Journal of Youth and Adolescence
https://doi.org/10.1007/s10964-021-01539-4

EMPIRICAL RESEARCH

Does Self-control Outdo IQ in Predicting Academic Performance?

Alexander T. Vazsonyi[1] · Magda Javakhishvili[2] · Marek Blatny[3]

Received: 8 October 2021 / Accepted: 1 November 2021

Abstract
Duckworth and Seligman's seminal work found that self-discipline (self-control) was more salient for academic achievement than intelligence. Very little replication work exists, including in different cultures; the current study addressed these gaps. Data were collected from 6th and 7th grade cohorts of early adolescents ($N = 589$; age: $Mean = 12.34$ years, and $SD = 0.89$; 58% female) over two years. The study tested whether self-control was a stronger predictor than intelligence in explaining academic performance two years later as well as in explaining developmental changes over the course of two years. Path analyses provided evidence that both self-control and intelligence longitudinally predicted teacher-reported academic competence as well as school-reported grades; however, intelligence was a significantly stronger predictor than self-control. In addition, only intelligence predicted developmental changes in each measure of academic performance over time, self-control did not.

Keywords Academic achievement · Self-discipline · Intelligence · Schools · Individual differences

Introduction

Understanding the ways in which students' academic achievement can be explained as well as improved is important because their future educational and occupational opportunities depend on it. Duckworth and Seligman's (2005) seminal work identified self-discipline (measured mostly by self-control instruments) as key to promoting academic achievement, in fact, more important than intelligence. Very few longitudinal studies, including outside of North America for generalizability, have followed since to replicate and further test this important finding. Thus, there remains a great need to do so, to better understand whether and how self-control outperforms measures of intelligence in accounting for variability in measures of academic performance. In addition, previous research has not tested the importance of other well-known correlates and predictors of academic achievement, including student motivation or school attachment, vis-à-vis self-control and intelligence. The current longitudinal study sought to address these gaps in the literature by testing whether self-control was in fact a stronger predictor of academic performance over time as well as of developmental changes in academic performance, and whether academic motivation or perceived school attachment uniquely explained additional variability in measures of academic performance, above and beyond the effects of self-control and intelligence.

Intelligence is known to be highly heritable, stable, and predictive of many important educational, occupational, and health outcomes, perhaps more so than any other trait (Plomin & von Stumm, 2018). Intelligence is a person's capacity to form comparisons, to reason by analogy, and to develop a logical method of thinking regardless of previously acquired information (Gottfredson, 1997). Self-discipline or self-control, on the other hand, is the ability to alter or override dominant response tendencies and to regulate one's behavior, to control impulses to act and astutely consider its consequences (De Ridder & Lensvelt-Mulders, 2018). Self-control has been found to be consistently associated with both internalizing and externalizing problems (Li et al., 2015; Vazsonyi et al., 2017), with academic and interpersonal success (Tangney et al., 2004), with career prospects and success (Daly et al., 2015), the quality of friendships and family relationships (Evans et al., 1997).

✉ Alexander T. Vazsonyi
vazsonyi@uky.edu

[1] University of Kentucky, Lexington, KY, USA

[2] John Jay College of Criminal Justice, City University of New York, New York, NY, USA

[3] Masaryk University, Brno, Czech Republic

Published online: 20 November 2021

Previous work (Duckworth & Seligman, 2005), based on the data from 8th grade US students, followed over 7 months, found that self-discipline (a composite measure of student-, parent-, and teacher-ratings and behavioral tasks, principally assessing self-control) predicted GPA twice as strongly as IQ did. Additionally, testing longitudinal changes, self-discipline significantly predicted GPA, net any effects by baseline GPA and IQ, whereas IQ did not. In a follow-up study (Duckworth et al., 2012), both self-control and IQ predicted developmental changes in report card GPA (from 8th to 9th grade), though the observed effect for IQ was more modest; however, only IQ predicted changes in standardized achievement scores. The authors (Duckworth et al., 2012) theorized that this could be because standardized achievement test scores quantify competencies that stem primarily from intelligence, whereas report card grades are based on competencies attained through diligence, hence the observed differences in study findings.

Academic achievement, performance, and for this matter, any criterion of academic success, would be expected to be influenced by intelligence or self-control only to the extent that these qualities are consistent with existing educational goals. Differences in the relationships between intelligence and academic achievement, or self-control and academic achievement will vary depending on what is required from students at any given stage of schooling to succeed. This is one of the main reasons why replications of these findings are very much needed across different developmental and cultural contexts, characterized by different educational systems and institutions, although there is little reason to believe that contextual effects would impact these relationships.

The search for influential predictors of academic achievement beyond IQ is certainly not new (Barton et al., 1972). It has been directed primarily at personality traits (particularly conscientiousness, or impulsivity) and self-regulatory abilities. However, less attention has been paid to motivational variables until quite recently (e.g., Valiente et al., 2007), although rarely tested together with intelligence. Several meta-analyses exist on the subject, highlighting the significance of these so called non-intellective constructs.

A meta-analysis by Roth et al. (2015) reported strong positive associations between standardized intelligence scores and school grades. Other meta-analyses have demonstrated significant positive links of self-control, as well as its related characteristics, such as doing homework and conscientiousness, with academic achievement (De Ridder & Lensvelt-Mulders, 2018; Fan, Xu, Cai, He & Fan, 2017; Kim & Seo, 2015; Poropat, 2009; Richardson et al., 2012) and between motivation and academic performance (Cerasoli et al., 2014). Fan et al. (2017) reported that the positive association between doing homework and achievement in math and/or science was particularly pronounced in studies conducted in the U.S. compared to those conducted in Asia and Europe.

