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Personality Psychology

Are Cognitive Ability and Conscientiousness Really More Important for Educational Attainment Than SES? A Replication and Extension of O'Connell and Marks (2022)

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Explaining which factors influence educational attainment is a highly relevant topic in disciplines like psychology and sociology. While in the past especially parental socioeconomic status (SES) has been seen as the most relevant factor, newer studies put psychological aspects such as personality traits and cognitive ability into focus. A recent study by O'Connell and Marks (2022) using British data concludes that these factors are much better able at explaining educational attainment (school grades) than SES. This study is replicated and extended using German NEPS data (N = 4,607). By utilizing dominance analysis, which goes beyond the original study, it can be demonstrated that the core findings are robust and the marginal share of explained variance is larger for cognitive ability and personality traits (both about 5%) than for SES (about 2.3%). Track placement has little influence on attainment (less than 1%). However, track placement itself depends to a large extent on SES and cognitive ability (both around 12 %) but much less so on personality traits (less than 1%). These findings successfully corroborate and extend the original study.

1. Introduction

The interplay between socioeconomic status (SES), personality traits, cognitive ability and educational attainment has been a major research topic in various disciplines for many decades (Husén, 1975). As educational attainment can be understood as the key factor for success in life, it is of greatest interest to better explain and understand why individuals differ in their outcomes. One of the most influential theoretical frameworks attempts to explain these variations through the social origin of an individual, that is especially the socioeconomic status of the family (Boudon, 1974; Shavit et al., 2007). The main assumption is that SES is able to affect attainment directly and indirectly. For example, wealthy parents can provide excellent care and nutrition for their offspring and foster an ideal biological development that has positive effects on brain development, resulting in higher cognitive skills (primary effects of SES) (Kulic et al., 2019). They are able to invest more in tutoring and provide a stimulating learning environment. Also, more highly educated parents usually value the role of educational qualifications as more significant, teach their children about the importance of valuable qualifications, and support them throughout their educational careers, which are described as the secondary effects of social origin (Breen & Goldthorpe, 1997).

However, other theories put not so much the parental SES and support into focus but personality traits and cognitive abilities (Marks, 2020; O'Connell, 2019). Clearly, cognitive ability and educational outcomes are highly correlated (Rindermann, 2018) and it is well established that personality traits, especially conscientiousness, explain educational success (Andersen et al., 2020). Individuals with high levels of conscientiousness are usually characterized by thoroughness and deliberation, which has positive influences on educational performance. Apparently, as previous studies show beyond any doubt, both theories are correct to some extent and are able to explain variations in educational attainment. The main research questions that arise are hence the following: how are these various factors

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related? Which factor is more important and better able at explaining attainment? Disentangling these influences is not only of greatest interest for further theoretical groundwork but also relevant as a practical question since resolving these issues might contribute to the creation of new forms of support for pupils, helping them learn and acquire relevant educational qualifications. In the following, I will first discuss the original study and outline its core findings. I will explain why some amendments are desirable to test and strengthen the original conclusions. Afterwards I introduce a new dataset from a different European country and a modified framework of analysis. At last, the results and implications for the original study are finally discussed.

1.1. Original study

The original study is provided by O'Connell and Marks (2022) and compares the influence of SES, personality traits, cognitive ability and a few other variables on educational attainment. The sample comprises 4,528 about 16 year old pupils in the UK, the outcome variable is the GCSE score (General Certificate of Secondary Education), which is of greatest relevance for further educational and occupational success. The data is the Millennium Cohort Study (MCS) - a high quality and large scale longitudinal assessment, which provides a rich set of information. The authors compute multiple OLS regression models to analyse which set of factors is able to explain attainment best. The following variable sets are used: pupils' personality traits, which comprise the Big Five inventory; SES, including parental income, education and occupational status; cognitive ability of the pupil and the mother; and the gender of the pupil (as a control variable). The central findings are that the full model including all these variables is able to explain the highest share of variance ($R^2 = 0.30$), cognitive factors (including motherly cognitive ability) alone explain about 0.25, personality factors alone about 0.05 and SES alone about 0.11. Further inspecting beta coefficients and t-values shows that conscientiousness has the single highest effect of the Big Five scales. Finally, the authors conclude that the "...result demonstrates the inadequacy of the dominant SES-achievement paradigm, as social class and income have much weaker effects than cognitive ability and conscientiousness." (p. 4).

