standard deviation (RTSD). Of that 40%, 63.5% was common to both variables, and 17.1% was specific to RTmd, and 19.4% was specific to RTSD. In addition to

* Corresponding author. Tel.: +1 216 368 6467; fax: +1 216 368 4891.
E-mail address: treena.rohde@case.edu (T.E. Rohde).

0160-2896/$ - see front matter © 2006 Elsevier Inc. All rights reserved.
doi:10.1016/j.intell.2006.05.004

processing speed, Jensen maintains that other "neurologically independent mechanisms" are likely to be related to general cognitive ability (Jensen, 1992, p. 879).

The working memory system involves several cognitive processes thought to be related to general cognitive ability. Some researchers believe processing speed is the bridge between working memory and general cognitive ability. Vernon (1983) suggests that the relationship between processing speed and general cognitive ability represents individual differences in the limitations of the components of working memory. Developmental research suggests a combination of processing speed and working memory are needed to explain the individual difference in general cognitive ability (Fry & Hale, 1996). In addition to processing speed and working memory other specific cognitive abilities could also be investigated to determine their importance to individual differences in psychometric 'g'.

Luo and Petrill (1999) using exploratory and confirmatory factor analysis, selected basic cognitive tasks to test whether or not speed of information processing or memory processing are intrinsic parts of general cognitive ability. Their findings revealed that general cognitive ability can be defined with a combination of basic cognitive tasks and traditional psychometric measures of general cognitive ability without altering the nature of the relationship between 'g' and academic achievement. Additionally, a learning and memory factor composed of non-chronometric variables was highly related yet independent of the general information processing component. This finding led the researchers to conclude that the learning and memory factor's relationship with general cognitive ability must tap into some aspect of information processing and memory that is not related to speed of information processing.

Luo, Thompson, and Detterman (2003) tested the hypothesis that the correlation between psychometric 'g' and academic achievement was in large part associated with a mental speed component. Initially, the shared variance between general intelligence and academic achievement was approximately 30%. However, after controlling for the mental speed component, the shared variance between psychometric 'g' and academic achievement was reduced to approximately 6% (Luo et al., 2003). This finding is strong evidence that the mental speed component is an important mediator between psychometric 'g' and academic achievement.

Spatial ability is also an important construct related to general cognitive ability. For the purpose of this research, spatial ability was defined as a type of visual perception or sensory input involved in the mental manipulation or rotation in the orientation or position of objects or shapes within a given area or space (Carroll, 1993, pp. 304–310). Stumpf (1994) found that subtypes of spatial ability are able to predict success in accelerated mathematics courses offered to gifted high school students. Baddeley and Logie (1999) proposed that working memory involved several distinct cognitive skills including: verbal ability, spatial ability, long-term memory retrieval, and of course executive functioning. Logie's (1995) theoretical model represents working memory, long-term memory retrieval, and sensory inputs such as spatial ability as separable cognitive processes that may individually account for unique variance in general cognitive ability. Johnson and Bouchard (2005) go a step further and propose a structural model of human intelligence that includes image rotation as one of the three main factors of general cognitive ability.

Spatial ability is a construct shown to add incremental validity to both math and verbal sections of the SAT when predicting the educational choices and occupation outcomes of academically gifted individuals (Shea, Lubinski, & Benbow, 2001). Spatial ability tasks, especially those involving visualization, are able to predict which engineering students will excel in the area of technical drawing (Adanez & Velasco, 2002). Spatial ability and its influence on performance in academic interests such as mathematics and the sciences could be very useful tools for educators to assist students in designing appropriate academic paths.

The aim of this study is to understand the role, if any, that specific cognitive abilities play when predicting academic achievement. Three cognitive constructs most consistently recognized in the literature as being important components of general cognitive ability are working memory, processing speed, and spatial ability. The first goal of the study was to establish whether general cognitive ability or a combination of specific cognitive abilities allowed for the best prediction of academic achievement. The second task was to verify if the specific cognitive abilities could account for unique variance when predicting the different measures of academic achievement after controlling for general cognitive ability. In order to determine if domain specific types of achievement are better predicted by different subsets of specific cognitive abilities, the SAT combined score was broken down into its two separate components — SAT verbal scores and SAT math scores.

1. Method

1.1. Participants

Participants were undergraduate students at a private Midwestern university and were at least 18 years of age at the time of the study. Students enrolled in Psychology 101 courses received ungraded course credit for