Previous research from different cultural contexts, both cross-sectional and longitudinal, supports an incremental predictive utility of self-control as well as of motivation above and beyond intelligence in academic achievement. For instance, based on a sample of 4th grade students from Germany and Chile ($N = 76$, and 167; Weis et al., 2016), a positive association between children's behavior regulation and school achievement (operationalized as school grades in mathematics and language) was found, controlling for effects by intelligence (assessed by Raven's Progressive Matrices). Among 3rd grade German students ($N = 789$; Von Suchodoletz et al., 2015), both intelligence and self-control were positively associated with reading fluency (assessed by standardized achievement tests), however, the effect of intelligence was significantly larger than that of self-control. Similar findings have been reported among Russian and Estonian school-aged adolescents (Morosanova, Fomina, & Bondarenko, 2015; Laidra et al., 2007).

Regarding motivation, there have been mostly mixed findings. For instance, among German students (Fischer, Schult, & Hell, 2013), a significant positive association was found between achievement motivation and the secondary school success, controlling for the effect of intelligence. However, based on the data from female students in Canada (age 12–14 years; Gagne & St Pere, 2002), no relationship was found between student motivation and academic achievement above and beyond cognitive ability, measured by Raven's Progressive Matrices (the same measure used in the current study).

School attachment refers to the sense of connectedness or belonging to school and has been shown to predict better academic achievement in socio-economically and ethnically diverse populations of school-age youth (Niehaus et al., 2012; Bond et al., 2007). However, it appears that research about school attachment has rarely included other known correlates (e.g., self-control or intelligence) as covariates to further test and clarify the observed relationships.

Surprisingly, there remains a general scarcity of longitudinal work, building upon or simply replicating the work by Duckworth and colleagues, particularly with longer-term follow up, with two exceptions. One study (Hofer et al., 2012) tested the predictive power of cognitive ability and self-control strength for self-reported grades and an achievement test score (measured by the Third International Mathematics and Science Study questions-TIMSS) over the course of eight months in a sample of $N = 697$ 8th graders in Germany. Findings revealed that self-control was a better predictor of self-reported grades, while cognitive ability better predicted the achievement test score. Another study (Murayama et al., 2013) based on a sample of $N = 3530$ German youth followed from 5th through 10th grade found that the initial level of achievement was strongly related to intelligence, with motivation and cognitive strategies

explaining unique variance; however, intelligence was unrelated to changes in achievement over time, whereas motivation and learning strategies both significantly predicted positive and negative growth.

In conclusion, few longitudinal investigations have followed the seminal work and findings by Duckworth and Seligman (2005), with the noted exceptions. The subsequent evidence has been at least partially supportive of the original findings; however, there remains a need to replicate and build upon this original work, to better understand the extent to which self-control (or self-discipline) does outperform measures of intelligence in explaining variability in measures of academic performance. This is also true for work that seeks to replicate the original work across different cultures, as there is no reason to believe that the effects of either self-control (e.g., Vazsonyi et al., 2017) or intelligence (e.g., Lynn et al., 2007) would vary across different developmental contexts.

Current Study

The present study sought to replicate and extend previous work focused on the importance of self-control, intelligence, motivation, and school attachment for student academic performance or achievement. It extends previous work by studying youth in the Czech Republic and by studying the question longitudinally, over the period of two years. Consistent with Duckworth and Seligman's (2005) original findings, and with previous research, it was hypothesized that self-control would longitudinally predict teacher-reported academic competence as well as school-reported grades, more strongly than intelligence (Hypothesis 1); that self-control would predict developmental changes between Time 1 and Time 4 in teacher-reported academic competence as well as school reported grades, more so than intelligence (Hypothesis 2). Finally, it was expected that student academic motivation and school attachment (i.e., positive attitude about school) would uniquely predict teacher-reported future academic competence as well as school-reported grades (longitudinally and developmental changes), net any effects of self-control and intelligence (Hypothesis 3).

Methods

Participants

Data were collected as part of the Brno Longitudinal Study of Youth (BLSY), an accelerated longitudinal study of 6th and 7th grade Czech adolescents ($N = 589$; *Mean* age = 12.34 years, $SD = 0.89$). Participants were approximately equally divided by sex (58% female). Data were collected over the course of two years, twice a year (during fall and spring semester), resulting in four assessments. The data collection included student self-reports, teacher ratings, school administrative data on student achievement, and results from an intelligence test. The convenience sample was recruited from nine local schools in Brno, a medium sized city in Czech Republic, that were selected based on school interest and willingness to participate. The study received University IRB approval and followed ethical guidelines; informed consent was obtained from all study participants and their parents.

Measures

Background variables

Control variables included adolescent sex, socioeconomic status (SES), family structure, and age, each assessed at Time 1.

Age Participants were asked to report their dates of birth (month and year) that was then converted into chronological age ($M_{age} = 12.34$ years, and $SD = 0.89$). Forty-nine percent of participants were in 6th grade, whereas 51% in 7th grade. Interaction terms of cohort by each key predictor were tested, but none was found significant. Also, due to high collinearity between age and cohort variables, only age was used as a control in model tests.

Sex The students were asked to indicate their sex by choosing either "male" (coded as 0) or "female" (coded as 1) as a response.

Family structure This variable was computed by dichotomizing 7 response categories to the question about participant's "home situation" (living with: 1 = biological parents; 2 = biological mother only; 3 = biological father only; 4 = biological mother and stepfather; 5 = biological father and stepmother; 6 = biological parent and significant other; 7 = shared custody) into a family structure with two biological parents (coded as 1) and all the remaining answers (coded as 0). This decision was based on both statistical (i.e., sparsity of chosen responses across categories 2–7) and substantive (i.e., a focus on a distinctly positive role associated with living with both biological parents).

