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Differences in cognitive, motivational and contextual variables between under-achieving, normally-achieving, and over-achieving students: A mixed-effects analysis

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Abstract

Background: There are few studies in Spain which analyze the influence of individual, motivational and contextual variables, which might be different between underachieving, normally achieving and overachieving students. **Method:** A total of 1,398 Spanish high school students participated. Mixed-effects models were used to analyze data. **Results:** The results showed some evidence of: (a) Partial mediational effect of self-concept on the association between cognitive ability and academic achievement. (b) Higher levels of learning goals in the overachieving group than in the underachieving group, but no differences in achievement and reinforcement goals between groups. (c) Positive effect of learning strategies on attainment, both in the underachieving and the non-underachieving students. (d) Little effect of context variables on academic achievement, both in the underachieving and non-underachieving students. **Conclusions:** Underachieving students seem to employ all the learning strategies considered to a lesser extent than normally and overachieving students. They also have a lower level of learning goals. On the contrary, overachieving students score more highly than under and normally achieving students in almost all of the above factors.

Keywords: Underachievement, overachievement, Compulsory Secondary Education, Mixed-Effect Analysis.

Resumen

Diferencias en variables cognitivas, motivacionales y contextuales entre alumnado con rendimiento menor, igual y mayor al esperado: análisis de efectos mixtos. **Antecedentes:** apenas existen estudios en España que analicen la influencia de variables cognitivas, motivacionales y contextuales capaces de establecer diferencias entre los estudiantes con rendimiento menor, igual y mayor al esperado. **Método:** participaron 1.398 estudiantes españoles de Educación Secundaria Obligatoria. Se emplearon modelos de efectos mixtos para el análisis de datos. **Resultados:** los resultados mostraron evidencia de: (a) efecto mediacional parcial del auto-concepto en la asociación de la habilidad cognitiva y el rendimiento académico; (b) mayores niveles de metas de aprendizaje en el grupo de estudiantes con rendimiento mayor al esperado; (c) efecto positivo de las estrategias de aprendizaje sobre el rendimiento en todos los grupos; (d) efecto pequeño de las variables contextuales sobre el rendimiento en todos los grupos. **Conclusiones:** los estudiantes con rendimiento menor al esperado emplean en menor medida las estrategias de aprendizaje y las metas orientadas al aprendizaje. Por el contrario, los estudiantes con rendimiento mayor al esperado muestran niveles superiores que el resto de grupos en la mayor parte de variables.

Palabras clave: rendimiento menor al esperado, rendimiento mayor al esperado, Educación Secundaria Obligatoria, Análisis de Efectos Mixtos.

During the last few decades, there has been notable interest in the analysis of students who do not obtain expected academic results (McCoach & del Siegle, 2011; Smith, 2003). In this sense, the concept of underachievement is the discrepancy between what can be expected and what is actually achieved (Phillipson, 2008). The same assertion could be applied to overachievement, but at the opposite end of the same continuum.

Some studies have included different types of variables to facilitate better comprehension of this phenomenon, especially with underachieving gifted students (McCoach & Siegle, 2003; Snyder & Linnenbrink-García, 2013). However, there are also recent studies which support the assumption that underachievement is not reserved exclusively for gifted students, but extends to students with varying intelligence levels (Dittrich, 2014).

The international literature describes multiple cognitive, motivational and contextual variables as important predictors of academic achievement (Jeynes, 2010; Zuffianò, Alessandri, Gerbino, & Luengo, 2013). It is therefore essential to detect whether this diversity of factors has different influences on underachieving, normally achieving and overachieving students. The more recent literature has analyzed individual factors such as motivation, learning behavior or emotions within the underachieving gifted population (Matthews & McBee, 2007; Obergriesser & Stoeger, 2015).

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Recently, Veas et al.(2016b) developed a psychometric model to detect underachieving students in a Spanish sample of Compulsory Secondary Education, but there was no analysis of the factors involved.

Given the lack of scientific studies in Spain, the aim of the present study was to examine individual, motivational and contextual factors that might predict and differentiate among underachieving, normally achieving and over-achieving students in compulsory secondary education. In the present study, a selection of the most important constructs is conducted based on the main explanatory models explained in the scientific literature: cognitive ability (Lu, Weber, Spinath, & Shi, 2011), self-concept (Dedrick, Shaunessy-Dedrick, Suldo, & Ferron, 2015), goal orientations (Hsieh, Sullivan, & Guerra, 2007), learning strategies (Preckel & Brunner, 2015), popularity (Schwartz, Gorman, Nakamoto, & McKay, 2006), and parent involvement (Wilder, 2014).