While these findings are clearly relevant, I have several theoretical and methodological concerns. First, the original study provides very little theoretical explanation and does not discuss the (causal) interrelations of the variables they subsequently test. For example, as shortly outlined above, the cognitive ability of the child partially depends on the SES of the family. Therefore, SES exerts a direct and an indirect (through cognitive ability) effect on educational attainment. This is a crucial aspect if one is interested in testing these various factors against each other. As soon as explanatory factors are correlated, this is no longer a trivial undertaking. A few regression models alone are not adequate to capture the influences of each factor in detail. Further below I will suggest a more elaborate analytical approach to resolve this issue. Second, while the original study reports point estimates for the share of variance explained by each factor, it does not quantify the uncertainty around these estimates. This is a problem if one is interested in actually ranking them. In statistics, it is common to quantify the variance of point estimates through some statistics like standard errors, p-values or confidence bands to demonstrate the robustness whenever samples are used (and not the entire population can be studied). For example, if the confidence bands of standardized coefficients of personality traits and SES would largely overlap, it would be incorrect to state that one of the two is more influential than the other even if point estimates differ. Third, the authors only include a single control variable, the gender of the child. In regression models, it is common to rule out (as much as possible) spurious correlations, especially when advice for policymakers or interventions should be gathered. One could assume that there are potentially more confounders[1] present, for example, the age of the child, the place of residence or whether a family has a migration background. By including more control variables, the robustness of the findings can be strengthened. Omitted control variables can be problematic due to two main reasons. Spurious correlations can arise so that path (beta) coefficients are incorrect. For example, one could assume that the migration status of a family explains both SES (as migrants often have a lower SES in comparison to the native population) and grades (as migrant children can have problems in school due to language barriers). In the worst case, the statistically significant effect of SES on grades could vanish by including migration status as a control variable. In this case, the "effect" of SES would be spurious. This issue not only concerns the coefficients but also the explained variance in the same way (variance is "explained away" by migration status and is not really an effect of SES). Detail information on control variables in the current study is given in section 2.2.6.

Fourth, the original study only includes a single country, the United Kingdom (excluding the Scottish cohort). The question arises whether the findings are generalizable to other countries and populations (external validity). If so, this would clearly strengthen the original conclusions. Lastly, a probably minor issue is that the original study uses an imputation method to account for missing data yet excludes the two central variables from this procedure (cognitive measurements and parental status). The reason given is that the share of missingness is high (over 30%). I believe that this approach can potentially introduce bias. It is not the aim of imputation to create more precise point estimates but to avoid bias due to selective non-response. If one assumes that especially low-performing pupils cancel their tests (as they are potentially frustrated), these subgroups are not adequately represented in the analytical models and the results can be affected. Also, there are apparently no auxiliary variables included in the imputation, which can further affect the efficiency of the computations.

1 In this context, a confounder is a variable that has an independent effect on the *cause* and the *effect* at the same time.

1.2. Replication study

To test the overall stability of the previous findings, the results are replicated and extended using German panel data under consideration of the concerns raised above. By introducing a slightly different analytical framework, the actual marginal contribution of each factor can be quantified. By doing so, the results are not only clearer and more precise but also come with confidence bands to compare the strength of each factor. First and foremost, a framework is introduced to account for the dependency of the variables of interest. This means that not only a single model is estimated (educational attainment) but there are three models (attainment, track placement in secondary school and filial cognitive performance). By doing so the interrelations and (causal) dependencies are made transparent and explained in more detail. In addition to these main models, some interaction models are considered as well in an exploratory fashion to see how the key explanatory variables (SES, cognitive ability and traits) work together. By using data from a different educational context, the external validity is put to the test. This different context is briefly outlined in the following section.