SES The students' socio-economic status was operationalized as a combined score of the three indicators: their family income, and mother's and father's education. They were asked to choose from one of the five categories describing their family's approximate total monthly income (1 = 20,000 Czech Crowns or less; 2 = 20,000 to

35,000 Czech Crowns; 3 = 35,000 to 60,000 Czech Crowns; 4 = 60,000 to 100,000 Czech Crowns; 5 = 100,000 Czech Crowns or more); to also indicate their mother's (or stepmother's or female caretaker's, if applicable) and father's (or stepfather's or male caretaker's, if applicable) education separately on a 7-point ordinal response scale (1 = I do not know; 2 = finished basic (through 9th grade); 3 = is trained (apprenticeship, she has a vocational certificate); 4 = finished some college or technical school (she has a high school diploma); 5 = finished higher vocational school (Dis. Title); 6 = has a graduate degree (Bc. title); 7 = has a graduate degree (advanced degree, e.g., masters or doctorate); category "1 = I do not know" was recoded to indicate missing). Responses to the three variables were standardized, using a z-score standardization (i.e., distribution with a mean of 0 and std. of 1) and averaged to represent the SES score.

Predictor variables

Self-control (Time 1) Adolescent's self-control was assessed by six items part of the Social Skills Improvement System (SSIS, Gresham & Elliott 2008). At Time 1, the teacher most familiar with the student was asked to rate students' behavioral characteristics (e.g., temper or conflict management skills) on a 4-point Likert-type scale (1 = not true, 2 = little true, 3 = a lot true, 4 = very true, $\alpha = 0.87$).

School attachment and academic motivation (Time 1) Adolescent school attachment was assessed by four items, whereas academic motivation by six items, both part of the School Environment scale (Weissberg et al., 1991) and rated by students. Responses ranged from 1 = definitely not true to 4 = definitely true ($\alpha = 0.85$ and $\alpha = 0.71$, for *school attachment* and *academic motivation*, respectively). Both were assessed at Time 1.

Intelligence (Time 3) Adolescent intelligence was assessed once during the study, at Time 3, using the Raven's Standard Progressive Matrices (Raven, Raven, & Court, 2003). Raven's Matrices are designed to measure a person's nonverbal intelligence. The instrument consists of 5 sets of 12 items scored as either correct or incorrect, which are then summed to provide a total score and converted into a percentile rank based on participant's age and the appropriate norms. Thus, a percentile rank score, adjusted for age and norms was used in the current study.

Criterion variables

Academic performance: Academic competence and school-reported grades (Time 1 and Time 4) The two criterion measures included teacher-rated academic competence and school-reported grades. Academic competence was assessed by 7 items part of the SSIS (Gresham & Elliott, 2008). Teachers were asked to rate each student on these 7 items that were indicative of overall academic performance and intellectual functioning, to situate them within the classroom (e.g., compared with other students in my classroom….); ratings ranged from 1 = lowest 10% to 5 = highest 10%. A scale score was computed which was highly internally consistent ($\alpha = 0.97$).

Participant school-reported grades were obtained annually across a number of school subjects. In the current study, Time 4 language and Time 4 math grades were used to compute a composite score. In the Czech Republic, grades range from 1 (best) to 5 (failing grade), where higher values indicated poorer academic performance; therefore, scores were reverse coded for ease of interpretation, where a high score indicated high achievement. The grades were simply averaged to compute a combined school-reported grade score. To test study hypotheses regarding developmental changes in measures of academic performance at Time 4, identical measures of academic competence and school grades were used that were assessed at Time 1.

Plan of Analysis

Study hypotheses were tested in a series of path models in Mplus 8.4 (Muthén & Muthén, 2017) using maximum likelihood estimation. The percentage of missing data across variables ranged from approximately 1% (for sex) to 20% (for intelligence), and for both criterion measures it was about 9% (see Table 1 for individual *N*s of all variables). Participants with missing on criterion variables did not differ significantly from those with no missing data by sex, SES, or cohort. Full-information maximum likelihood estimation (FIML) was implemented to handle missing data. The models (shown in Fig. 1a, b) tested the longitudinal effects by Time 1 self-control, Time 1 school attachment, Time 1 academic motivation, and Time 3 intelligence on Time 4 academic competence and Time 4 school grades, controlling for participant's sex, SES, family structure, and age, with the specific aim to address and test study hypotheses. In addition, model constraints were used to test whether the difference between two standardized coefficients was statistically significant (i.e., the effects of intelligence versus self-control on the two measures of academic performance). The model constraints procedure involved computing a new variable representing path "a" (e.g., the path from intelligence to academic performance) minus a path "b" (e.g., the path from self-control to academic performance), and testing the significance of this new predictor (Muthén & Muthén, 2017; Nitzl, 2010). Finally, models testing developmental changes in both measures of academic performance were

Table 1 Descriptive Statistics of the Study Variables

Variables	Mean	SD	*N*	Min; Max	Skewness (SE)	Kurtosis (SE)
Sex (female)	0.58	0.49	582	[0; 1]	−0.34 (0.10)	−1.89 (0.20)
Family structure (two biological parents)	0.76	0.43	505	[0; 1]	−1.22 (0.11)	−0.50 (0.22)
SES	−0.04	0.83	508	[−1.82; 2.23]	−0.08 (0.11)	−0.87 (0.22)
Age	12.34	0.89	581	[8; 16]	−1.76 (0.10)	8.49 (0.20)
Self-control (T1)	2.90	0.46	558	[1; 4]	−0.46 (0.10)	1.43 (0.21)
School attachment (T1)	2.68	0.68	504	[1; 4]	−1.07 (0.11)	0.81 (0.22)
Academic motivation	2.98	0.53	502	[1; 4]	−0.60 (0.11)	0.55 (0.22)
Intelligence (T3)	72.73	27.69	472	[0; 100]	−0.96 (0.11)	−0.16 (0.22)
Grades (T1) (Math and Language)	4.17	0.77	555	[1.5; 5]	−0.91 (0.10)	0.39 (0.21)
Academic competence (T1)	3.60	0.98	563	[1; 5]	−0.51 (0.10)	−0.12 (0.21)
Grades (T4) (Math and Language)	4.10	0.82	539	[1.5; 5]	−0.80 (0.11)	−0.02 (0.21)
Academic competence (T4)	3.59	1.02	536	[1; 5]	−0.46 (0.11)	−0.29 (0.21)

