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AUTHOR	Dillon, Ronna F.; Vineyard, George M.
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ABSTRACT

The study reported in this paper is designed to provide evidence of the convergent and discriminant validity of the Flexible Combination Test (R. Dillon). Two premises were tested: (1) flexible combination accounts for significant variation in cumulative grade-point average, high school rank, and cumulative Act Assessment scores; and (2) the importance of flexible combination ability to academic success varies as a function of the type of academic abilities being measured. Data from 99 undergraduates indicate that flexible combination ability predicts each of the criterion measures. In addition, data indicate that the relationships between cognitive flexibility and academic success vary as a function of academic subject areas. Flexible combination ability is more important to achievement in mathematics and English than natural science or social science. Data from this study provide further evidence of the importance of flexible combination ability to academic success and point to the importance of including cognitive flexibility in models of intelligence. (SLD)

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RUNNING HEAD: COGNITIVE FLEXIBILITY

Cognitive Flexibility: Further Validation of Flexible Combination

Ronna F. Dillon and George M. Vineyard

Southern Illinois University

Send requests for reprints to:

Dr.Ronna F. Dillon
Department of Educational Psychology and
Special Education
Southern Illinois University
Carbondale, Illinois 62901

Abstract

The study reported is this paper is designed to provide evidence of convergent and discriminant validity of the Flexible Combination Test. We test the premises that (a) flexible combination accounts for significant variation in cumulative grade-point average, high school rank, and cumulative ACT, and (b) the importance of flexible combination ability to academic success varies as a function of the type of academic abilities being measured. Data indicate that flexible combination ability predicts each of the criterion measures. In addition, data indicate that the relationships between cognitive flexibility and academic success vary as a function of academic subject area. Specifically, flexible combination ability is more important to achievement in mathematics and English than natural science or social science. Data from this study provide further evidence of the importance of flexible combination ability to academic success and point to the importance of including cognitive flexibility in models of intelligence.

Convergent and Discriminant Validation of Flexible Combination Ability

The importance of flexible thinking and problem solving are clear, as educational and professional demands change at an accelerated rate in our society. Professional and practical life events often require that individuals be able to combine stimulus or situation elements in more than one way to arrive at a correct solution to a problem.

Dillon's multiple component information-processing model is an elaboration of Sternberg's (1985) triarchic theory. Dillon's model is comprised of six components: (a) encoding; (b) rule inference; (c) rule application; (d) confirmation; (e) learning; and (f) flexibility. Flexibility, in turn, is comprised of three components: flexible encoding; flexible combination; and flexible comparison.

"A major hallmark of cognitive development is the ability to apply strategies flexibly and appropriately." (Plumert, 1994) The theory of cognitive flexibility is not a new one:

> It has long been recognized that the ability to vary one's mode of approach to solving complex problems is an important factor in achieving a successful outcome. Being able to view a problem from a flexible stance, in which alternative options are freely considered, is an important feature of intelligent behavior, and is particularly important in higher order cognitive functioning. Cognitive flexibility is thought to be important because it allows the human to consider a variety of behavioral options or solutions prior to executing an overt

> response. In this fashion, overt trial and error behavior is reduced to some minimum level. (Cosden, 1979)

Though most cognitive psychologists agree that some form of flexibility exists, often their respective definitions differ. Murray (1990) reported that flexibility was the ability to not only perceive interrelationships between concepts but also to understand the important distinctions between them. In other words, flexibility is the ability to see the similarities and differences between things. This definition is slightly different than the one offered by Spiro in 1991. Spiro believed that

> cognitive flexibility includes the ability to represent knowledge from different conceptual and case perspectives, and then the knowledge must later be used to construct from those different conceptual and case representations a knowledge ensemble tailored to the needs of the understanding or problem solving situation at hand. (Spiro, 1991)

The major distinction between these two definitions is that Spiro believed that the insight gained from flexibility later must be utilized, and that it is specific to the situation at hand (Spiro, 1991). It is this type of applied flexibility that Dillon had in mind when she generated her three component model of flexibility. Dillon defines flexibility as the

> ability to define stimulus attributes in more than one way, the ability to generate more than one tactic in solving tasks or items that can be solved in more than one way, and the ability to change tacticswhen the demands of the task change. (Dillon, 1992)

Dillon's (1992) cognitive flexibility model decomposes aspects of cognitive flexibility that are confounded in other flexibility work. The flexibility model is made up of three subcomponents: (a) flexible encoding, (b) flexible combination, and (c) flexible comparison. This three component division of flexibility is a departure from the other researchers in this area. Most researchers confound the three components of flexibility, using only one predictor in their models. However, their definitions encompass all of Dillon's separate components. (Cosden, 1979, Murray, 1990, Spiro, 1991) Dillon contends that each component should be viewed individually.

