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The relationship between intelligence and academic achievement throughout middle school: The role of students' prior academic performance

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ABSTRACT

The association between intelligence and academic achievement is well established. However, how this relationship changes throughout schooling remains undefined. In this 3-year longitudinal study, 284 Portuguese middle school students completed three reasoning subtests (abstract, numerical, and verbal) by the end of 7th grade (intelligence), and their academic grades were collected at the same time (prior academic achievement, AA7) and by the end of 9th grade (final academic achievement, AA9). The main findings show that i) when intelligence and AA7 are analyzed as two independent predictors of AA9, AA9 is best predicted by intelligence when considering the mediation effect of AA7, and ii) the inclusion of AA7 in the pathway between intelligence and AA9 produces a considerable increase in the predictive validity of intelligence. Implications for cognitive assessment and psychological practice are emphasized based on this Gf–Gc relationship.

1. Introduction

An extensive body of research has been developed in order to understand the relationship between intelligence and achievement in different life domains, such as job performance (Gottfredson, 2002; Schmidt & Hunter, 2004), health outcomes (Der, Batty, & Deary, 2009), or even wealth (Zagorsky, 2007). Particularly in educational settings, intelligence plays a crucial role in learning and academic performance. Several studies show high correlation indices between them, ranging from .50 to .70 (Lynn & Vanhanen, 2012). For instance, Mackintosh (1998) revealed a .50 correlation between 11-year-olds' intelligence scores and later educational achievement at the age of 16. In addition, in a 5-year longitudinal study with 70,000 children, Deary, Strand, Smith, and Fernandes (2007) found a .81 correlation between intelligence at the age of 11 and educational achievement at the age of 16 in 25 academic subjects. Other studies also identify intelligence as a relevant predictor of academic achievement (Colom & Flores-Mendoza, 2007; Karbach, Gottschling, Spengler, Hegewald, & Spinath, 2013; Laidra, Pullmann, & Allik, 2007; Lemos, Abad, Almeida, & Colom, 2013; Primi, Ferrão, & Almeida, 2010; Rohde & Thompson, 2007; Watkins, Lei, & Canivez, 2007; Weber, Lu, Shi, & Spinath, 2013).

General intelligence, also named fluid intelligence – Gf (Cattell, 1971), is usually measured by administering tests of inductive and deductive reasoning, which are assumed to reflect the ability to think, solve problems, make inferences, identify relations, and transform information in a significant way (Lemos, Almeida, & Colom, 2011; Nickerson, 2011). Longitudinal growth modeling attests that Gf predicts, not only the initial level of math achievement, but also, the rate of change in learning and achievement (Primi et al., 2010).

In turn, academic achievement is usually measured by administering tests to assess knowledge that is formally taught in schools. As a broad concept, achievement could be associated with crystallized intelligence – Gc, which is defined as the "depth and breadth of knowledge that are valued by one's culture" (Schneider & McGrew, 2012, p. 122).

Accordingly, Schneider (2013) claims that intelligence is related to potential, and achievement to the execution of potential. Although considered as separate abilities, both are viewed as two aspects of the g factor according to Cattell's investment theory (1971). In light of Cattell's model, fluid intelligence is one of the main causes of achievement, since more capacity to learn predicts more efficient and rapid learning. This potential is invested in experiences, and is transformed into knowledge, that is, crystallized intelligence. In the process of transformation of potential (Gf) into fulfilled potential (Gc), other factors play a role, such as

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availability, or quality of formal (e.g., school) and informal (e.g., family, or community) learning experiences, and also, personal factors, such as interests, motivation, and persistence (Kvist & Gustafsson, 2008).

In this sense, when hypothesizing which factor best predicts final academic achievement (academic achievement measured in time 2) – if prior academic achievement (academic achievement measured in time 1), or if Gf – there are three underlying issues. First, fluid intelligence is recognized as a causal factor in learning, especially in novel situations, supporting the acquisition of new skills and knowledge (Voelkle, Wittmann, & Ackerman, 2006; Watkins et al., 2007). Second, crystallized intelligence is not only a reflection of Gf, it also includes the specific ability of knowledge, which in turn will facilitate acquisition of more complex knowledge (Schneider, 2013; Schneider & McGrew, 2012). Third, academic curriculum is organized by progressive levels of complexity and difficulty in a temporal dimension (Dochy, De Ridjt, & Dyck, 2002; Harackiewicz, Barron, Tauer, & Elliot, 2002; Trigwell, Ashwin, & Millan, 2013). Based on these evidences, the present paper examines the hypothesis that, in longitudinal measurements of Gf and academic achievement in time 1 and academic achievement in time 2, the academic achievement measured in time 1 will be a more important predictor of academic achievement in time 2, when compared to the predictive value of Gf.

