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The role of IQ in the use of cognitive strategies to learn information from a map

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ABSTRACT

The role of IQ in individual differences in real-life problem solving and strategies use was explored. Repeated trials of learning and recall of information from a map were analyzed with high IQ and average IQ Korean students. IQ correlated with the selection and use of strategies in recall. However, the performance and strategic behaviors of low-recall high IQ students and high-recall average IQ students cautions the overgeneralization of the advantage of high IQ in the selection and use of cognitive and metacognitive strategies. The individual's mind set about learning and domain-specific ability needs to be considered as compensatory mechanisms to explain the relationship between IQ and strategies use.

Numerous research studies have employed IQ, the psychometric measure of general intelligence, to understand individual differences in academic performance. Although IQ predicts an individual's academic achievement (e.g., Gaultney, Bjorklund, & Goldstein, 1996; Roberts, 2007), IQ does not inform in detail why high IQ individuals perform well. Furthermore, critics of the general intelligence factor, *g*, often assert that IQ is merely "book smarts" and, therefore, provides little or no advantage in the real world (e.g., Gardner, 1983; for critical reviews, see Davies, Stankov, & Roberts, 1998; Hunt, 2001; Lubinski & Benbow, 1995). Likewise, not all high IQ individuals perform favorably with problems in specific domains (Alexander, Johnson, Leibham, & DeBauge, 2004; Gardner, 1983; Schneider, Bjorklund, & Maier-Brückner, 1996). In fact, an individual's performance may vary depending on the congruence between the domains of that person's strengths and what the task requires. In addition, individuals who hold incremental beliefs about intelligence may achieve higher because they believe achievement is determined more by effort and strategy than by inherent ability (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2002; Mangels, Butterfield, Lamb, Good, & Dweck, 2006).

Unfortunately, little research on the role of IQ employs tasks that allow participants to select strategies appropriate for domain specific tasks in real-life problem solving. In the past, laboratory tasks with limited pre-selected processes were mainly used, such as the use of sentences with distorted meanings (e.g., Sheppard & Kanevsky, 1999), vocabulary cards (e.g., Cho & Ahn, 2003; Coyle, Read, Gaultney, & Bjorklund, 1999; Geary & Brown, 1991), analogy problems (e.g., Geake, 2008), and word fluency tests (e.g., Arffa, 2007).

To understand the advantages of high IQ in individuals' use of strategies, it is necessary to employ tasks that allow a purposeful selection of strategies to solve problems in real life. Compared to average IQ students, high IQ children are better, more flexible, more adaptive, and efficient at choosing and utilizing effective strategies (Cho & Ahn, 2003; Jausovec, 1991; Muir-Broaddus, 1995; Pressley & Hilden, 2006; Shore, 2000; Steiner, 2006). High IQ students are generally observed to show goal-driven selection and changes in cognitive strategy according to the demand of the task.

Cultural context also accounts for differences in learning. Confucianism teaches that success is within reach for anyone through practice with single-minded effort (Confucius, 1979; W. O. Lee, 1996). This philosophy is congruent with Dweck's (2002) claim that achievement is determined more by effort and strategy than by inherent ability.

Domain specificity may explain children's learning behaviors (Gardner, 1983), where the same task can be approached using different strategies, depending on their intellectual strengths. Children with higher spatial IQ used more spatial strategies and those with higher verbal IQ used more verbal strategies in solving the same problems (Alexander et al., 2004; Schneider et al., 1996; Shore & Carey, 1984). Most likely, domain specificity influences the use of strategies, which results in different performance.

Maps are appropriate tasks to assess executive functions because they present various features simultaneously with structural information (Kulhavy & Stock, 1996). The salient features and "interpretive framework" provide an organizing structure to interpret a map, which carries implicit and explicit information in both analogue and analytic codes (Rossano & Morrison, 1996; Schwartz, 1997; Taylor & Tversky,

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1992). Maps also allow learners to construct representations of stimuli in working memory, hold the map in long-term memory, use it to create associative links among the features on the map (Kulhavy & Stock, 1996; Schwartz, 1997), use diverse and rich high-level strategies, evaluate their performance, and shift to more effective strategies (Postigo & Pozo, 1998; Thorndyke & Stasz, 1980). It is hypothesized that learning information from a map repeatedly requires individuals to plan, encode verbal and spatial information, monitor, and evaluate using various strategies for successful recall.

This study explored the role of IQ in the selection and use of strategies during map interpretation and learning. Differences in strategies usage and performance between high and low IQ student groups were examined.

1. Methods

1.1. Participants

Teachers from 26 middle schools in middle-class areas of four Korean metropolitan cities were requested to recommend academically superior and average students to take part in the research study. Among the students whom teachers recommended as either superior or average, 295 (93%) students and their parents provided informed consent. The students were administered the Korean version of the WISC-III (Kwak, Park, & Kim, 2002), which scores for Total, Verbal and Performance IQ. A total of 118 students whose Total IQ score was above 130 were selected. From the remaining participants with an average IQ score (Total IQ between 95 and 105), an equivalent number ($n=119$) were then randomly selected.