Dillon's first component, flexible encoding, taps an individual's ability to encode multiple meanings for each stimulus. The task stimuli require examinees to construct multiple spatial forms using multiple definitions of each stimulus. The second component, flexible combination, assesses an individual's ability to generate multiple tactics for solution for a range of inductive reasoning items. The third component, flexible comparison, is developed to assess an individual's ability to change solution tactic as the demands of the complex reasoning task change. Here, examinees solve a set of items of the same type and then switch to a different type of item. Each component of Dillon's cognitive flexibility model has been found to be a significant contributors of academic success. (Dillon, 1992)

The work reported in this paper has three objectives. The first objective is to provide evidence of the psychometric credibility of Dillon's Flexible Combination test. The second objective is to provide evidence of criterion-related validity by testing the premise that flexible combination ability accounts for significant variation in concurrent and postdictive indices of academic achievement. The third objective is to provide evidence of convergent and discriminant validity by examining patterns of relationships between flexible combination and different subtests of the ACT. Specifically, we test the premise that the importance of flexible combination ability to academic success is greatest in mathematics, then English, then natural science, then social science.

Method

Participants

The sample was comprised of 99 upper-division, college undergraduates. Males and females were approximately equally represented.

Instruments

Twelve complex figural analogies, taken from the Advanced Progressive Matrices (APM; Raven, 1965), were used as test stimuli. Each item could be solved in at least three ways to yield the same correct answer. Figure 1 depicts a sample item.

Insert Figure 1 about here

In addition, cumulative grade-point average (GPA), high school rank, and ACT Composite data were tabulated.

Procedure

Examinees were instructed to solve each item, generating a written protocol during item solution. Subsequently, examinees were instructed to solve the same item -- using a different tactic to arrive at the same correct answer. Examinees were instructed to generate as many solution protocols as possible for each item before proceeding to the next item. Examinees were required to attempt all 12 items.

Results

Data were analyzed in three phases. A .05 significance level is used in all analyses. First, internal consistency reliability was computed for the total test using Cronbach Alpha. Data indicate a Cronbach Alpha of .76 for the present test administration. Using the Spearman Brown Formula (Allen & Yen, 1979), data indicate that, if the test were increased to the full length of the APM, reliability for this test administration would be .927.

During the second phase of analysis, data indicate that flexible combination ability predicts cumulative GPA, $F(1, 98) = 5.55$, $p < .05$. In addition, flexible combination ability accounts for significant variance in high school rank, $F(1, 52) = 22.47$, $p < .001$. Similarly, flexible combination accounts for significant variance in ACT Composite, $F(1, 67) = 31.88$, $p < .001$.

During the third phase of analysis, data are analyzed to test the premise that flexible combination ability is more important for success math and English subtests of the ACT than for natural science and social science subtests. When ACT math is excluded from the model, the reduction in R^2 is significant, $F(1, 63) = 9.14$, $p < .001$. When ACT English is excluded from the model, the reduction in R^2 is significant, $F(1, 63) = 2.49)$, $p < .05$. when ACT Natural Science is excluded from the model, the reduction in R^2 is not significant, $F(1, 63) = 1.07$, $p > .05$. When ACT Social Science is excluded from the model, the reduction in R^2 is not significant, $F(1, 63) = .13$, $p > .05$.

Discussion

Flexible combination ability is an important predictor of concurrent and postdictive measures of academic achievement for the present sample of college students. The consistent pattern of results across the three criterion measures reflects the robustness of cognitive flexibility. Evidence of convergent and discriminant validity of this test administration comes from the pattern of data when flexible combination ability is validated against ACT subtests. The relationship between flexibility and mathematics achievement is greatest because the reasoning strategies used to solve the figural analogies are logico-mathematical in nature. Flexible combination also is an important predictor of English achievement because most people represent figural analogies verbally in addition to figurally.