1.2.1. The German educational system

In Germany, primary school lasts from grade 1 to 4 (pupils aged approximately 6 to 10 years), afterwards pupils transition to secondary schooling in most federal states. Traditionally, there were three tracks available: lower secondary education (*Hauptschule*) to prepare pupils for manual and blue-collar occupations, intermediate secondary education (*Realschule*) for non-academic white-collar occupations and the academic track (*Gymnasium*) as a preparation for tertiary education and academic professions. Nowadays, the two lower tracks are either abolished, unified, or merged into comprehensive schools (*Gesamtschulen*) while the academic track still exists unchanged and has become the most popular track. While the selection at the first transition used to be based on academic performance in primary school and the decision of the class teacher in grade 4, nowadays the parents can overrule this decision in most federal states and choose the track on their own, regardless of prior performance. Overall, the most relevant distinction is whether to enter the academic track in grade 5 or not, since this is the direct pathway to tertiary education and gives the best prospects for future careers. It is known that grades are usually better in the academic track, even under the control of prior academic performance and other variables (Bittmann & Mantwill, 2020). This means that the track itself can exert an influence on the grades received and must be considered in the following framework.

1.2.2. Interrelation of variables

Clearly, the independent variables used to explain the variation of educational attainment are correlated. Furthermore, one can also assume some causal relationships. To summarize it very shortly, SES can influence filial cognitive ability through nutrition, care, tutoring and support (Boudon, 1974). Vice versa, this is rather impossible (also, I assume a stable SES for the study). However, one could also assume that the variables SES and ability are simply *correlated* (and no causal pathway should be present), potentially due to gene-environment correlations. In this case one can ignore this specific model (where cognitive ability is the dependent variable); the subsequent models are not empirically influenced by this decision. It is not the goal of the current replication study to answer in detail how SES and cognitive ability are related causally since this would require some different analyses, probably with different data. The track placement in secondary schooling depends especially on cognitive ability but also on SES as parents with a high social status usually want their children to at least reproduce their status (status maintenance hypothesis (Breen & Goldthorpe, 1997)). Finally, educational attainment depends on all these factors as well as personality traits (as, for example, the teacher might want to grade interested and deliberate pupils better, even under the control of cognitive ability). This is the main model and replicates the original study. The framework is visualized graphically in Figure 1. By providing this outline, the original study is extended as two more outcome variables (track placement and cognitive ability) are included. Note that while cognitive ability and personality traits are surely correlated, it is difficult to say whether one of them *causes* the other. In the following, they are regarded as correlated yet no causal pathways are included.

2. Methodology

2.1. Data and sample

The analyses are conducted using German National Educational Panel Study (NEPS) data - a high quality and large scale assessment - implemented as a multicohort-sequence study (Blossfeld & Roßbach, 2019). For the study, starting cohort 3 is utilized which sampled pupils at the beginning of secondary education in grade 5 and surveyed them annually since 2010/11. Additionally, parents and teachers are also integrated to give a complete picture of the family and schooling situation. The NEPS furthermore conducts comprehensive assessment tests within the classroom contexts to provide highly standardized information on student ability that is independent of school tracks and teachers. For the analyses, the first five waves of the panel are relevant, covering school grades 5 to 9.

The original NEPS SC3 sample (that is, all pupils actually participating in wave 1 of the survey, N = 5,778) is restricted. First, all pupils transferring to a special needs school (*Förderschule*) in grade 5 are excluded from the analyses. Second, the federal states Berlin and Brandenburg are excluded since primary school is attended until grade six (not four, as in all other states), therefore no secondary schooling track can be computed for them. Finally, pupils switching tracks between wave 1 and 4 are removed since for these individuals the track effect is not homogeneous. This leaves a total of 4,607 pupils for analysis. The implications of this are that the sample is no longer perfectly representative of the overall German population (note that the original study faces the same problem as the Scottish cohort is not available). Regarding the special needs schools, this is however of less concern as grades play a minor role for these students as they face other challenges. Track switchers are

a more interesting issue since these are either very high or very low performing students. Empirically, these are usually students that perform badly and thus transfer to an academically less demanding track as upgrades are rare. This step hence removes underperforming pupils from the sample, which is however of minor relevance as fewer than 300 individuals are concerned.

