Prediction of school achievement through a multi-factorial approach – The unique role of chronotype

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ARTICLE INFO

ABSTRACT

The present study examined the predictability of school achievement with variables from biosocial, cognitive, and psychological domains: gender, chronotype, intelligence, and conscientiousness. Results showed a positive relationship between GPA and chronotype ($r = 0.13$), GPA and intelligence ($r = 0.34$), and between chronotype and conscientiousness ($r = 0.22$). The predictors together explained about 14% of variance in GPA. The variance in school achievement was explained the most by intelligence followed by gender and chronotype. Chronotype was significantly correlated with school achievement even when controlled for the effects of intelligence and gender. These findings add to our knowledge about the nature of school achievement and also about the particular role of chronotype in learning.

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1. Introduction

When striving for a deeper understanding of human phenomena, it is advised to view them as multi-dimensional with manifold layers emerging on top of others. That is, more than one prerequisite is involved in the formation of biologically or culturally driven concepts. Therefore, variables contributing to school achievement vary from biological to cognitive, behavioral and social ones. Thus, in the present study, we examined the predictive power of biopsychological, cognitive, behavioral, and social variables for school achievement as outcome. Chronotype and gender were employed as biosocial predictors, intelligence as a cognitive one, and conscientiousness as a personality variable. Another focus of this study was to assess the incremental contribution of chronotype to school achievement in a non-Western sample. To the present, this aspect has not been investigated in Iranian students, and we would like to elaborate on it, since Iran has a fairly different school system and cultural setting. Here we introduce the predictors and their explicit role in an academic outcome one by one and then explain how this study differs from earlier ones.

1.1. Chronotype

One important aspect of humans' sleep-wake behavior is their preferred sleep-wake time. Based on this distinction three differentiated chronotypes have been identified: 'Morning' ones are those who go to bed earlier and wake up early in the morning, feel fresh in the morning and get tired early in the evening; 'evening' types tend to have their sleep at a later time, get up later in the morning, and feel more energetic in evening hours; and finally, 'Neither' types are the ones with a fair sleep and rising time and locate in-between. Others (e.g., Natale & Cicogna, 2002) see these variations as a continuum from extreme morningness to extreme eveningness. Research shows a constant but small correlation between being more shifted toward morningness and a better grade in school (Preckel, Lipnevich, Schneider, & Roberts, 2011; Vollmer, Pötsch, & Randler, 2013) or in university (Beşoluk, 2011). In two reviews (Preckel et al., 2011; Tonetti, Natale, & Randler, 2015), it was indicated that there was a constant negative relationship between eveningness and school achievement, however the relationship was weaker in university students (Tonetti et al., 2015). This is probably because of the early schools starting times in the morning that make the school students get up early in the morning even though it might not fit their preferred time for learning.

1.2. Intelligence

Cattell (1971) differentiates between fluid and crystallized intelligence. Fluid intelligence is the ability of solving problems without relying on past experiences or learning. On the other hand, crystallized intelligence is the ability to employ tools and activate prior knowledge to solve problems. Among the most relevant predictors of academic achievement are cognitive abilities (e.g., Mayes, Calhoun, Bixler & Zimmerman, 2009) and intelligence has been identified as a key variable of cognitive performance which directly affects academic

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achievement. In a plethora of studies and several meta-analyses, it has been strongly evidenced that intelligence can solely predict about 40–70% of the changes in academic achievement's variance (Mackintosh, 1998; Brody, 1992; Gustafsson & Undheim, 1996; Jensen, 1998; Gottfredson, 2002). Rohde and Thompson (2007) examined the effect of intelligence as a general cognitive ability while some specific cognitive abilities like working memory, processing speed, and spatial speed were present. The results yielded a unique role of intelligence in prediction of academic achievement even when controlled for the specific cognitive abilities. In another study (Laidra, Pullmann, & Allik, 2007), intelligence and Big Five personality traits have been employed to predict academic achievement. Findings indicated that, even when all the variables were entered into a regression model, intelligence was the strongest predictor of GPA.

1.3. Conscientiousness

Conscientiousness is characterized by the tendency to follow socially prescribed norms for impulse control, to be goal-directed, plan-oriented, able to delay gratification, and to follow norms and rules (Roberts, Jackson, Fayard, Edmonds, & Meints, 2009). Among the Big Five personality dimensions – alongside openness to experience, extraversion, agreeableness, and neuroticism (Costa & McCrae, 1989), conscientiousness is the only one which has a steady positive relationship with morningness (e.g. Adan et al., 2012; Randler, 2008; Walker, Kribs, Christopher, Shewach, & Wieth, 2014) and academic achievement (Arbabi, Vollmer, Dörfler, & Randler, 2015; Paunonen & Ashton, 2001). In connection with this research area, two meta-analyses (O'Connor & Paunonen, 2007; Vedel, 2014) have been performed, suggesting that conscientiousness is the strongest personality correlate of academic achievement among the other personality dimensions ($r = 0.25$). Despite this remarkable association, studies are inconclusive on the relationship between conscientiousness and cognitive ability (e.g., positive association: Arbabi et al., 2015; negative association: Moutafi, Furnham, & Paltiel, 2004; and no relationship: Ackerman & Heggestad, 1997). Since conscientiousness is tightly connected to both morningness and better grades in an academic environment, it has a high priority to be taken into account as one of the critical predictors of school achievement.