It becomes necessary to test the extent to which these factors have different prediction levels among underachieving, normally achieving and overachieving students so that different educational interventions can be proposed. In concrete, based on previous relationships of these factors in the Spanish achievement model proposed by Veas et al. (2015), we propose the following hypotheses for the dynamic process of under, normal and over achievement processes: (1) Cognitive ability affects the academic achievement of students under the mediation of Self-concept, regardless of the classification of the student (under-, normally or over-achieving). (2) Underachieving students show lower levels of learning goals compared to overachieving students. (3) Underachieving students show lower levels of achievement goals compared to overachieving students. (4) Underachieving students show higher levels of reinforcement goals compared to overachieving students. (5) The learning strategies variables, i.e., the Elaboration Strategy and the Meta-cognition Strategy, significantly affect academic achievement, and there are significant differences between underachieving students and other students. (6) The Learning Strategy variable, i.e., Personalization, negatively affects academic achievement; and there are significant differences between underachieving students and other students. (7) Popularity directly affects academic achievement, regardless of the type of student. (8) The parent involvement variable Effective Help with Homework negatively affects academic achievement, with significant differences between underachieving students and other students. (9) The parent involvement variables Perception of Support, Expectations and School Relationship positively affect academic achievement, and there are significant differences between underachieving students and other students.

Method

Participants

Eight schools with different socioeconomic and cultural environments in the province of Alicante (Spain) took part in the survey. Two of the schools were state-assisted private schools, and six were state schools.

A total of 1,456 students in their first or second year of compulsory secondary education participated in this study. Of these, 58 students were excluded due to errors or omissions in their answers or due to an insufficient command of Spanish.

Of the 1,398 students who took part, 732 were enrolled in their first year (52.4 %), and the remaining 666 were enrolled in their second year (47. 6%). Fifty-three percent of the sample was male, and 47 % was female, ranging from 11 to 15 years of age (*mean* = 12. 5, SD = 0.67). The majority of participants (1137, 81. 4%) studied at a state school, whereas 261 (18. 6 %) studied at a private school. The ethnic composition of the sample was: 85. 5% Spaniards, 8. 6% Latin Americans, 4. 3% European, 0. 7% Asian, and 0. 9% Arab. Childhood socioeconomic status (SES) was indexed according to parental occupation. There was a wide range of socioeconomic status, with a predominance of middle-class children.

Instruments

Factor G (Cattell, 1994). This test was adapted into Spanish by TEA Ediciones, and the scale 2 was used to measure intellectual ability. This scale produces an intelligence quotient (IQ) that measures fluid general intelligence. The reliability, obtained by the two-halves method and corrected by the Spearman-Brown formula, was .78 in first-year participants and .69 in second-year participants.

Self-concept Evaluation Scale for Adolescents (ESEA-2). This instrument was expanded by González-Pienda et al. (2002), and it is a Spanish adaptation of the *Self-Description Questionnaire* (SDQ-II) by Marsh (1990), validated in a study with 503 students in compulsory secondary education. It is composed of 70 items measuring 11 specific self-concept dimensions to which students must respond on a Likert scale from 1 to 6, depending on the extent to which they agree or disagree with each statement. In the authors' evaluation, all Cronbach's alpha values were between .73 and .91. For this study, we selected only verbal, math and academic self-concept factors with Cronbach's alpha values of .84, .90 and .75, respectively.

Academy Goal Questionnaire (García et al., 1998). This self-report instrument is a Spanish adaptation of the *Achievement Goal Tendencies Questionnaire* (AGTD) by Hayamizu and Weiner (1991). The instrument contains 20 items and measures three types of goal orientations identified through factor analysis: learning goals, performance goals and reinforcement goals. Students must indicate on a Likert scale from 1 to 5 the frequency of the activity in each statement *(1 = never; 5 = always).* The psychometric properties of the CMA have been analyzed with Spanish students, and have good levels of reliability and construct validity (González-Pienda et al., 2000). In our sample, the Cronbach's alpha values were .75 for learning goals, .72 for reinforcement goals and .85 for performance goals.