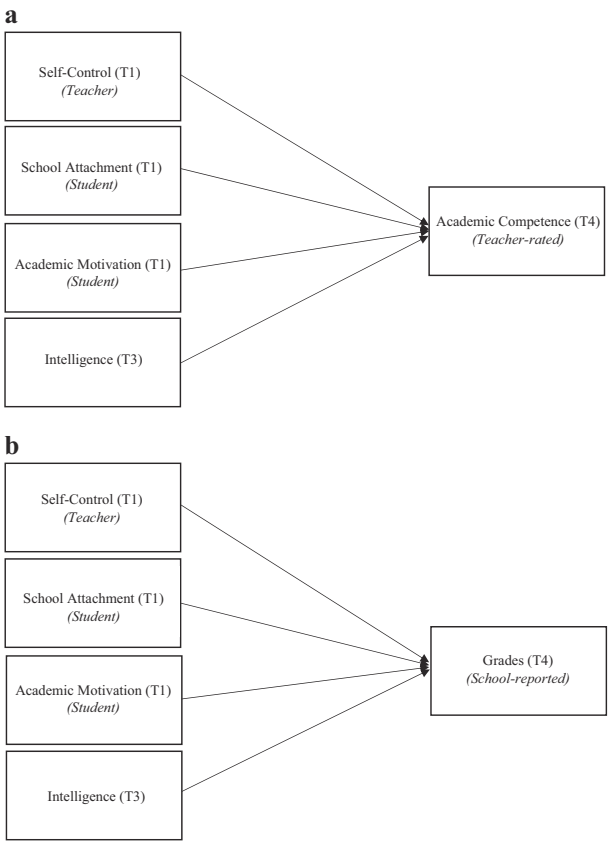

Fig. 1 **a** Predicting Teacher-rated Academic Competence. **b** Predicting School-reported Grades

tested where, in addition to all noted predictors, Time 1 academic competence or Time 1 school-reported grades was added to the model, to control for baseline academic performance. Because path analysis represents a solution of a saturated model (with df = 0), reporting model fit statistics is not relevant, as each would indicate perfect fit (with $\chi^2 = 0$, RMSEA = 0, and CFI/TLI = 1). Thus, model fit is not reported.

Results

Descriptive statistics of all study variables are reported in Table 1 and Pearson's correlations are shown in Table 2. As Table 2 indicates, from demographic variables, only sex (being female) was significantly and positively correlated with self-control. School attachment and academic motivation were each positively and significantly associated with sex (female) and SES. Sex (female), family structure (two biological parents), and SES were positively associated with intelligence as well as academic achievement, both teacher-reported and school-reported measures. Self-control and intelligence were unrelated; however, both were positively and moderately-to-strongly associated with measures of academic performance. In addition, age was negatively associated with school-reported grades as well as with academic motivation and intelligence, but unrelated to teacher-reported academic competence.

Results from the path models are reported in Table 3 and illustrated in Fig. 2a, b. Findings indicated that both self-control and intelligence uniquely predicted Time 4 teacher-rated academic competence (see Fig. 2a); this was also found for both school attachment and academic motivation. This model explained 26.5% of variance in teacher-reported academic competence. In the second model predicting Time 4 school-reported grades (see Fig. 2b), the findings followed the same pattern. Each of the four main predictors (self-control, school attachment, academic motivation, and intelligence), was a significant positive predictor of Time 4 school-reported grades. The model remarkably explained 49.3% of the variance in school-reported grades.

Self-control versus Intelligence Effects on Academic Performance

Follow-up tests of the similarity or difference of effects by each self-control and intelligence on predicting

Table 2 Bivariate pearson correlations between study variables

	1	2	3	4	5	6	7	8	9	10	11
1. Sex $_{(Female)}$											
2. Age	0.01										
3. SES	−0.08	−0.09*									
4. Family Structure $_{(two\ bio)}$	0.01	−0.05	0.11*								
5. Self-control (T1)	0.23***	0.01	−0.04	0.01							
6. Attachment (T1)	0.14**	−0.08	0.15**	−0.05	0.11*						
7. Motivation (T1)	0.10*	−0.13**	0.20***	0.01	0.02	0.44***					
8. Intelligence (T3)	0.13**	−0.19***	0.35***	0.13**	0.07	0.16***	0.12*				
9. Grades (T1)	0.18***	−0.33**	0.29***	0.17***	0.26***	0.27***	0.31***	0.50***			
10. Academic Competence (T1)	0.16***	0.03	0.13**	0.13**	0.27***	0.16***	0.16***	0.32***	0.58***		
11. Grades (T4)	0.14**	−0.26***	0.36***	0.18***	0.19***	0.28***	0.26***	0.57***	0.84***	0.54***	
12. Academic Competence (T4)	0.10*	0.01	0.23***	0.12*	0.22***	0.28***	0.23***	0.38***	0.62***	0.69***	0.67***

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 3 Path coefficients from longitudinal and developmental change models

