Intelligence 42 (2014) 89–97

Contents lists available at ScienceDirect

Intelligence

Dynamic mutualism versus g factor theory: An empirical test

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ARTICLE INFO

Article history:
Received 31 July 2013
Received in revised form 3 November 2013
Accepted 4 November 2013
Available online 14 December 2013

Keywords:
Dynamic mutualism
g
Intelligence
Bifactor
Omega hierarchical

ABSTRACT

The positive manifold associated with correlation matrices of diverse batteries of cognitive abilities has garnered a substantial amount of psychometric and theoretical consideration. General (*g*) factor theorists purport the positive manifold to be due to a *g* factor, which is believed to be representative of an important psychological construct. By contrast, the dynamic mutualism theory of the positive manifold asserts that it is an epiphenomenon, which emerges progressively during development, as a consequence of mutually beneficial interactions between originally uncorrelated cognitive processes. To test the competing dynamic mutualism versus *g* factor theories of the *g* factor, the strength of the *g* factor (as estimated by omega hierarchical, ω_h) was plotted across the ages of 2.5 to 90 years ($N = 5200$). Although there was an observed increase in ω_h from the ages of 2.5 to approximately 10.0, the observed slope was weak in magnitude. Furthermore, the results based on the mean of the bifactor model *g* loadings suggested that much, if not all, of the upward slope in ω_h was due to differences in the number of subtests across age groups. Consequently, the results are interpreted to suggest that the dynamic mutualism theory of *g* was failed to be confirmed, however, important limitations associated with this investigation are highlighted and an alternative explanation is presented.

1. Introduction

Cognitive ability batteries have long been recognized to be associated with a positive manifold (Burt, 1939): positive correlations of varying magnitudes between subtests. Despite consensus on the observation of a positive manifold in the area of conventional intelligence testing (Sternberg, 2003), the psychological significance of the positive manifold remains a contentious issue. Perhaps the most widely published explanation of the positive manifold is the general factor (*g*) theory of intelligence (Jensen, 1998).[1] Proponents of *g* factor theory contend that the *g* factor is an important psychological construct with many consequential outcomes (Jensen, 1998). According to the standard multifactorial view of cognitive abilities (Carroll, 2003), *g* factor theorists do not claim that *g* is the only factor of intelligence. Instead, *g* is considered the most substantial factor, alongside several, smaller, group-level factors (e.g., fluid intelligence, crystallized intelligence, visual intelligence, etc.). In addition to recognizing psychometric *g* as a representation of an important construct, *g* factor theorists typically posit that it is determined, in part, by several elementary processes and neurophysiological substrates. Examples of these fundamental processes and neurophysiological substrates include inspection time, reaction time, nerve conduction velocity, brain size, and genes (Deary, Penke, & Johnson, 2010). Although *g* factor theory research is frequently encountered in the published literature, several alternative theories have been proposed to explain the observation of the *g* factor. One of the more recent and increasingly popular theories is dynamic mutualism (Van Der Maas et al., 2006).

Dynamic mutualism (Van Der Maas et al., 2006) does not consider the *g* factor to be a statistical artifact, per se. Instead, the positive manifold associated with a diverse battery of cognitive ability tests is viewed as a robust empirical observation. However, the positive manifold (and the *g* factor) is contended to be an epiphenomenon. It is an epiphenomenon because the

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[1] In this paper, the term '*g* factor' is reserved for the general factor of intelligence. The term 'general factor' will also be used to refer to general factors within a broader context.

0160-2896/$ – see front matter
http://dx.doi.org/10.1016/j.intell.2013.11.004

positive correlations between subtests (or group factors) are theorized to emerge during human development, as a consequence of mutually beneficial interactions between originally uncorrelated cognitive processes. Thus, as the originally orthogonal cognitive processes interact beneficially over time, positive associations emerge between their respective capacities.

Unfortunately, the dynamic mutualism representation of cognitive abilities cannot be tested or falsified using confirmatory factor analysis (CFA), in the absence of imposing several implausible constraints to the model (Van Der Maas et al., 2006). However, one hypothesis that has been articulated by dynamic mutualism theorists is that the *g* factor should not be observed in very young children or infants: "…we expect that it takes some time for the positive manifold, and thus the psychometric *g* factor, to emerge" (Van Der Maas et al., p. 851). Although there are no widely regarded valid tests of intelligence for infants, the hypothesis may be considered testable indirectly by plotting the strength of the *g* factor across age, as valid measures of intelligence and normative databases are available for children as young as two-and-half years and adults of 90 years (e.g., Wechsler, 2002a, 2003a, 2008a). Based on the dynamic mutualism theory of the positive manifold, one would predict an appreciable upward slope associated with the strength of the *g* factor across age, particularly amongst those in relatively early development (2 to 4 years). By contrast, *g* factor theory, which postulates biological and genetic substrates for *g* (Jensen, 1998), may be suggested to predict the strength of the *g* factor to be largely constant across all ages. Consequently, the purpose of this investigation was to test these two competing hypotheses.

