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## The factorial structure of cognitive abilities in childhood



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### KEYWORDS

Structure of  
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**Abstract** Recent studies have shown contradictory evidence regarding cognitive abilities differentiation and organization in childhood. Cattell's investment theory postulated that during the early stages of life, the individual begins with a single and general ability (fluid intelligence), in which the relevance tends to decrease during adolescence, due to the appearance of differentiated abilities developed through the process of socialization and associated with the motivations, interests and experiences. This study analyses whether the factorial structure of the results in a battery of tests supports the existence of a general factor or, instead, a structure formed by different specific factors. A sample of 472 Portuguese children, aged between 4 and 10 years old, completed the Cognitive Competencies Scale for Children (ECCOs 4/10), and four subtests of the Wechsler Intelligence Scale for Children-Third Edition (WISC-III) and Wechsler Preschool and Primary Scale of Intelligence – Revised (WPPSI-R). The adjustment of some models that reflect different psychometric theories of intelligence was tested by several confirmatory factor analyses (CFA). The implications of the tested models in the organization of cognitive abilities for cognitive development and school learning in childhood are also discussed. © 2015 European Journal of Education and Psychology. Published by Elsevier España, S.L.U. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

### PALABRAS CLAVE

Estructura de la  
inteligencia;  
Factor g;  
Diferenciación  
cognitiva;  
Infancia

### La estructura factorial de las habilidades cognitivas en la infancia

**Resumen** Estudios recientes señalan evidencias contradictorias con respecto a la diferenciación y organización de las habilidades cognitivas en la infancia. La teoría de la inversión de Cattell sostiene que durante las primeras etapas de la vida, el individuo comienza con una habilidad general (inteligencia fluida), cuya relevancia tiende a disminuir debido a la aparición durante la adolescencia de habilidades diferenciadas desarrolladas a través del proceso de socialización y que están asociadas a las motivaciones, intereses y experiencias. Con este

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estudio se pretende investigar si la estructura factorial de los resultados en una batería de pruebas apoya la existencia de un factor general o, en cambio, una estructura formada por diferentes factores específicos. Una muestra de 472 escolares portugueses, con edades entre los 4 y 10 años, llevó a cabo la *Escala de Competências Cognitivas para Crianças* (ECCOs 4/10) y cuatro sub-pruebas del *Wechsler Intelligence Scale for Children – Third Edition* (WISC-III) y *Wechsler Preschool and Primary Scale of Intelligence – Revised* (WPPSI-R). El ajuste de algunos modelos que reflejan diferentes teorías psicométricas de la inteligencia se puso a prueba mediante varios análisis factoriales confirmatorios (AFC). Se analizaron además las implicaciones de los modelos probados en la organización de las habilidades cognitivas para el desarrollo cognitivo y para el aprendizaje escolar en la infancia.

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## Introduction

The controversy surrounding the cognitive differentiation or, in other words, a general intelligence versus different intellectual abilities, has been debated since the 20th century, continuing currently unclear whether intelligence is less complex in young children or if is simply more difficult to assess (Almeida, Guisande, Primi, & Lemos, 2008; Carroll, 1993; Keith & Reynolds, 2010). The differentiation hypothesis has been linked to two different phenomena: the first one refers to the differentiation that can be observed at different levels of ability, but in the same age groups (Abad, Colom, Juan-Espinosa, & García, 2003; Coyle & Rindermann, 2013; Facon, 2006; Jensen, 2003; Kane, Oakland, & Brand, 2006; Reynolds & Keith, 2007; Reynolds, Keith, & Beretvas, 2010); the second one, over which this study concerns, relates to the differentiation that comes from development and learning, which is visible in different age groups. Garrett (1946) was the first to propose the age differentiation hypothesis arguing that the child's development would be accompanied by a change in terms of its intelligence structure, once its general ability would gradually give rise to a different set of specific abilities. Operationally, this would mean that the correlations between cognitive abilities measures would decrease during the child's development.

Cattell's investment theory (Cattell, 1971) proposes that during the early stages of life, the individuals begin with a single general ability (fluid intelligence, *Gf*) whose relevance tends to decrease due to the emergence and development of specific abilities (crystallized intelligence, *Gc*), seen as the result of life experiences, learning, interests and motivations (Horn & Noll, 1997; McArdle, Hamagami, Meredith, & Bradway, 2000). However, recent studies show contradictory evidence regarding the differentiation of cognitive abilities with age. Some studies have been unable to support this hypothesis (Juan-Espinosa et al., 2002; Juan-Espinosa, Cuevas, Escorial, & García, 2006; Molenaar, Dolan, Wicherts, & van der Maas, 2010; Rietveld, Dolan, Baal, & Boomsma, 2003), although there is a considerable amount of studies that support the progressive differentiation of intellectual abilities. Li et al. (2004), after dividing a sample of 291 individuals into six age groups ranging from 6 to 89 years old, found that the correlations between *Gf*

and *Gc* in the adolescents and adults had a lower magnitude than the correlations in young children and older adult groups, and that the same trend was present in the percentage of variance in cognitive and intellectual measures explained by the first factor in a factorial analysis. Tideman and Gustafsson (2004) applying a multi-group confirmatory modeling approach, tested different factor structures using data ( $N = 1,047$ , 3–7 years of age) from *Wechsler Preschool and Primary Scale of Intelligence – Revised* (WPPSI-R) and demonstrated that the correlation between the two factors model (verbal and performance factors) diminishes as function of age, from .78 for the youngest age-group (3 and 4 years) to .53 to .58 for older age-groups (5 and 6 years). Kane and Brand (2006), from the results obtained in the *Woodcock-Johnson-Revised Tests of Cognitive Ability* (WJ-R) found support for the belief that the cognitive abilities effectively differentiate as a function of development, in that *g* accounted for substantially less variability among adolescents (13–22 years) than among children (6–12 years), regardless the level of ability. More specifically, for low-ability group, Spearman's *g* (1927) was associated with 53% (children) and 21% (adolescents) of the variability in performance, while in the high-ability group the Spearman's *g* accounted respectively 62% (children) and 26% (adolescents) of the variance. To conclude, note that some of these studies support the emergence of different cognitive factors in childhood. For example, Tusing and Ford (2004) used tests and subtests from the *Differential Ability Scales: Upper Pre-school Level* (DAS) and the WJ-R with a sample of 158 children between 4 and 5 years of age in a series of joint factor analyses and five broad ability factors were reliably identified: crystallized intelligence (*Gc*), long-term memory (*Gl*), short-term memory (*Gsm*), auditory processing (*Ga*), and a fifth factor referred to as nonverbal ability.

Given the controversy described, we intend to verify the possibility of a cognitive differentiation in childhood. Thus, through confirmatory factor analyses of results in a set of subtests from two intelligence batteries, it is intended: firstly, describe the structure of the cognitive abilities of children through the validation of some psychometric theories of intelligence; and, secondly, determine if these structures remain unchanged when analyzing the results divided into three age groups.

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