1.4. Gender

Gender also has an impact on school grades because girls and boys differ in certain cognitive abilities and school domains. For example, a review spanning over 24 years (Nowell & Hedges, 1998) exhibited a tendency in girls to achieve higher scores in tests of reading, perceptual speed, and writing whereas boys outperformed girls in mathematics, science, and the composite. This pattern was stable over the time period considered by Nowell and Hedges (1998). However, the gender differences in mathematics and science were not as pronounced. Still, taking GPA into consideration as the main indicator of school achievement has eventuated in girls' grades exceeding boys' (Chee, Pino, & Smith, 2005; Freudenthaler, Spinath, & Neubauer, 2008). Others have pointed to a gender similarity hypothesis contending that boys and girls are similar on most, but not all psychological variables (see Hyde, 2005).

1.5. Other predictors of academic achievement

Aside from chronotype, intelligence, conscientiousness, and gender, there are relevant predictors which are not addressed by the present study. For example, a meta-analysis by Crede, Roch, and Kieszczynka (2010) concluded that class attendance has a strong relationship with class grades ($r = 0.44$) and GPA ($r = 0.37$). Also, academic motivational beliefs (Eccles et al., 1983), situational interest (learning emotions), subject-specific dispositional interest (Krapp, Hidi, & Renninger, 1992), and self-efficacy (Ferla, Valcke, & Cai, 2009; Robbins et al., 2004) are predictors of academic achievement.

1.6. Iran's educational context

While most of the studies on chronotype and academic achievement are from Western countries (e.g., Henrich, Heine, & Norenzayan, 2010), the present study was implemented in a quite different cultural setting, in Iran, which, at the time that our participants started their schooling, had five years of elementary school, three years of middle school, and four years of high school (since 2011 it has changed to a 6-3-3 school system). In addition, some Iranian students have experienced rotating school shifts (i.e. one week morning-hours school time and the following week afternoon-hours school time) during their elementary or middle school, for which it is worthy to consider the effect of sleep habits in this context. Another interesting aspect, which might justify entering gender as an important variable in this study, might be the fact that boys and girls in Iran are segregated at school or they go to male or female schools based on their sex and this covers all the school years until they reunite again when they enter university.

1.7. The present study

The major aim of our study was to assess the relationship between GPA and chronotype, which was done in bivariate correlations in many countries (see Tonetti et al., 2015) and by maximizing the power of prediction of school achievement by using well-known control variables that impact on school achievement. Thus, we wanted to present a more complex picture from the Iranian context. Since the variables addressed by the present study originate from different areas of research and are all associated with achievement, we assume they could explain a notable share in the variance of Iranian GPA. In a previous study carried out in Iran on the effect of chronotype on school achievement by controlling test anxiety, gender, and conscientiousness, researchers found that gender followed by test anxiety were the strongest predictors of school achievement (explained 15.8% of GPA variance) and chronotype was not a significant predictor but it was significantly mediated by conscientiousness in its relationship with school achievement only in girls (Rahafar, Maghsudloo, Farhangnia, Vollmer, & Randler, 2016). However, the authors did not control for the effect of intelligence as the strongest predictor of school achievement and a correlate of eveningness (Preckel et al., 2011). In a recent study, Arbabi et al. (2015) estimated predictors of educational outcomes using almost the same variables as the present study (in addition, they used learning motivation and midpoint of sleep) in a group of 10-year old German pupils in primary school ($N = 1125$). Their findings revealed that intelligence was the strongest predictor of academic achievement followed by conscientiousness. Moreover, although chronotype did not contribute to GPA directly, it increased the share of GPA variance when mediated by midpoint of sleep and conscientiousness. The uniqueness of our study was to test this set of variables among the students in the last grade of high school. At this age (17–18 years of age), the majority of teenagers are evening oriented (Roenneberg et al., 2004) and a great number of students experience sleep deprivation which influences their achievement, in turn (Andershed, 2005). Second, we used GPA as a standard report of an Iranian nationwide test rather than relying on self-reported grades as in similar studies. The GPA here was an average score of 13 different subjects, which reflects the academic outcome more precisely as compared to single subject grades or an average of a few of them. Lastly, in the present study we employed intelligence to control for its considerable amount of shared variance with school achievement, which has not been considered by Rahafar et al. (2016). Therefore, the main goal of this study was to see whether the relationship between morningness and school achievement still remains significant when we control for confounding variables. The second major aim was to apply this study in Iran. As Henrich et al. (2010) pointed out, most studies in psychology