		T4 Academic competence (Teacher-rated)		T4 Grades (School reported)	
		b	*SE*	*b*	*SE*
Model 1: Longitudinal	Self-control (T1)	0.37***	0.09	0.21***	0.07
	School attachment (T1)	0.22***	0.09	0.12**	0.05
	Academic motivation (T1)	0.23**	0.09	0.18**	0.06
	Intelligence (T3)	0.01***	0.00	0.01***	0.00
R^2		0.27		0.49	
Model 2: Developmental Changes					
	Self-control (T1)	0.10	0.07	0.01	0.04
	School attachment (T1)	0.17**	0.05	0.05	0.02
	Academic motivation (T1)	0.10	0.07	0.02	0.01
	Intelligence (T3)	0.01***	0.00	0.01***	0.00
	Academic competence/Grades (T1)	0.62***	0.04	0.77***	0.03
R^2		0.54		0.77	

Note. Unstandardized coefficients are reported. SE denotes standard error. For the first model, with T4 Academic Competence as the criterion variable, the last coefficient listed across the variable name: "Academic Competence/Grades (T1)" refers to the effect of Time 1 Academic Competence, whereas for the second model, with T4 (Time 4) Grades as the criterion variable, the same refers to the effect of Time 1 Grades. Each model controlled for participants' age, sex, family structure, and SES. T stands for time of assessment.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Time 4 academic competence and Time 4 school grades were conducted. Findings from these tests showed that the effect by intelligence was significantly greater than the one by self-control ($z = 2.79$, $p = 0.005$ and $z = 5.85$, $p < 0.001$, in both the model predicting academic competence and the one for school grades, respectively). To further contextualize these findings, Fig. 3 plots school-reported school grades (math and language combined) as a function of both intelligence and self-control quintiles.

Predictor Effects on Academic Competence versus School Grades

In an additional follow-up test, the magnitude of effects of each intelligence and self-control on each of the two measures of academic performance were compared. Findings indicated that the effects of intelligence on academic competence versus school grades were indistinguishable, not significantly different; the same finding was made for the effect by self-control.

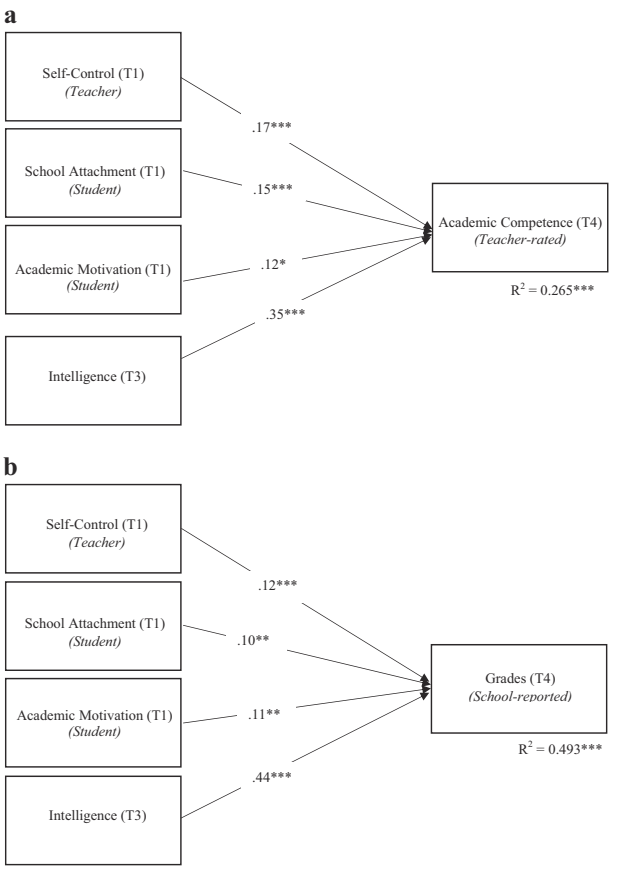

Fig. 2 **a** Predicting teacher-rated academic competence. **b** Predicting school-reported Grades. Note. Standardized coefficients are reported. In both models, the effects of sex, age, SES, and family structure are entered as controls; all exogenous variables are allowed to covary. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

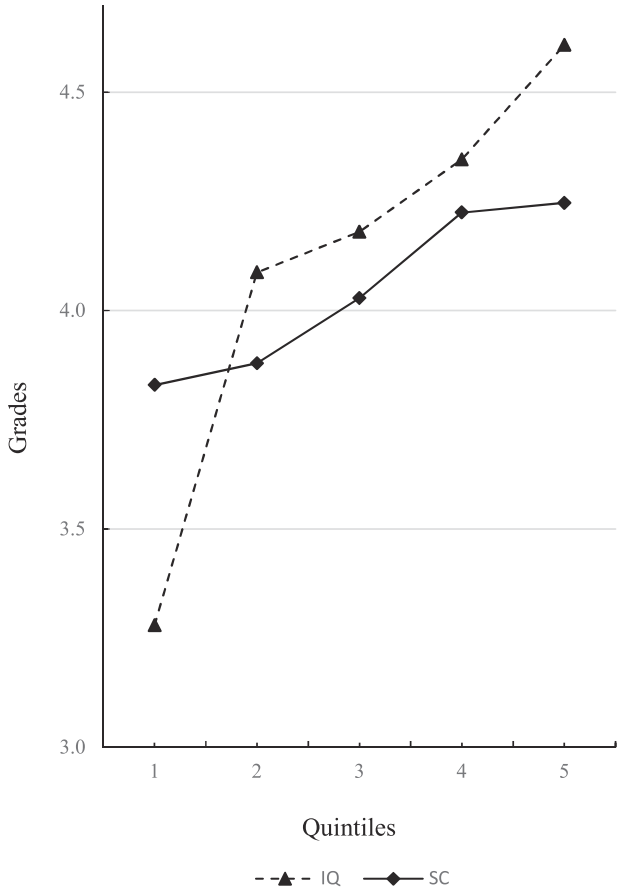

Fig. 3 School-reported grades as a function of ranked IQ and self-control quintiles. Notes. Five quantiles on X-axis represent 1/5th of the distribution of IQ and self-control scores ranked from low to high; defined based on 20th, 40th, 60th, 80th percentiles as cutoff values. Specific points on the plot denoted by diamonds (for SC or self-control) and by rectangles (for IQ or intelligence) represent the mean grades for a given fraction of the data