In all, 118 (60 males, 58 females) high IQ (HQ) and 119 (59 males, 60 females) average IQ (AQ) 4th grade students with mean ages of 10.7 and 10.6, respectively, were included. The mean IQ score for the HQ group was 135 ($SD=3.5$) and 101 ($SD=1.3$) for the AQ group. Less than 5% of the participants were enrolled in gifted education programs, not surprisingly, considering the Korean government screens students for gifted education with a focus on math and science, not IQ score.

1.2. Task

A reproduced map of a mid-sized city in Korea was used for the task. The map contained 26 verbal and 65 spatial information units. To control for the influence of knowledge base, only features familiar to all children were included. A description about the form, pattern, or relation of spatial information was used as the unit of measurement to count the number of informational segments recalled. To assure high inter-rater reliability, continuous spatial landmarks were divided into several units of either a specific shape or pattern.

1.3. Pilot study

Two pilot tests were conducted with a group of 25 randomly selected 4th grade students to determine the appropriate amount of information contained in the map. During each pilot test of approximately 20 min for each individual, a map was presented three times for learning and immediate recall. For each trial, the student reviewed the map for 1 min and then reproduced it from memory without time constraints. Three trained graduate students reviewed each student's three reproduced maps using a detailed rubric for scoring. Inter-rater reliabilities of scoring spatial information of the 75 reproduced maps were $r=0.89$–0.94.

1.4. Data collection and analyses

Students were randomly assigned to one of three graduate students and tested individually with one practice trial followed by five continuous learning and recall trials. For each of the five trials, students studied the information from the map for 1 min using their best strategies and to "think aloud." During recall immediately after their learning, they were asked to draw as much information from their memory as possible. There was no time limit during recall.

"Think aloud" has been used widely to assess cognitive processes (e.g., Chi, 1997; Davison, Vogel, & Coffman, 1997; Leow & Morgan-Short, 2004) with high validity and reliability, especially when the task performance requires conscious thinking and involves verbal information (Young, 2005). However, this approach is dependent on participants' ability to think, pay attention, and verbalize appropriately (Branch, 2000; Crutcher, 1994; Young, 2005). Accordingly, the participants' learning and recall behaviors were videotaped. The verbal data were transcribed and coded using Winograd's (1983) system of clausal analysis and the behavioral data from the video recordings were referred to whenever the nature of the verbal data was unclear.

Each verbal statement by the participants from their think aloud was categorized into a strategy of attention, encoding, or evaluation based on criteria developed by Thorndyke and Stasz (1980). Attention strategies were categorized into either systematic sampling that followed a plan or a rule; proximal sampling that attended to the adjacent; or random sampling, which had no specific plan or rule. Encoding strategies were classified into either three verbal strategies or four spatial strategies (Thorndyke & Stasz, 1980). Verbal encoding strategies include counting (e.g., "three schools"), rehearsal (e.g., "school, school, school"), and association (e.g., "The road is like a fork."). Spatial encoding strategies comprise of visual imagery (e.g., drawing an image with a finger in the air), labeling (e.g., "It is a face."), pattern encoding (e.g., "The road is winding to the right."), and relation encoding (e.g., "The school is above the hospital."). Evaluation strategies were grouped into positive (e.g., "I got that right.") or negative strategies (e.g., "I missed the road."), depending on whether the participant confirmed the learned information or recognized unlearned or incorrect information, respectively. Recalled information was scored as correct when the name, shape, and its location on the reproduced map were the same as on the map they were given to learn.

Differences between the HQ and AQ students in the recall of total, spatial, and verbal information from the last trial were analyzed. General linear modeling for repeated measures (Hair, Black, Babin, Anderson, & Tatham, 2006) examined the increase in differences in recall between HQ and AQ students along the five trials. Mann–Whitney U tests tested for significant differences between HQ and AQ students on verbal and spatial strategies use. The relationships between IQ and strategies use (attention, encoding, or evaluation strategies) and between recall performance and strategies use were analyzed by Pearson's point bi-serial correlation coefficients.

The main and interaction effects between IQ and recall group on the use of cognitive strategies were tested by two-way ANOVA.

2. Results

2.1. Group differences in the recall of information from a map

Significant differences were found in the amount of total ($t[235]=3.34$, $p<0.001$), spatial ($t[235]=4.88$, $p<0.001$) and verbal ($t[235]=4.76$, $p<0.001$) information recalled between HQ and AQ students on the last trial (see Table 1).

Participants' recorded behaviors revealed that HQ students utilized structural components of the map for learning and recall. They started recall by drawing the river and main roads across the map and then filled in the remaining items with specific map features, such as buildings. In contrast, most of the AQ students started drawing specific features in one corner of the map and continued drawing the details in that corner without recognizing the overall structure.