Taken together, the data indicate that flexible combination ability is an important source of individual differences variation. Models of intelligent performance well might include measures of cognitive flexibility.

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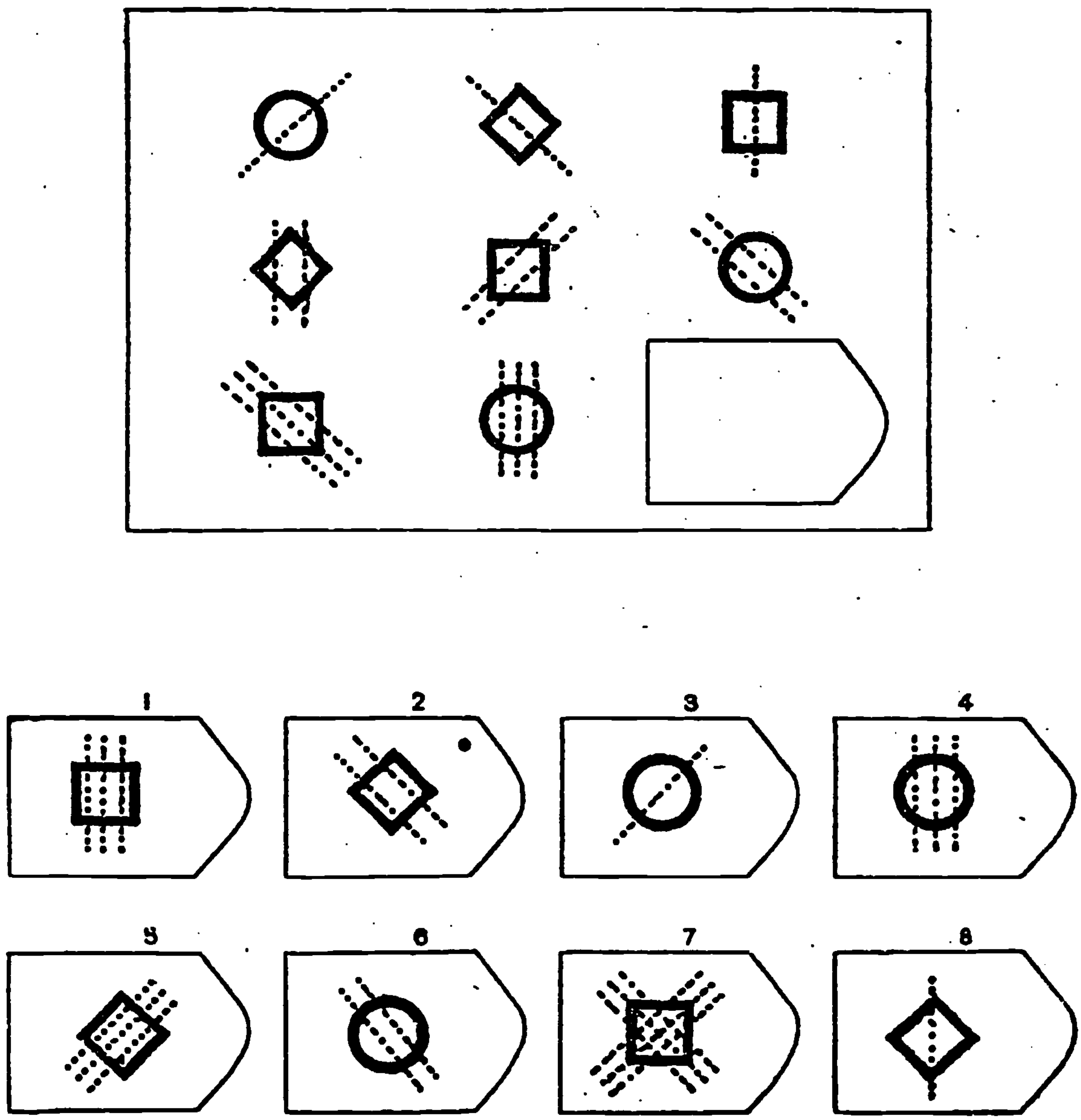
<u>**Figure 1.**</u>

Sample Item From the Advanced Progressive Matrices



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Organization/Address: Southern Illinois University Department of Educational Psychology and Special Educ. Carbondale, IL 62901	Telephone: 618-453-6925	Fax: 618-549-9057
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