Self-control versus Intelligence Effects on Developmental Changes in Academic Performance

Finally, results from the model testing the same set of predictors for developmental changes in the two measures of academic performance are also reported in Table 3. Controlling for Time 1 academic competence, self-control and academic motivation were no longer statistically significant predictors of Time 4 academic competence. Only intelligence and school attachment predicted developmental changes in teacher-rated academic competence. Findings from the model testing developmental changes in school-reported grades provided evidence that only intelligence remained statistically significant. It is worth noting that only family SES was significant of the background variables, which positively predicted developmental changes in academic competence ($\beta = 0.08$, $p = 0.025$) as well as in school grades ($\beta = 0.08$, $p = 0.002$).

Discussion

Duckworth and Seligman (2005) provided very insightful findings important for the understanding of what explains academic success among youth, highlighting what they termed self-discipline, over the importance of intelligence. Only a very modest number of studies have followed to both replicate and further test this important work, including generalizability studies carried out outside of North America. Thus, it is unknown whether self-control outdoes intelligence consistently as a predictor of academic achievement, or the extent to which academic motivation and school attachment affect these observed relationships, and explain unique variability in measures of achievement. The present study addressed these gaps. In addition to replicating and extending the original work to a different developmental context, the current study followed youth over the course of two years, thus permitting a longer-term

assessment of these relationships. The current study findings were only partially supportive of previous findings.

Contrary to expectations, self-control did not predict academic performance measures more strongly than intelligence. The effects of intelligence were in fact significantly greater than the ones of self-control. The observed differences in study findings might be related to and explained by differences in the measures of academic performance (e.g., first marking period GPA versus a language/math GPA; the original work also included measures of selection into the school's high school program as well as school attendance, while the present study included independent teacher ratings of student academic competence, composed of comparative ratings vis-a-vis other students in the class on reading achievement, math achievement, and motivation to learn) as well as in the focus on self-control in the present study, versus a larger "self-discipline" (although principally assessed by measures of self-control and delay of gratification) in the original work.

It is also possible that the importance of and effects by intelligence versus self-control simply varies across cultures. For instance, self-control might be more important among American youth as there exists greater variability in self-control in the United States in comparison to youth in the Czech Republic. It is also possible that academic success in the United States is simply associated with self-regulatory skills to a greater extent than it is elsewhere, where intelligence more significantly differentiates between student achievement. Future work, carried out both in North America as well as other (European) countries, is likely to provide additional answers to these rather significant questions that have important implications not only for student achievement, but also for school curricula as well as teacher training, for instance.

Despite the fact that self-control had a significantly smaller effect than intelligence, the effect of self-control remains salient, net any IQ effects, which is consistent with previous research (e.g., Poropat, 2009). To the extent that self-control can be improved, and is malleable (Piquero et al., 2016), more so than intelligence, this finding carries significant policy implications. Teaching students the necessary self-discipline skills can be beneficial for their academic success, independent of their cognitive skills, their intelligence.

Next, regarding developmental changes in the measures of academic performance, the evidence consistently indicated that only intelligence, not self-control, predicted changes in both teacher-rated academic competence as well as school-reported grades, unlike previous findings by Duckworth and colleagues (Duckworth & Seligman, 2005; Duckworth et al. 2012). Thus, findings illustrate both the importance of self-control for academic performance, but also the limits of how important self-control is for student success in school over time, based on this sample. Again, it is certainly possible, though very unlikely, that these findings explaining developmental changes in academic performance are to some extent culturally idiosyncratic somehow, where instruction and/or testing favors student intelligence over self-control, in comparison to what students experience in the United States, for instance. On the other hand, it is more plausible that the interplay between and importance of both student self-control and intelligence for academic performance is quite similar across national and cultural boundaries, thus giving the present study findings substantial relevance and importance in our understanding of predicting student success as well as developmental changes in student success over time.

Finally, it is important to note that study findings also provided support for the importance of motivation and school attachment, where each Time 1 assessment was significant in predicting both Time 4 academic performance measures, but only school attachment for explaining variability in developmental changes in teacher-rated academic competence. These findings are consistent with the evidence from previous cross-sectional studies which used a similar measure of intelligence. For instance, among Dutch adolescents, a positive association was found between motivation and school performance (Meijer & van den Wittenboer, 2004), net the effects by intelligence. The present study provided similar evidence based on longitudinal data. One additional point should be made regarding the effects of demographic variables. The finding that an adolescent's family SES positively and uniquely predicted developmental changes in academic competence as well as school grades (above and beyond the effects of intelligence, self-control and all other predictors) indicates that families with greater resources are able to provide youth with more favorable environments supporting academic achievement, and ultimately, success. This might be related to their access to additional tutoring or similar academic supports, or simply a whole host of different activities that further enrich adolescents' academic potential.

The present study is not without limitations. First, the study used a convenience sample, focused on Czech youth from one city, and thus, findings may not be generalizable to Czech adolescents, or to other cultural or national settings. It is worth mentioning that sampling, even within a single culture, may impact the observed relationships. For example, sampling from a school with high levels of academic motivation may eliminate the relationship with school grades due to low variability. Secondly, although the reports were obtained from various sources, most of the study variables were assessed by individual measures from one rater which could potentially introduce mono-method bias. For example, it would be important to have multiple measures of and multiple independent raters of self-control (self-reports or parent ratings, something which the original

work by Duckworth and Seligman included; however, these constructs were only associated ~0.31 and 0.32 across measures, across the two samples, respectively, quite modest support at best for combining them). In addition, there exist a number of competing or alternative models that could have been tested. For instance, it is possible that academic motivation leads to greater achievement because it promotes greater self-control. Nevertheless, study strengths greatly outweigh its limitations. The study focused on both official grades as well as teacher assessments of student academic competence to measure academic performance or achievement. Also, study constructs were operationalized using well-established, reliable measures. And even though the sampling strategy was not representative, the sample was considerable in size, included students from a variety of schools (e.g., private and public), and was from a unique and different cultural context.

