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The relation between fluid intelligence and the general factor as a function of cultural background: A test of Cattell's Investment theory

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Abstract

According to Cattell's [Cattell, R.B. (1987). Intelligence: Its structure, growth and action. New York: North-Holland.] Investment theory individual differences in acquisition of knowledge and skills are partly the result of investment of Fluid Intelligence (*Gf)* in learning situations demanding insights in complex relations. If this theory holds true *Gf* will be a factor of General Intelligence (*g*) because it is involved in all domains of learning. The purpose of the current study was to test the Investment theory, through investigating the effects on the relation between *Gf* and *g* of differential learning opportunities for different subsets of a population. A second-order model was fitted with confirmatory factor analysis to a battery of 17 tests hypothesized to measure four broad cognitive abilities The model was estimated for three groups with different learning opportunities ($N=2358$ Swedes, $N=620$ European immigrants, $N=591$ non-European immigrants), as well as for the total group. For this group the *g*–*Gf* relationship was .83, while it was close to unity within each of the three subgroups. These results support the Investment theory.

Keywords: Structure of intelligence; Cattell's Investment theory; Fluid intelligence; General intelligence

1. Introduction

Ever since Spearman (1904, 1927) introduced his "Theory of Two Factors", issues concerning the structure of human intelligence have been the focus of attention of much research. While there certainly are differences in opinion regarding a wide range of issues, consensus has been achieved that a hierarchical representation of the structure of cognitive abilities is required to capture the complexities of the phenomenon (e.g., Carroll, 1993; Gustafsson, 1988; Jensen, 1998; Messick, 1992). The currently most widely accepted hierarchical model is the Carroll (1993) "Three-Stratum Model". Since this model may be regarded as an extension of the Cattell and Horn "*Gf*–*Gc*" model (see e. g., Horn & Cattell, 1966) it is also referred to as the Carroll–Horn–Cattell (CHC) model (McGrew, 2005).

The CHC model includes factors of three degrees of generality (Carroll, 1993; McGrew, 2005). At the lowest level (stratum I) there are at least some 60 narrow factors, many of which correspond to factors previously identified by Thurstone (1938), Guilford (1967) and other researchers working in the tradition of multiple

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factor analysis. At stratum II some ten broad factors are identified, and among these, a few are seen as especially prominent, primarily because of the attention they have been given in the research conducted by Cattell and Horn (see, e. g., Cattell, 1963, 1971, 1987; Horn, 1968; Horn & Cattell, 1966). One is *Fluid Intelligence* (*Gf*), which is interpreted as the capacity to solve novel, complex problems, using operations such as inductive and deductive reasoning, concept formation, and classification. Another factor is *Crystallized Intelligence* (*Gc*), which represents individual differences in breath and depth of knowledge of the language, information and concepts of a culture. *Gc* is acquired through education and experience and it primarily reflects verbal knowledge and skills, as well as declarative knowledge in wide areas. Another important factor is *Broad Visual Perception* (*Gv*), which is an ability to generate, retain, retrieve and transform visual images. *Cognitive Processing Speed* (*Gs*) is a broad ability to fluently perform relatively easy or overlearned tasks, particularly when attention and focused concentration is required.

At the third stratum the CHC model includes a factor of *General Intelligence* (*g*). This factor relates most highly to complex reasoning tasks while it has lower relations to the stratum II factors involving simpler speeded tasks. According to Carroll (1993) this suggests that the *g*-factor involves complex higher-order cognitive processes.

However, even though there is consensus at a general level that such a hierarchical arrangement of factors represents a useful taxonomy of human cognitive abilities, there are substantial differences in opinion concerning fundamental theoretical issues between the three researchers after which the CHC model has its name. The most striking locus of differences concerns the need for a *g*-factor at the apex of the hierarchy, and, if such a factor is accepted, the nature of this factor (cf. McGrew, 2005).

1.1. The general factor in hierarchical models of intelligence

According to Carroll (1993) the empirical evidence strongly supports the existence of a *g*-factor, and Jensen (1998), along with many others (e.g., Gustafsson, 1988), has arrived at the same conclusion. However, Horn (see, e.g., Horn & Blankson, 2005; Horn & Noll, 1997) has strongly objected to the idea of a general factor, favoring instead a hierarchical model with broad correlated factors at stratum II. The main reason for Horn's resistance against a stratum III *g*-factor is that he regards such a factor as a hybrid factor, which is a composite of different stratum II factor. Since the nature of the *g*-factor is determined by the composition of the test battery, it lacks factorial invariance, and *g* is therefore not a meaningful scientific concept (Horn & Noll, 1997).

Undheim (1981) and Gustafsson (1984) suggested one approach to solving the problem of the potential non-invariance of *g*. They argued that the characteristics of the *g*-factor as described by Spearman (1904, 1927) agree so well with the characteristics of the *Gf*-factor as described by Horn and Cattell (1966), that *g* and *Gf* should be considered to be one and the same factor. The equality of *g* and *Gf* also has been demonstrated empirically in a series of studies in which a higher-order *g*-factor has been shown to have a perfect relationship with the *Gf*-factor (e. g., Gustafsson, 1984, 1988, 1994, 2002; Undheim, 1981; Undheim & Gustafsson, 1987). Since *Gf* is identified in an invariant manner, it follows that *g* too is invariantly defined as an apex factor in the CHC model.

Horn and Blankson (2005, p. 53) rejected this line of reasoning, arguing that *Gf* does not account for the interrelationships among other variables indicative of intelligence. However, if *Gf* is equivalent to a stratum III *g*-factor in the CHC model which accounts for the intercorrelations among the stratum II factors this statement is incorrect. This issue thus could and should be determined on the basis of empirical research.

While the $g = Gf$ relationship has been observed in many other studies as well (e. g., Keith, 2005; Reynolds & Keith, 2007), all attempts at replication have not been successful. Carroll (1993) reanalyzed the Gustafsson (1984) data, and failed to find the perfect relationship between *g* and *Gf*. One reason for this may be that Carroll (1993) relied on exploratory factor analysis, and with this technique he failed to identify the inductive factor, which in turn caused him difficulties separating *Gf* and *Gv*. However, in another study of the relationship between *Gf* and *g*, Carroll (2003) used confirmatory factor analysis (CFA), without quite being able to show the identity. It thus must be concluded that the empirical support for the equivalence between *Gf* and *g* is strong, but not unanimous. The results presented by Carroll (1993) show, however, that *Gf* is the stratum II factor which has the highest loading on the stratum III *g*-factor.

However, strong opposition also has been voiced against the idea that the *g*-factor is equivalent with *Gf*, and instead it has been argued that measures of crystallized abilities are better indicators of *g* (e.g., Gignac, 2006; Robinson, 1999). One of the bases for this argument is the observation that the verbal subtests (e.g., Vocabulary and Information) in the Wechsler