2.2. Measures

Univariate statistics are available in the appendix in Table A1. A correlation matrix of all continuous measurements is presented in Table 1.

2.2.1. Educational attainment in secondary education

To measure educational attainment, school grades are used. In Germany, no nationwide standardized tests exist in secondary education. Not even the higher educational entrance qualification (*Abitur*), which is taken in the academic track after 12 or 13 years (depending on the federal state) is standardized but either provided by the school or the federal state ministry of education. Consequently, to measure attainment, regular school grades as self-reported by the pupils are utilized. The grades were reported in wave 5 of the survey and represent the grades the pupil received in school grade eight. The traditional German grading system with values from 1 ("very good") to 6 ("insufficient") is reversed and recoded with values from 0 (worst grade) to 5 (best grade) for a more convenient interpretation. The average grade over the following subjects is computed to give a comprehensive overview over the average educational attainment: German, Mathematics, Biology, Chemistry and Physics. The reliability of the resulting scale is high (Cronbach Alpha = 0.83). A principal component analysis furthermore shows that only a single component with an Eigenvalue larger than 1 can be extracted, underlining the robustness of the variable.

2.2.2. Cognitive ability

Three variables are used to measure cognitive ability. They are all parts of the comprehensive tests the NEPS conducts within the classroom context. The main advantage of these tests is that they are independent of the school, tracks or teachers and the same tests are administered for all pupils, rendering them highly comparable. The three components are cognitive basic skills (perceptual speed and reasoning) and the mathematics test since math performance can be regarded as an approximate indicator of overall cognitive ability (Cowan et al., 2011; Moenikia & Zahed-Babelan, 2010). The first two components follow the framework of Baltes et al. (1999), the math test is oriented at the PISA definition of mathematical literacy. The test results are taken from wave 1 when children just entered secondary school.[2] Therefore, it is unlikely that track has an effect on cognitive performance in such a short time and reverse causality should not occur. Rather, cognitive performance explains track placement. Out of the three components, a single continuous measurement is generated via Empirical Bayes Means in a SEM framework. The resulting score is approximately normally distributed and rescaled to have a mean of 100 and a standard deviation of 10 for a more convenient interpretation.

2.2.3. Socio-economic status (SES) measures

2.2.3.1. Household income

Based on the total after-tax household income, as reported by the parents, and the total number of parents and children in the household, the equivalent income is computed (OECD definition). By doing so the total income is adjusted for the number of persons living in the household. For each family, the median of this value is taken for all waves available, and the logarithm is applied to create a more normally distributed variable to ease statistical inference. This variable, therefore, indicates the financial situation of the family.

2.2.3.2. Parental education

Instead of applying the principle of dominance, which might introduce bias (Thaning & Hällsten, 2020), information for both parents (if available) about their level of education is included in the analyses. The original variables based on the CASMIN scale are recoded into four categories to reflect the most relevant degrees in the German system: low or no achievement in secondary school (*Hauptschulabschluss*), intermediate secondary achievement (*Mittlere Reife*), higher education eligibility (HEE, *Abitur*), or having completed any tertiary degree.

2.2.3.3. Parental occupational status

Information on the occupation of the parents is available for the majority of all families. The NEPS provides the ISCO-88 and the derived ISEI (International Socio-Economic Index of Occupational Status) to indicate the social status of a position in society based on the occupation (Ganzeboom, 2010). If both parents provide information, the mean value is computed. The range of the scale is from 16 to 88.