Learning Strategies Questionnaire (CEA). This instrument was produced by Beltrán, Pérez, & Ortega (2006). The test evaluates four large scales, from which only the development, personalization and meta-cognitive scales were used in this study. To obtain the scores , students answered a total of 50 items indicating the extent to which each formulated strategy was true on a Likert scale from 1 to 5, and we obtained sample Cronbach's alpha values of .87, .77 and .77 for the three scales, respectively.

BULL-S (Cerezo, 2000). This instrument was used to measure the variable popularity, as tt is a computerized instrument correction that detects different coexisting profiles: acceptation, rejection, victimization and isolation. The test follows the methodological line of sociometry using the peer nomination

technique and analyzes the internal structure of the classroom. It is composed of 15 items, although we used only the first four items related to sociometric questions. The test has two versions: *P* for parents and *A* for students. We used only version *A*, and an index of peer acceptance called *popularity* was extracted for the purpose of this study.

Parent Involvement Questionnaire (CIF) (Veas et al.,2015). This questionnaire is aimed at students who value the perception of involvement of their parents in the educational process, their monitoring and the level of importance of the educational process to themselves. The instrument is structured as 20 items that evaluate 4 factors: perception of support, organization and interest in the educational process, expectations (professional future) and the school relationship and time of support with homework. Students must indicate on a Likert scale from 1 to 5 the frequency of the activity in each statement *(1 = never or hardly ever; 5 = always or mostly)*. An example of an item is *My parents help me organize my homework*. In our study, we obtained Cronbach's alpha values of .70 for the first, .65 for the second, .65 for the third and .71 for the last factor.

School grades were used as an indicator of academic achievement. Teachers provided full-term grades in nine subjects, and the average grades were calculated on continuous scales ranging from 0 to 10. The scores of the subjects of each course presented a high reliability, with Cronbach's alpha values of .93 for the first-course participants and .94 for the second-course participants.

Procedure

Prior to data collection, the necessary permission was requested from the educational administration and school boards of the various schools. The data were obtained in the classroom and during school hours. The volunteer students participated with the informed consent of their parents or legal guardians and with a guarantee of confidentiality. The tests were conducted in the various schools by several specialists who received prior general training on how to apply the various instruments. The study was conducted over four sessions that each lasted an hour.

Data analysis

First, to identify the underachieving, normally achieving and overachieving students, the regression method was applied (Lau & Chan, 2001). This method is based on the deviation of students' scores from the regression line of the achievement measure on the ability measure. Students are considered underachieving if this deviation is negative and greater than one standard error of the estimate, and they are considered overachieving if this deviation is positive and greater than one standard error of the estimate. Students between -1 and +1 standard error are considered normally achieving.

For the inferential analyses, we used a mixed-effects modelling approach accounting for the nested nature of our students (Raudenbush & Bryk, 2002) to examine the effects of individual-level factors among underachieving, normally achieving and overachieving students. We included two random effects in our models to account for school and grade. Moreover, we tested mediational hypotheses within a stepwise regression framework, as initially proposed by Baron and Kenny (1986), but we used 95% bootstrap confidence intervals to assess the existence of mediation in our models (Zhao, Lynch, & Chen, 2010). We used likelihood ratio tests (LRT) to test our hypotheses, by comparing the deviance of the null model (e.g., a model with no predictors) with that of the model including the predictor of interest. We performed our statistical analyses using SPSS software package version 21.0 and the *lme4* package (Bates et al., 2015) within the R statistical environment (v3.2.5) (R Core Team, 2016), and used the SPSS macros provided by Preacher and Hayes (2008) to compute CIs using the bootstrap approach.

The dependent variable in our main set of analyses was the average of the marks obtained by each student among all compulsory subjects. However, we also ran a supplementary set of analyses in which we considered only language and math to compute the average mark for each student.

Results

Descriptive statistics for different types of students

The regression method yielded a total of 230 (16.4%) underachieving, 922 (66%) normally achieving and 246 (17.6%) overachieving students. Table 1 shows summary statistics for each group. The sex distribution was different across groups, with a higher percentage of girls among overachieving (62.2%) than among underachieving (38.7%) and normal students (45.4%). Moreover, underachieving students were slightly older (the mean age was 12.8 years) than normal and overachieving students (12.5 and 12.4, respectively).