2. Previous related empirical research

Although there does not appear to be any empirical published research directly relevant to the dynamic mutualism theory of the *g* factor, some of the age differentiation hypothesis (Garrett, 1946) research may be considered pertinent, as some of these investigations included very young children (≤4 years). Although there is a relatively substantial amount of age differentiation hypothesis research that has been published, the review below is restricted to those investigations which included very young children (≤4 years) and high quality samples (i.e., normative test samples), as these were considered relevant to the hypothesis central to this investigation.

Tideman and Gustafsson (2004) tested the age differentiation hypothesis based on data from four age groups (3, 4, 5 and 6 years old) derived from the *Wechsler Preschool and Primary Scale of Intelligence - Revised* (WPPSI-R; Wechsler, 2002a) Swedish normative sample ($N = 221$ to 280 in each group). As the WPPSI-R was designed to measure two correlated factors (verbal and performance), Tideman et al. estimated an oblique factor model. The magnitude of the correlation between the two latent variables was considered representative of the degree of differentiation, whereby a smaller correlation was indicative of greater differentiation. The oblique two-factor model correlations across the ages of 3, 4, 5, and 6, years were reported at .78, .72, .54, and .58, respectively, thus suggesting a reduction in the size of the *g* factor across age. Tideman et al. interpreted their results as supportive of the age differentiation hypothesis. Furthermore, the inter-latent variable correlation of .78 is suggestive of a non-negligible positive manifold associated with cognitive ability tests measured in 3-year-olds.

Hülür, Wilhelm, and Robitzsch (2011) used the normative sample data from the Snijders–Oomen Nonverbal Intelligence Test (SON-R 2.5–7; Tellegen, Laros, & Petermann, 2007) battery which was developed to measure two intelligence factors (performance and reasoning) in children between the ages of 2.7 and 7 years. To evaluate the strength of the positive manifold across age, Hülür et al. plotted the correlation between the performance and reasoning latent variables. At age 2.5, the correlation was .92 and peaked in magnitude at age 3.8 ($r =$ .96). The magnitude of the correlation reduced in size progressively to $r = .86$ up to the age of approximately 7 years (the maximum age in the data set). Thus, as approximately 85% of the true score variance between the two latent variables was shared at the age of 2.5, a non-negligible positive manifold may be suggested to have been observed with cognitive ability test scores of very young children. Hülür et al. interpreted their results as consistent with the age differentiation hypothesis.

Finally, Tucker-Drob (2009) analyzed the normative sample data associated with the Woodcock Johnson-III (WJ-III; Woodcock, McGrew, & Mather, 2001), which was designed to measure seven group-level factors and a second-order *g* factor. The WJ-III normative sample includes participants from the ages of 4 to 80. Tucker-Drob's analysis of the data was novel in that it incorporated both linear and non-linear relations between variables, which may be expected to yield greater levels of shared variance. The strength of the *g* factor across age was determined based on the magnitude of the second-order factor loadings (or communalities, more precisely) associated with a higher-order model of the WJ-III. An increasing trend in the magnitude of the second-order factor communalities across age was reported, although the effects appeared to be restricted to *Gc* and *Gv*. Although the results were interpreted by Tuker-Drob as possibly consistent with the dynamic mutualism theory of *g*, it will be noted that a *g* factor was observed in the data associated with the youngest children included in the analysis.

The three investigations reviewed above shared in common the observation that there appears to have been a positive manifold amongst cognitive ability test scores in young children. That is, across all three investigations, either substantial inter-latent variable correlations or second-order factors loadings were observed in cognitive ability data derived from young children. However, it should probably be acknowledged that the SON-R 2.5–7 is not a comprehensive measure of intelligence, as there are no subtests relevant to crystallized intelligence or memory, for example. Thus, the general cognitive process represented by the correlation between the two factors measured by the SON-R 2.5–7 battery should probably be considered rather narrow. Additionally, the Tucker-Drob (2009) investigation included children only as young as four years old.

Even more importantly, however, than the limitations identified above, the magnitude of the correlation between two latent variables, and the magnitude of second-order factor loadings associated with a general factor, are arguably not valid indicators of the strength of a general factor. As will be demonstrated below, the magnitude of a correlation between two latent variables, as well as the magnitude of second-order factor loadings, can increase when the average correlations between subtests *decrease* in magnitude. Arguably,