Conclusion

This longitudinal study replicated and extended previous research on the extent to which self-control and intelligence matter for academic achievement among adolescents. It also tested whether student motivation and school attachment added to explaining achievement, above and beyond self-control and intelligence. Findings provided support that similar to some previous work carried out on US samples, self-control predicted academic performance over time, above and beyond IQ; however, in contrast to previous work, IQ was significantly more salient than self-control. In addition, again contrary to previous findings, self-control was unrelated to developmental changes in either teacher rated academic competence or school reported grades. Both academic motivation and school attachment were unique longitudinal predictors of academic performance, together with self-control and intelligence. Despite comparatively modest effects, self-control, student motivation, and perceived school attachment remain salient, modifiable targets for improving academic outcomes for children and adolescents.

Acknowledgements We would like to sincerely thank the school administrators, students, and teachers for their participation.

Author Contributions A.V. conceived of the study, designed it, participated in its measurement and statistical analyses, and drafted the manuscript; M.J. carried out the statistical analyses and interpretation, and drafted the manuscript; M.B. participated in the design and measurement of the study, and coordinated data collection. All authors read and approved the final manuscript.

Funding The study was funded by the John I. and Patricia J. Buster Endowment of Family Sciences, awarded to the first author; some additional support was provided by the Institute of Psychology, Academy of Sciences of the Czech Republic. No funding was received to assist with the preparation of this manuscript.

Data Sharing Declaration The datasets generated and/or analyzed during the current study are not publicly available but are available from the corresponding author on reasonable request.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Compliance with Ethical Standards The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments.

Ethical Approval The study was approved by the University of Kentucky Institutional Review Board and the Institutional Board of the Institute of Psychology, Academy of Sciences of the Czech Republic.

Informed Consent Written informed consent was obtained from the parents of study participants; participants also provided assent to participate in the study.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

References

Barton, K., Dielman, T. E., & Cattell, R. B. (1972). Personality and IQ measures as predictors of school achievement. *Journal of Educational Psychology*, *63*(4), 398–404. https://doi.org/10.1037/h0033573.

Bond, L., Butler, H., Thomas, L., Carlin, J., Glover, S., Bowes, G., & Patton, G. (2007). Social and school connectedness in early secondary school as predictors of late teenage substance use, mental health, and academic outcomes. *Journal of Adolescent Health*, *40*(4), 357–e9. https://doi.org/10.1016/j.jadohealth.2006.10.013.

Cerasoli, C. P., Nicklin, J. M., & Ford, M. T. (2014). Intrinsic motivation and extrinsic incentives jointly predict performance: A 40-year meta-analysis. *Psychological Bulletin*, *140*(4), 980–1008. https://doi.org/10.1037/a0035661.

Daly, M., Delaney, L., Egan, M., & Baumeister, R. F. (2015). Childhood self-control and unemployment throughout the life span: Evidence from two British cohort studies. *Psychological Science*, *26*(6), 709–723. https://doi.org/10.1177/0956797615569001.

Duckworth, A. L., & Seligman, M. P. (2005). Self-discipline outdoes IQ in predicting academic performance of adolescents. *Psychological Science*, *16*(12), 939–944. https://doi.org/10.1111/j.1467-9280.2005.01641.x.

Duckworth, A. L., Quinn, P. D., & Tsukayama, E. (2012). What *No Child Left Behind* leaves behind: The roles of IQ and self-control in predicting standardized achievement test scores and report card grades. *Journal of Educational Psychology*, *104*(2), 439–451. https://doi.org/10.1037/a0026280.

Evans, T. D., Cullen, F. T., Burton, V. S., Dunaway, R. G., & Benson, M. L. (1997). The social consequences of self-control: Testing the general theory of crime. *Criminology*, *35*, 475–504. https://doi.org/10.1111/j.1745-9125.1997.tb01226.x.

Fan, H., Xu, J., Cai, Z., He, J., & Fan, X. (2017). Homework and students' achievement in math and science: A 30-year meta-

