

Complexity of geometric inductive reasoning tasks Contribution to the understanding of fluid intelligence

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Abstract

Studies of the complexity of geometric inductive matrix items used to measure fluid intelligence (Gf) indicate that such complexity may be related to (a) an increase in the number of figures, (b) an increase in the number of rules relating these figures, (c) the complexity of these rules, and (d) the perceptual complexity of the stimulus. One limitation of these studies is that complex items present all of these characteristics simultaneously. Thus, no information regarding their relative importance is available, nor is it clear whether all these factors have a significant effect on complexity. In the present study, two matrix tests were created by orthogonally manipulating these four sources of complexity, and the results show that perceptual organization has the strongest effect, followed by the increase in the amount of information (figures and rules). These results suggest that Gf is most strongly associated with that part of the central executive component of working memory that is related to the controlled attention processing and selective encoding. © 2001 Elsevier Science Inc. All rights reserved.

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1. Introduction

Initially defined by Cattell (1941) and further elaborated by Horn and Cattell (1966), fluid intelligence (Gf) is one of the broad factors of intelligence, (Carroll, 1993a, 1993b, 1997; Horn & Noll, 1997). It is a mental activity that “involves making meaning out of confusion;

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developing new insights; going beyond the given to perceive that which is not immediately obvious; forming (largely nonverbal) constructs which facilitate the handling of complex problems involving many mutually dependent variables” (Raven, Raven, & Court, 1998, p. G4).

In the last four decades, the basic component processes that comprise this complex mental activity have been under study by various cognitive psychologists (Bethell-Fox, Lohman, & Snow, 1984; Carpenter, Just, & Shell, 1990; Embretson, 1995, 1998; Evans, 1968; Goldman & Pellegrino, 1984; Gonzales Labra, 1990; Gonzales Labra, & Ballesteros Jimenez, 1993; Green & Kluever, 1992; Hornke & Habon, 1986; Hunt, 1974; Mulholland, Pellegrino, & Glaser, 1980; Primi, 1995; Primi & Rosado, 1995; Primi, Rosado, & Almeida, 1995; Rumelhart & Abrahamson, 1973; Sternberg, 1977, 1978, 1980, 1984, 1986, 1997; Sternberg & Gardner, 1983). This research has tried to identify the cognitive processes people use to solve geometric analogy tasks which, according to Marshalek, Lohman, and Snow (1983), are the prototype tasks to assess Gf. Basically these studies (a) identify the basic component processes and the strategies that organize them in a complex chain, (b) investigate the correlations between component and traditional psychometric measures, (c) discover complexity factors underlying the tasks, and (d) simulate problem-solving behavior using artificial intelligence.

Fig. 1 displays four examples of the geometric 3×3 matrix problems used in the present study. Each of these problems consists of an organized set of geometric figures obeying either two or four rules; the subject must discover them so that he or she can generalize from them to decide which of the eight options is the most appropriate to fit into the blank space.

The basic components of the problem-solving behavior involved in such problems can be organized into three stages. The first stage is associated with the creation of a mental representation of the attributes of the problem and the rules relating these attributes. In the literature, these two aspects have received various labels, including encoding and inference (Sternberg, 1977), perceptual and conceptual analysis (Carpenter et al., 1990), pattern comparison and decomposition, and transformational analysis and rule generation (Mulholland et al., 1980). The second stage is associated with the recognition of the parallels between these rules and a new, but analogous, situation. This component has been variously denominated as mapping (Sternberg, 1977), perceptual and generalized conceptual analysis (Carpenter et al., 1990), and rule comparison (Mulholland et al., 1980). The third stage is associated with the application of the rules to create an appropriate representation to fill the blank, and the selection of an answer from the options provided. The terms used to denominate this process of representation generation are application, comparison and response (Sternberg, 1977), and response generation and selection (Carpenter et al., 1990).

Recently, research has suggested that Gf is associated with working memory capacity (Duncan, Emslie, & Williams, 1996; Embretson, 1995, 1998; Engle, Tuholski, Laughlin, & Conway, 1999; Hunt, 1996, 1999; Jurden, 1995; Kyllonen & Christal, 1990; Prabhakaran, Smith, Desmond, Glover, & Gabrieli, 1997). According to Baddeley and Hitch (1994), working memory capacity can be decomposed into memory buffers responsible for storing speech-based information and visuospatial information (phonological loop and visuospatial sketchpad) as well as a central executive component responsible for the coordination of the basic components and attentional control.

Engle et al. (1999) use the term short-term memory to denote memory buffers and suggest that they are related to the amount of information that can be maintained active at any one

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