Next, we will present the results of the statistical analyses that we conducted to test our hypotheses. The observed trends did not change as a function of the dependent variable used; therefore, we will only display results using the most comprehensive dependent variable (e.g., the average of all subjects).

Is self-concept a mediator of the relationship between cognitive ability and educational achievement?

In the first step, we fitted several simple linear regression models (e.g., including only one fixed-effects predictor) and found cognitive ability, self-concept and achievement to be strongly associated to each other, with all LRTs yielding p-values smaller than 0.001. The slope signs displayed in Figure 1 also reveal that these associations were positive. Furthermore, we found strong evidence that both cognitive ability and self-concept improved the model fit when included as predictor variables in a multiple regression model. Nonetheless, we observed a substantial reduction in the slope for cognitive ability after adding self-concept to the model (from 0.05 to 0.03), whereas the impact on the slope for

Table 1
Descriptive statistics by type of student

	Underachievers (n = 230)	**Normal (n = 922)**	**Overachievers (n = 246)**
Girls/boys	89/141	419/503	153/93
Age in years (mean, sd)	12.8 (.78)	12.5 (.64)	12.4 (.56)
State/Private school	204/26	742/180	191/55
First/Second course	111/119	489/433	133/113

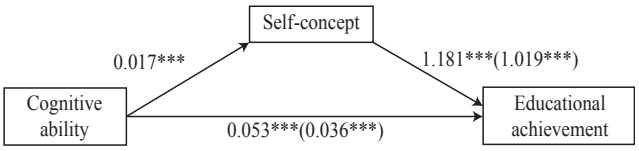

Figure 1. Model testing self-concept as a mediator in the cognitive ability and educational achievement association. The numbers in the figure are beta coefficients (β mediational model are in parentheses). *** $p < .001$

self-concept was relatively small after adding cognitive ability as a second predictor (from 1.18 to 1.06). The indirect effect estimate was 0.017, with 95% bootstrap confidence limits from 0.013 to 0.021. This is consistent with the hypothesis of a partial mediational effect of self-concept on the association between cognitive ability and academic achievement. We found the same trends when we analyzed under-, normally and over-achieving students separately.

Do academic goals predict academic achievement?

To test hypotheses 2 to 4, we excluded normally achieving students from this set of analyses. Our goal variables were discrete, and there was a narrow range of values (less than 10); therefore, we dichotomized them to create binary variables (0 = Low; 1 = High) that were used as predictors in simple logistic regression models in which the dependent variable was type of student (0 = Underachiever; 1 = Overachiever). The results are displayed in Table 2.

Table 2
Prediction of goals on academic achievement

	Underachievers (% High)	Overachievers (% High)	Model deviance	LRT
Null model	–	–	635.38	–
Learning goals	53.9%	71.0%	616.19	19.2***
Achievement goals	88.6%	85.7%	635.20	0.19
Reinforcement goals	41.1%	34.3%	631.78	3.60^

^ $.05 < p < .10$; *** $p < .001$

Regarding learning goals, the percentage of students with high levels was greater in the overachieving group (71%) than in the underachieving group (54%). This variable also showed a statistically significant association with academic achievement, as the deviance of the logistic regression model reduced from 635.38 to 616.19 after including learning goals as a predictor. Achievement goals showed a very similar distribution for both student types. Last, the percentage of underachieving students with high levels of reinforcement goals was slightly greater than that of overachieving students. This variable showed a marginally significant relationship with academic achievement in the logistic regression model ($p = .0577$).

Do learning strategies, popularity and parent involvement predict academic achievement?

We also followed a stepwise approach in this section. In a first step, we fitted simple linear regression models, adding each of the remaining variables hypothesized to be associated with academic achievement, and we used LRTs to formally test each hypothesis. We also computed a pseudo R^2 for each of these models based on the decrease in the residual variance compared to the null model (Raudenbush & Bryk, 2002). In a further step, we took a stepwise regression approach to fit a multiple linear regression model. This strategy enabled us to discard spurious findings due to multiple testing and to find a predictive model for academic achievement in each group. We added values to the model according to the predictive power shown in the simple models, represented by R^2. The results of the analyses of all students and underachieving students are presented in Table 3.