2.2.4. Personality measures

The NEPS implements the 10-item short version of the Big Five Inventory (Rammstedt & John, 2007) in wave 3 of the survey (grade 7). The instrument uses two or three items to measure each dimension. As is known from other studies, while the quality and reliability of this well-established instrument are high, the low number of variables used leads to rather low values of Cronbach Alpha (between 0.37 and

2 For detail information on the testing framework refer to https://www.neps-data.de/Portals/0/NEPS/Datenzentrum/Forschungsdaten/SC3/1-0-0/NEPS_SC3_Competences_W1_en.pdf (2022-01-20).

Table 1. Correlation matrix of continuous variables

	1	2	3	4	5	6	7	8	9	10	11	12
1 Grades	1.00											
2 Cognitive ability	0.33***	1.00										
3 Neuroticism	-0.07***	-0.09***	1.00									
4 Openness	0.07***	0.10***	0.04**	1.00								
5 Agreeableness	0.07***	-0.02	-0.04*	0.21***	1.00							
6 Conscientiousness	0.25***	-0.04**	-0.06***	0.09***	0.31***	1.00						
7 Extraversion	0.04**	0.01	-0.24***	0.08***	-0.01	0.03	1.00					
8 Age in 2015	-0.19***	-0.24***	0.05***	-0.06***	-0.02	-0.01	-0.08***	1.00				
9 HH Income	0.24***	0.29***	-0.10***	0.08***	0.05***	0.04**	0.11***	-0.29***	1.00			
10 Parental ISEI	0.26***	0.33***	-0.09***	0.07***	0.05**	0.03*	0.07***	-0.30***	0.61***	1.00		
11 Education of mother	0.24***	0.33***	-0.08***	0.08***	0.03*	0.03*	0.07***	-0.30***	0.53***	0.66***	1.00	
12 Education of father	0.26***	0.33***	-0.07***	0.11***	0.01	0.01	0.09***	-0.26***	0.52***	0.61***	0.58***	1.00

Source: NEPS SC3. Imputed data (N = 4,607; M = 20).
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

0.50), which is neither surprising nor concerning (Heilmann et al., 2021). However, it should be acknowledged that effected sizes might potentially be attenuated by using a short scale instrument for the Big Five Inventory, as has been demonstrated in past research (Credé et al., 2012).

2.2.5. School track in secondary education

The school track of the pupil is recoded into a binary variable for either attending the academic track (*Gymnasium*, coded 1) or attending any other track (including *Hauptschule*, *Realschule*, or *Gesamtschule*, coded 0).

2.2.6. Control variables

As discussed before, some more variables are included to avoid spurious correlations in the regression models. These are the gender of the child (male or female), the age of the child in 2015 (as cognitive ability also depends on age and higher SES parents might therefore delay the enrollment in school), the place of residence at the school year when grades are taken (West or East Germany due to the still persisting social, cultural and political differences between the two former countries)[3] and the migration background of the family (if at least one parent was born abroad, this is counted as having a migration background, otherwise not). If the parents reported that they are living together in a household for each point in the survey from wave 1 to 5, this is counted as living in a nuclear family, otherwise as a single household (also including being divorced or widowed). Single parents usually have less time for their children since they have to take on all other obligations alone, which can also influence grades and SES of a single parent household is often lower. Note that the cognitive ability of the mother is not available in the NEPS data.

2.3. Imputation of data

To account for missing information due to non-response, multiple imputation by chained equations (MICE) is conducted. This approach avoids bias due to selective non-response as long as the assumption missing-at-random (MAR) holds (Azur et al., 2011). Whenever some predictors of missingness are available, imputation is superior to listwise deletion. This means that some variables that are associated with the missingness are included to predict the loss of information. For example, parental items have the highest share of missing data as some parents refused to participate in the study at all. However, these groups are non-random as especially less educated parents often choose to not participate. This missingness can be partially predicted from the pupil questionnaire as there are also indicators of social origin included. Note that the dependent variable is imputed as well, as this can never create bias and there are strong predictors available (for example, the grades given in previous waves) (Sullivan et al., 2015). To further enhance the quality, some auxiliary variables and weights are included in this process.[4] 20 complete datasets are generated and the quality of the results is inspected and approved (e.g., no monotonic missingness patterns, convergence, and no generation of impossible values). The share of imputed values is reported in the descriptive table as well.

