Intelligence 38 (2010) 481–496

Contents lists available at ScienceDirect

Intelligence

Confirmatory factor analysis of Project Spectrum activities. A second-order *g* factor or multiple intelligences?

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ARTICLE INFO

Article history:
Received 23 October 2007
Received in revised form 3 May 2010
Accepted 8 July 2010
Available online 3 August 2010

Keywords:
Multiple intelligences
Confirmatory factor analysis
g factor

ABSTRACT

This paper compares different theoretical models of the structure of intelligence, based on the analysis of data obtained in a series of measured abilities corresponding to the Spectrum assessment activities (Gardner, Feldman & Krechevsky, 1998) in a sample of 393 children enrolled in kindergarten and first grade. The data were analyzed using confirmatory factor analysis. The models compared were: a) a model with six first-order uncorrelated factors, b) a model with six first-order factors and one second-order general factor, *g*; c) a model with two correlated second-order general factors, in which the cognitive intelligences load on a "cognitive" general factor and the non-cognitive intelligences load on a "non-cognitive" general factor, and d) a model with six first-order correlated factors. The percentage of variance in measured abilities due to *g* and to first-order factors was also estimated. Overall, the results indicate that the Spectrum activities are not as separate from *g* as proposed by the defenders of multiple intelligences theory, nor as unitary as argued by the defenders of *g* factor models.

Psychometric and differential traditions in research into intelligence have generated a very broad set of research results regarding mental abilities and their structure. Most studies are based on correlational methods, which chiefly use exploratory and confirmatory factor analysis techniques (Brody, 2000).

One of the main goals of this approach to the study of intelligence is to identify the number of distinguishable factors or aptitudes that exist, as well as to establish the possible structure of relationships between these mental abilities. The results of a wide range of research projects reveal the existence of a large group of factors (Carroll, 1993): the verbal factor, containing verbal material; the spatial visualization factor; numerical reasoning; mechanical reasoning; and the memory factor, referring to recall of specific previously acquired information.

According to the *g* factor theory, there is also one large general factor over and above all of these group factors, which encompasses the common variance between the above mentioned factors. This factor becomes clearer when a diverse set of cognitive tasks and a larger more representative sample of the general population are considered (Carroll, 1993; Jensen, 1998). Its existence was originally hypothesized by Spearman (1904), who labeled it simply *g*.

The crystallization of an empirically-based psychometric taxonomy of mental abilities occurred in the late 1980s to early 1990s (McGrew, 2005). During the past decade the Cattell–Horn *Gf-Gc* and Carroll, CHC, three-stratum models have emerged as the consensus psychometric-based theory for understanding the structure of human intelligence and as a working taxonomy to test and evaluate structural models of human intelligence (McGrew, 2009). For example, Johnson and Bouchard (2005) and Johnson, Nijenhuis, and Bouchard (2008) applied confirmatory factor analysis (CFA) methods to datasets analyzed by Carroll. They used CFA methods to compare versions of the Carroll, Cattell–Horn *Gf-Gc*, Vernon verbal–perceptual model, and Johnson and Bouchard verbal–perceptual–rotation (VPR) model. Support for the VPR model

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doi:10.1016/j.intell.2010.07.002

was presented via the CFA analyses. This constitutes a refinement and extension of the CHC taxonomy.

In contrast with the *g* factor theory, a number of scholars defend positions that challenge the strong version of IQ that emerged from the psychometric tradition (Gardner, 2003, 2006; Horn & Cattell, 1966). In these theories, intelligence is seen as having several, at least partially, dissociable aspects, and the primacy of *g* is questioned. The term intelligence refers not only to the general factor but also to several broad organizations of abilities and more narrow primary specific factors (Carroll, 1993; Horn & Noll, 1994). Intelligence is the full hierarchical structure of abilities as conceived by these authors, not just the highest-order factor, *g*. The existence of a single higher-order general factor *g* is the focus of much debate, even among the supporters of the CHC theory (Horn, 2007; McGrew, 2005).

Drawing on evidence from a range of disciplines, including biology, anthropology, and psychology, Gardner (1983, 1999) concluded that humans have a number of relatively autonomous intellectual capacities, called *multiple intelligences*. Gardner's theory diverges from certain traditional conceptions. Like other theorists (Ceci, 1990/1996; Sternberg, 1985, 2003; Sternberg, Castejón, Prieto, Hautamäki, & Grigorenko, 2001; Thurstone, 1938), Gardner argued for a notion of intelligence that included non-cognitive abilities as opposed to other theories such as those proposed by Jensen (1998), and Carroll (1993).