In short, this study aims to examine the relationship between intelligence, prior academic achievement (both measured in time 1) and final academic achievement (measured in time 2) in a 3-year longitudinal design. Intelligence scores were obtained at the beginning of middle school (7th grade), and repeated measures of students' academic achievement were collected at the same time and by the end of middle school, when these students were in 9th grade.

Two models were tested. Model 1 tests the hypothesis that fluid intelligence and prior academic achievement add unique prediction value of academic achievement in time 2 (final academic achievement). This model is related to the hypothesis that, although related abilities, Gf–Gc have specific variance that will account for part of the achievement in a later time. Model 2 tests the hypothesis outlined from the investment theory. It states that crystallized intelligence (related with academic achievement) is a close reflection of fluid intelligence. Therefore, crystallized intelligence in time 1 should be a significant predictor of academic achievement in time 2, that is, prior academic achievement predicts final academic achievement. Fluid intelligence will play a role on the explanation of final academic achievement only by the mediation of prior academic achievement. This means that the ability to learn, measured by fluid intelligence tests, will be reflected in high levels of knowledge acquired in time 1, and this shared information in scores of achievement will be the only predictor of academic achievement in time 2. If only fluid intelligence and final academic achievement are considered, the predictive validity of fluid intelligence should be confirmed. However, when we also include prior academic achievement as a predictor, the unique contribution of fluid intelligence will be reduced, since it is already reflected in the academic achievement measurement in time 1.

Although investment theory (Gf–Gc) has been proposed a long time ago (cf. Cattell, 1971), only a few longitudinal studies have been presented with similar characteristics to the present paper, which tests its prediction value. Moreover, in case our hypothesis is confirmed, it brings relevant implications to psychological practice. Indeed, the relevance of prior academic achievement and the role played by crystallized intelligence to explain subsequent learning and achievement imply that the cognitive assessment of students' learning difficulties should not be based only on standard intelligence tests.

2. Method

2.1. Participants

A total of 284 Portuguese adolescents enrolled in three public schools located in the northern suburbs of the country participated in this study. These students were first assessed in 7th grade (the beginning of middle school), when they were 12–13 years old ($M = 12.27$, $SD = 0.75$), and 2 years later when they were in 9th grade (the end of middle school). All 284 students participated in both assessment times, and no missing values were registered. Participants were equally distributed by gender (49% boys and 51% girls).

In Portugal, compulsory education is organized in three basic levels of education, and also, a secondary education level. The “1st cycle” concerns a 4-year basic education; “2nd cycle” refers to 5th and 6th grade; “3rd cycle” is equivalent to middle school, composed of 7th, 8th and 9th grades; and finally, there is secondary education, from 10th to 12th grade. This study considered adolescents in the “3rd cycle” of basic education (i.e., middle school).

2.2. Measures

2.2.1. Reasoning Tests Battery

Intelligence was assessed with the Reasoning Tests Battery (RTB), using a version designed for middle school students (RTB7/9; Almeida & Lemos, 2007). The RTB is composed of five reasoning subtests that measure the ability to infer and apply relationships between elements that make part of a problem or a situation considering different contents (abstract reasoning, verbal reasoning, numerical reasoning, mechanical reasoning, and spatial reasoning). In this study, by the end of the third trimester of the 7th grade, students completed three of the five subtests, the ones more directly related to academic learning, namely, abstract reasoning ([AR]; 25 figural analogies in 5 min); verbal reasoning ([VR]; 25 verbal analogies in 4 min); and numerical reasoning ([NR]; 20 numerical series in 10 min).

Reliability indices were estimated using test–retest and internal consistency methods; the coefficients obtained in different samples are appropriate and assure the use of this intelligence instrument, as shown elsewhere (Lemos et al., 2011). A factor analysis suggests a common or general factor explaining 50–60% of the variance. Reliability indices were appropriate, with α values about .77, .83 and .73 for AR, NR and RN, respectively (Almeida & Lemos, 2007). More recently, a confirmatory factor analysis testing a general factor revealed appropriate fit indices, $\chi^2 = 15.7$, CMIN/DF = 3.1, RMSEA = .033, and CFI = .99 (Lemos et al., 2011).

2.2.2. Academic achievement

The measures of students' academic achievement were obtained in two assessment times: by the end of 7th grade, and exactly 2 years later, by the end of 9th grade. In this study, academic achievement in 7th grade will be referred to as students' prior academic achievement. Academic achievement in 9th grade is named as students' final academic achievement.

Each academic achievement measure was calculated as a result of four subjects, collected from the administrative school's offices: Language (Portuguese), foreign language (English), sciences, and mathematics. These four subjects are usually referred by teachers as critical indicators to infer the quality of learning, and a privileged source of information concerning the level of academic achievement of each student. In the Portuguese school system (from 5th to 9th grade), teachers evaluate their students using a grading system that ranges from 1 to 5 points in each subject (1 and 2 = failure; 3 to 5 = approval).