2.4. Strategy of analysis

It is the main goal of this study to quantify the relative marginal importance of predictors in multiple regression analyses. This is the share of explained variance that a variable contributes additionally to all other remaining variables in the model. As soon as predictors are correlated, this is no longer a trivial task due to commonly shared explained variance. A well-established solution is dominance analysis (Azen & Budescu, 2006; Budescu, 1993). The idea behind this approach is conceptually simple yet can be computationally intensive. Assuming that there are three predictor variables (A, B, C), all combinations of regressions are computed, and marginal contributions averaged over all models. This example requires seven models with the following predictors: A, B, C, A+B, A+C, B+C, A+B+C. By testing all combinations in an exhaustive fashion, the marginal relative importance is quantified. The approach also allows grouping predictors together into sets (for example, all Big Five scales into a set that accounts for personality traits). This principle is applied to R^2 values in OLS regression models. The marginal explanatory power is computed and the uncertainty around the point estimates is quantified using bootstrapping (bias-corrected) (Bittmann, 2021a; Brand et al., 2019). All analyses are conducted in Stata 16.1, the dominance analyses are computed using the package *domin* (Luchman, 2015). Imputed datasets are combined using the command *mimrgns* (Klein, 2014). Complete do-files are available on request.

3. Results

The correlation matrix for all continuous measurements in Table 1 indicates that the grade received correlates the highest with the cognitive ability of the child (0.33) but also with the social origin as indicated by the measures of parental education and status (reported is Pearson's R). Regarding the personality traits, the main correlation is with conscientiousness (0.25) while the other correlations are minor (< 0.08). The German findings replicate the original correlation matrix very well with the exception of neuroticism, where the sign is switched. The correlation between

3 Further tests have shown that including the actual federal state does not much change and improve computations and the simpler West / East solution was chosen, also due to restrictions concerning data protection of the NEPS.

4 These variables are the number of books in the household, school grades from previous waves, overall life satisfaction, the native language (German vs any other language), and the aspirations parents have for their child. As all these variables are reported by the pupils, they are not affected by parental non-response and provide further background information on the household.

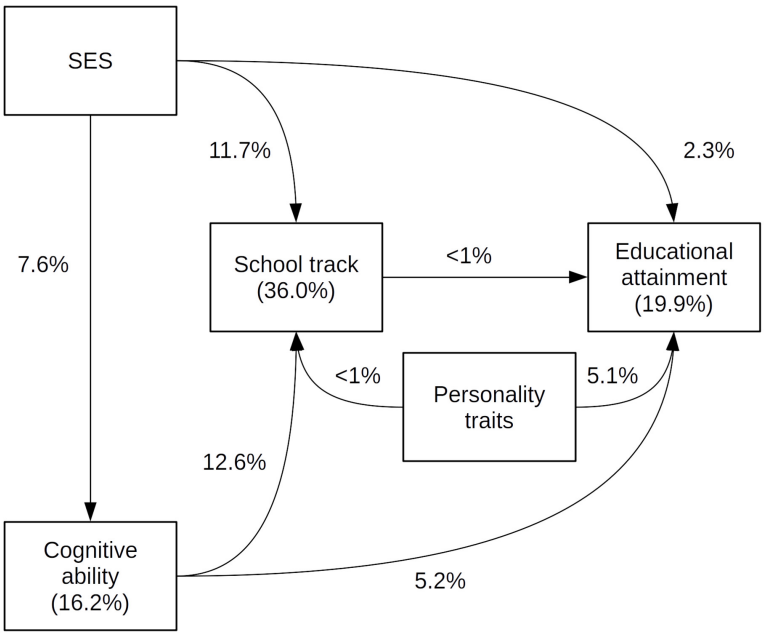

Figure 1. Visualization of the analytical framework including explained variance (in parentheses) and absolute marginal contribution of explanatory variables.

