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The relationships between cognitive ability and dynamic decision making

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Abstract

This study investigated the relationships between cognitive ability (as assessed by the Raven Progressive Matrices Test [RPM] and the Visual-Span Test [VSPAN]) and individuals' performance in three dynamic decision making (DDM) tasks (i.e., regular Water Purification Plant [WPP], Team WPP, and Firechief). Participants interacted repeatedly with one of the three microworlds. Our results indicate a positive association between VSPAN and RPM scores and between each of those measures and performance in the three dynamic tasks. Practice had no effect on the correlation between RPM score and performance in any of the microworlds, but it led to an increased correlation between VSPAN score and performance in Team WPP. The pattern of associations between performance in microworlds and assessments of cognitive ability was consistent with the task requirements of the microworlds. These findings provide insight into the cognitive demands of dynamic decision making and the dynamics of the relationships between cognitive ability and performance with task practice.

Keywords: Cognitive ability; Dynamic decision making; Practice

1. Introduction

Dynamic decision making (DDM) shares many of the characteristics and complexities of real-world decision making. Like the decision making required in many real-world situations, DDM is

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characterized by multiple and interdependent real-time decisions that must be made in an environment that changes as a function of the sequence of actions, independently from exogenous events, or in both ways (Brehmer, 1992; Edwards, 1962). DDM and much of real-world decision making are dynamically complex because of the nonlinear relationships that exist among variables, multiple loops, and feedback delays (Sterman, 2000). Typical real-world examples of DDM include command and control in battle situations, firefighting, air traffic control, production scheduling, and emergency dispatch.

The study of individuals' differences is a traditional topic in DDM research (Brehmer & Dörner, 1993). Researchers working in this area both aim to characterize individual abilities that would help to explain performance and to explore the demands of DDM tasks. Although seemingly promising, this approach has yielded only limited success. Many studies have indicated that performance in dynamic tasks varies tremendously among individuals, but psychological assessments of cognitive abilities and personality have been unable to explain this variability (Brehmer, 1992; Rigas & Brehmer, 1999). This state of affairs in DDM research is surprising because many studies in psychology have documented greater correlation between performance and ability as task complexity increases (Ackerman, 1988; Kyllonen, 1985). On the basis of both this research in psychology and the complexity of DDM, one would expect greater correlation between DDM performance and general cognitive ability.

Rigas and Brehmer (1999) have proposed the *different-demands hypothesis* as an explanation for the weak correlations that researchers have observed between a measure of general fluid intelligence (Gf) (i.e., the Raven Progressive Matrices Test [RPM]) and DDM performance. This hypothesis suggests that dynamic tasks demand the performance of more complex mental processes than do intelligence tests. There is some laboratory support for the different-demands hypothesis. Joslyn and Hunt (1998) developed a task that could predict operators' performance in two real-world DDM domains: public safety dispatch (911 operators) and air traffic control (air traffic controllers), but no correlations existed between this task and an RPM-like measure of Gf (Joslyn & Hunt, 1998).

Recently, Rigas, Carling, and Brehmer (2002) reported significant correlations between RPM score and performance in two dynamic tasks (Rigas et al., 2002). These findings led Rigas et al. to offer the *low-reliability hypothesis* as a possible explanation of why prior research failed to establish an association between performance in DDM tasks and intelligence. The low-reliability hypothesis argues that intelligence scores have failed to correlate with performance measures in most dynamic tasks because the performance measures have suffered from low reliability. There is evidence that some past studies have suffered from poor reliability (e.g., α-coefficients <0.44) (as cited in Rigas et al., 2002). The reliability coefficients of the DDM performance measures reported in Rigas et al.—the only study to find a significant correlation between performance and intelligence in DDM tasks—were within acceptable limits, with all α-coefficients >0.77.

Both of the aforementioned hypotheses warrant further investigation. Low reliability is a concern for any study involving the performance of dynamic tasks (Funke, 1995) and, because very little is known about which cognitive abilities are necessary for successful performance of dynamic tasks, the different-demands hypothesis also appears well-founded. Our study, reported below, extends this previous research in two ways. First, we observed correlations between cognitive ability and performance in three DDM tasks involving realistic simulations in the laboratory setting (i.e., microworlds): Water Purification Plant (WPP) (Gonzalez, Lerch, & Lebiere, 2003), Firechief (Omodei & Wearing, 1995), and a team-oriented variation of WPP (Team WPP). We calculated the reliability of the performance measure used for each of these tasks. In addition to using the RPM measure of fluid intelligence, we used the Visual-Span Test (VSPAN), which measures working memory (WM) capacity, and identified any