analysis, 1986–2015. *Educational Research Review*, *20*, 35–54. https://doi.org/10.1016/j.edurev.2016.11.003.
Fischer, F., Schult, J., & Hell, B. (2013). Sex differences in secondary school success: why female students perform better. *European Journal of Psychology of Education*, *28*(2), 529–543. https://doi.org/10.1007/s10212-012-0127-4.
Gagné, F., & St Père, F. (2002). When IQ is controlled, does motivation still predict achievement? *Intelligence*, *30*(1), 71–100. https://doi.org/10.1016/S0160-2896(01)00068-X.
Gottfredson, L. S. (1997). Why g matters: the complexity of everyday life. *Intelligence*, *24*, 79–132. https://doi.org/10.1016/S0160-2896(97)90014-3.
Gresham, F. & Elliott, S. N. (2008). *Social skills improvement system (SSIS) rating scales*. San Antonio, TX: Pearson.
Hofer, M., Kuhnle, C., Kilian, B., & Fries, S. (2012). Cognitive ability and personality variables as predictors of school grades and test scores in adolescents. *Learning and Instruction*, *22*(5), 368–375. https://doi.org/10.1016/j.learninstruc.2012.02.003.
Kim, K. R., & Seo, E. H. (2015). The relationship between procrastination and academic performance: A meta-analysis. *Personality and Individual Differences*, *82*, 26–33. https://doi.org/10.1016/j.paid.2015.02.038.
Laidra, K., Pullmann, H., & Allik, J. (2007). Personality and intelligence as predictors of academic achievement: A cross-sectional study from elementary to secondary school. *Personality and Individual Differences*, *42*(3), 441–451. https://doi.org/10.1016/j.paid.2006.08.001.
Li, J. B., Delvecchio, E., Lis, A., Nie, Y. G., & Di Riso, D. (2015). Parental attachment, self-control, and depressive symptoms in Chinese and Italian adolescents: Test of a mediation model. *Journal of Adolescence*, *43*, 159–170. https://doi.org/10.1016/j.adolescence.2015.06.006.
Lynn, R., Meisenberg, G., Mikk, J., & Williams, A. (2007). National IQs predict differences in scholastic achievement in 67 countries. *Journal of Biosocial Science*, *39*(6), 861–874. https://doi.org/10.1017/S0021932007001964.
Meijer, A. M., & van den Wittenboer, G. L. (2004). The joint contribution of sleep, intelligence and motivation to school performance. *Personality and Individual Differences*, *37*(1), 95–106. https://doi.org/10.1016/j.paid.2003.08.002.
Morosanova, V. I., Fomina, T.G., & Bondarenko, I. N. (2015). Academic achievement: Intelligence, regulatory, and cognitive predictors. *Psychology in Russia: State of the Art*, *8*(3), 136–156. https://doi.org/10.11621/pir.2015.0311.
Murayama, K., Pekrun, R., Lichtenfeld, S., & Vom Hofe, R. (2013). Predicting long-term growth in students' mathematics achievement: The unique contributions of motivation and cognitive strategies. *Child Development*, *84*(4), 1475–1490. https://doi.org/10.1111/cdev.12036.
Muthén, L. K., & Muthén, B. O. (2017). Mplus: Statistical analysis with latent variables: User's guide (Version 8). Los Angeles, CA: Authors.
Niehaus, K., Rudasill, K. M., & Rakes, C. R. (2012). A longitudinal study of school connectedness and academic outcomes across sixth grade. *Journal of School Psychology*, *50*(4), 443–460. https://doi.org/10.1016/j.jsp.2012.03.002.
Nitzl, C. (2010). *Eine anwenderorientierte einführung in die partial least square (PLS)-methode*. Inst. für Industrielles Management.
Piquero, A. R., Jennings, W. G., Farrington, D. P., Diamond, B., & Gonzalez, J. M. R. (2016). A meta-analysis update on the effectiveness of early self-control improvement programs to improve self-control and reduce delinquency. *Journal of Experimental Criminology*, *12*(2), 249–264. https://doi.org/10.1007/s11292-016-9257-z.
Plomin, R., & von Stumm, S. (2018). The new genetics of intelligence. *Nature Reviews Genetics*, *19*(3), 148–159. https://doi.org/10.1038/nrg.2017.104.
Poropat, A. E. (2009). A meta-analysis of the five-factor model of personality and academic performance. *Psychological Bulletin*, *135*(2), 322–338. https://doi.org/10.1037/a0014996.
Raven, J., Raven, J.C., & Court, J.H. (2003). *Manual for Raven's Progressive Matrices and Vocabulary Scales*. San Antonio, TX: Harcourt Assessment.
Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: A systematic review and meta-analysis. *Psychological Bulletin*, *138*(2), 353–387. https://doi.org/10.1037/a0026838.
De Ridder, D. T., & Lensvelt-Mulders, G. (2018). Taking stock of self-control: A meta-analysis of how trait self-control relates to a wide range of behaviors. In *Self-Regulation and Self-Control* (pp. 221–274). Routledge.
Roth, B., Becker, N., Romeyke, S., Schäfer, S., Domnick, F., & Spinath, F. M. (2015). Intelligence and school grades: A meta-analysis. *Intelligence*, *53*, 118–137. https://doi.org/10.1016/j.intell.2015.09.002.
Von Suchodoletz, A., Larsen, R. A., Gunzenhauser, C., & Fäsche, A. (2015). Reading and spelling skills in German third graders: Examining the role of student and context characteristics. *British Journal of Educational Psychology*, *85*(4), 533–550.
Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality*, *72*, 271–324. https://doi.org/10.1111/j.0022-3506.2004.00263.x.
Valiente, C., Lemery-Chalfant, K., & Castro, K. S. (2007). Children's effortful control and academic competence mediation through school liking. *Merrill-Palmer Quarterly*, *53*(1), 1–25.
Vazsonyi, A. T., Mikuška, J., & Kelley, E. L. (2017). It's time: A meta-analysis on the self-control-deviance link. *Journal of Criminal Justice*, *48*, 48–63. https://doi.org/10.1016/j.jcrimjus.2016.10.001.
Weis, M., Trommsdorff, G., & Muñoz, L. (2016). Children's self-regulation and school achievement in cultural contexts: the role of maternal restrictive control. *Frontiers in Psychology*, *7*, 722 https://doi.org/10.3389/fpsyg.2016.00722.
Weissberg, R. P., Voyce, C. K., Kasprow, W. J., Arthur, M. W., & Shriver, T. P. (1991). *The social and health assessment*. Chicago, IL: Authors.

Alexander T. Vazsonyi is a Professor at the University of Kentucky. His major research interests include self-control, sleep, and adjustment and well-being (problem behaviors, deviance, violence, and health compromising behaviors), with a focus on development in context (family, school, and culture).

Magda Javakhishvili is a Postdoctoral Research Fellow at City University of New York, John Jay School of Criminal Justice. Her research interests include the etiology and developmental sequelae of mental health and behavioral problems, self-control and empathy.

Marek Blatny is a Professor at Masaryk University. His main research interests include risk and protective factors of development in adolescence, conditions of adaptive psychological and social functioning in adulthood and the quality of life of cancer survivors.