Gardner (1983/1993) defined intelligence as the ability to solve problems or to fashion new products that are valued in at least one culture. The major claim in the theory is that the human intellect is better described as consisting of a set of semi-autonomous computational devices, each of which has evolved to process certain kinds of information in certain kinds of ways. Each of the major intelligences is itself composed of subintelligences. To what extent these subcomponents correlate with one another is an empirical question (Gardner, 1993, 2006).

Gardner (1983, 2006) argued that standard intelligence tests typically probe only *linguistic* and *logical–mathematical* intelligences, and certain forms of *spatial* intelligence. In Gardner's view, there are at least five other human intelligences: *musical* intelligence, *bodily-kinesthetic* intelligence, *naturalistic* intelligence, *interpersonal* intelligence, and *intrapersonal* intelligence. According to Gardner, all human beings possess all of the intelligences, but we differ in relative strengths and weaknesses. Each of these intelligences is concisely and fully described in Gardner (1999, pp. 41–43).

The degree of correlation among intelligences is another open question in Gardner's theory: "Nowadays an increasing number of researchers believe the opposite; that there exists a multitude of intelligences, *quite independent* [italics added] of each other; that each intelligence has its own strengths and constraints;" (Gardner, 1993, p. xxiii). This corresponds to an initial or strong version of multiple intelligences theory.

However, in more recent developments Gardner recognized that: "The degree of correlation among intelligences is yet to be determined (because we do not have adequate measures for most of the intelligences). In any event, there is no reason to think that they will be dominated by a single *g* factor"(Gardner, 2003, p. 47). Nor did Gardner agree that the multiple intelligences may be perceived as "special talents" within this general factor (Gardner, 2006). This view that permits intelligences to correlate can be defined as the recent or weak version of multiple intelligences theory.

Although some critics (Brody, 2006; Visser, Ashton, & Vernon, 2006a) claim that there is no empirical evidence to support a theory of multiple intelligences, Gardner (1983) examined several empirical studies when identifying the seven intelligences. Nevertheless, only a few correlational studies exist that support Gardner's theory, most studies are experimental and based on clinical evidence. The lack of correlational studies providing empirical support for Gardner's theory of multiple intelligences is due to several reasons, including the argument of the theory itself against using standardized tests to measure intelligence, and the lack of appropriate tools to do so, as Gardner (2003, 2006) himself admits.

Only a few studies have tested the structural validity of this theory using correlational methodology, and exploratory and confirmatory factor analysis techniques. The aim of these studies was to confirm the presence of different types of intelligence in a battery of activities derived from Project Spectrum. Plucker, Callahan, and Tomchin (1996) performed exploratory factor analysis in order to test the existence of four types of intelligence – spatial, logical/mathematical, linguistic and interpersonal – in a sample of 1813 children in kindergarten and first grade, using the Multiple Intelligences Assessment Technique, which is based upon the assessment activities used in Project Spectrum (Gardner et al., 1998). The technique consisted of 13 performance-based activities, teacher ratings, and observational checklists corresponding to the four intelligences. The factor analysis – principal component extraction and varimax rotation – supported the presence of the linguistic, logical–mathematical and spatial subscales, and the combination of interpersonal and linguistic intelligence activities in the first factor. Although these factor analysis results appear to provide some support for the theory of multiple intelligences, they are limited by the fact that they were obtained using exploratory factor analysis, rather than CFA, a much better procedure to study this issue.

Pyryt (2000) reanalyzed the correlation matrix of Plucker et al. (1996) to illustrate how higher-order exploratory factor analysis using more adequate procedures – maximum likelihood and direct oblimin – might be used to explain the constructs found in the initial factor analysis. Consistent with Carroll's (1993) factor analysis study of mental abilities, results indicated that the *g* factor underlies correlations between first-order factors.

Gridley (2002) reanalyzed data from Plucker et al. (1996) to illustrate how the use of CFA might help to determine the factorial structure that fits these empirical data. The findings obtained by Gridley (2002) showed that a model with several correlated factors fitted the data from Plucker et al. (1996) better than did a hierarchical model with *g* at the top.

The results obtained by Gridley (2002), using a higher-order CFA model, showed that, although as might be expected some tasks were more highly *g*-loaded or *g*-influenced than others, each individual task retained variance that was not attributable to *g*, which suggests that the individual tasks do tap into abilities other than *g*.

Visser, Ashton, and Vernon (2006a) investigated Gardner's Theory of Multiple Intelligences by examining the