Regarding the results including the whole sample of students, learning strategies (elaboration, meta-cognition and personalization strategies), popularity and parent involvement variables (parent involvement, support perception, expectations and central relationship) all yielded a statistically significant association with academic achievement. However, the R^2 values shown in Table 3 (left) suggest that the proportion of variance explained for some of these variables was modest. In fact, we found that once meta-cognition, expectations and popularity were incorporated into the model, which showed a positive relationship with academic achievement in all cases, the remaining variables did not substantially improve the model's predictive power.

Table 3
Prediction of learning strategies, popularity and parent involvement on academic achievement

	All students				Underachievers only			
	Slope	Deviance	LRT	R^2	Slope	Deviance	LRT	R^2
Null model	–	5340.2	–	–	–	534.3	–	–
Elaboration scale	0.046	5223.6	117***	.081	0.017	523.3	11.0***	.044
Meta-cognition scale	0.104	5120.7	220***	.149	0.026	525.2	9.13**	.041
Personalization	0.029	5271.7	68.5***	.050	0.009	530.0	4.34*	.017
Popularity	0.121	5227.1	113***	.081	0.021	532.5	1.80	.012
Parent involvement	-0.047	5317.9	22.3***	.016	-0.01	532.9	1.41	.008
Support perception	0.118	5272	68.3***	.048	0.009	533.9	0.38	.003
Expectations	0.182	5134.1	203***	.140	0.029	529.2	5.10*	.026
School relationship	0.071	5308.4	31.9***	.023	0.025	530.8	3.53^	.015

^ $.05 < p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

The multiple regression model including those three predictor variables accounted for 26.8% of the total variability in academic achievement.

On the other hand, popularity, parent involvement and support perception were not found to be statistically associated with academic achievement for underachieving students. A marginally significant association was observed for school relationship, whereas learning strategies (elaboration, meta-cognition and personalization scales) and parent expectations yielded statistically significant associations. However, all R^2 values were below 0.05, suggesting a low explanatory power for all of these variables and therefore limiting the usefulness of a predictive model for underachieving students. The highest proportions of variance explained were observed for elaboration and meta-cognition strategies (4.4% and 4.1%, respectively).

Discussion

The aim of the present study was to examine cognitive, motivational and contextual factors that might predict and differentiate among underachieving, normally achieving and overachieving students in compulsory secondary education.

The analysis of the first hypothesis indicated that cognitive ability affected academic achievement under a partial mediation of self-concept, regardless of the classification of the student (under-, normally or over-achieving). It is therefore possible that underachieving students did not differ from the other groups in most self-concept dimensions. Therefore, given the complexity of the construct, more studies are needed to analyze whether different types of self-concept—social self-concept, physical self-concept—result in a possible decompensation among groups (Marsh, 1990) or other variables that can participate in the mediating process (Liem & Martin, 2011).

In relation to the hypotheses related to goal orientation variables, it seems that learning goals emerged as the main variable of the construct, whereas there was weak evidence with respect to the rest of the goal orientation variables. At this point, underachieving students showed a deficit in comparison to overachieving students in terms of learning goals. These results are similar to those obtained by Preckel & Brunner (2015), who only found positive relations for mastery goals when comparing under and overachieving students.

With respect to the rest of the hypotheses, different conclusions can be drawn. First, three variables showed an important level of prediction of academic achievement, specifically those related to learning strategies—elaboration, meta-cognition and personalization strategies—and they were used to a lesser extent by the underachieving students. These results are interesting, as they indicate that the higher academic achievement of overachieving students is due to a major use of learning strategies, and there are few studies that compare overachieving with normally and underachieving students, in all ranges of intellectual ability.

Second, in this study, contextual variables were not sufficiently important to be established as predictors of academic achievement for underachieving students, presenting a low explanatory power. Only the variable expectation showed a reasonable level of significance, and it is considered the best predictor of parent involvement, according to the recent meta-analysis by Jeynes (2010).

In sum, given these results, underachieving students seem to employ, to a lesser extent than normally and overachieving students, all the learning strategies considered. They also have a lower level of learning goals. On the contrary, overachieving students stand out with respect to under and normally achieving students in all the above factors.

Lastly, some limitations may need to be addressed. Other important variables like teaching's approaches or teacher-student's interactions are also important beyond those treated in this work. This kind of variables should be considered in future research. Additionally, future analyses could be made to see whether these differences between groups are maintained when using other identification methods, such as the Rasch model (Veas et al., 2016b), given that the percentage of underachieving students identified in a Spanish sample with the Rasch method was not the same compared with the traditional methods (Veas et al., 2016a).

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