Source: NEPS SC3. Imputed data (N = 4,607; M = 20). Shares in parentheses give the total explained variance by the respective explanatory variables and all control variables. Other shares give the total marginal share explained by a specific independent variable.

grades and cognitive ability is slightly smaller than in the original (0.47).

3.1. Dominance analyses

Based on OLS regression models, dominance analyses are conducted. As outlined before, three different dependent variables are inspected. The results are summarized graphically in Figure 1 and in Table 2. For the replication most relevant are the grades of the pupils (attainment). The main finding is that the saturated model including all predictors explains 19.9% of the total variance. This value is lower than in the original study (30.1%). The most important predictor is the cognitive ability with a total share explained of 5.2% (contributing about 26.1% to the *explained* variance). The second rank goes to personality with 5.1%. SES takes the third rank with 2.3%. The confidence bands of SES do not overlap with either cognitive ability or personality traits. Finally, the type school track attended explains less than 1% of the total variance of grades. Note that these numbers are not directly comparable to the original study since it does not apply dominance analysis and the reported numbers there cannot quantify the marginal contribution with precision. Next, regarding the dependent variable track, the most relevant predictor is, again, the cognitive ability with about 12.6% of explained variance. SES follows second (11.7%) and finally personality traits (< 1%). With respect to cognitive ability, SES explains about 7.6% of the total variance. The remainders are due to the control variables which are included in all models and not quantified in detail.

3.2. Beta coefficients

For completeness, the beta coefficients are reported in the appendix in Table A2. When grades are the dependent variable, conscientiousness is the most relevant personality trait with a t-value of 13.5.

3.3. Interaction analyses

By now, only the main effects of the central variables of interest have been considered. As other researchers have pointed out, it might be possible that different influences on grades compensate for each other (Damian et al., 2015). For example, do high SES students profit more from their cognitive abilities than low SES ones? These additional analyses can be considered as exploratory to guide further research, even if not directly related to the research question of the original study. There are three main interactions of interest: SES with ability, SES with conscientiousness (which has been shown to be the most relevant personality trait to explain grades) and ability with conscientiousness. To conduct these analyses, it is necessary to create a single variable for SES, which follows the same process as described above for cognitive ability (Empirical Bayes Means in a SEM framework). By doing so, the combined influence of ISEI, household income and parental education is integrated into a single, continuous variable that is approximately normally distributed and z-standardized for easier interpretation. The results are found in Table 3, where all control variables are included as before. Grades are the dependent variable.

Table 2. Absolute and relative explained variance (R squared)

	Absolute influence			Relative influence		
Variable	**Variance explained**	**95% CI**		**Variance explained**	**95% CI**	
Grade	0.1988	0.170	0.228	1		
Personality traits	0.051	0.037	0.065	0.2569	0.196	0.318
Track	0.009	0.005	0.013	0.0453	0.026	0.065
Cognitive ability	0.0519	0.033	0.071	0.2611	0.187	0.335
SES	0.0232	0.013	0.033	0.116	0.069	0.165
Track	0.3602	0.326	0.394	1		
Personality traits	0.0074	0.003	0.012	0.02	0.009	0.033
Cognitive ability	0.1256	0.089	0.162	0.3488	0.271	0.426
SES	0.1168	0.098	0.136	0.3244	0.264	0.385
Cognitive ability	0.162	0.113	0.211	1		
SES	0.076	0.052	0.100	0.469	41.0	52.39

Source: NEPS SC3. Imputed data (N = 4,607; M = 20). 600 bootstrap resamples for CIs. For example, personality traits, track, cognitive ability, SES and all control variables explain 19.88% of the variation of grades. The total contribution of personality traits is 5.1%. This means that about 25.69% of the explained variance is due to personality traits (5.1/19.88).

The first model is the baseline model without interactions. Clearly, SES has a positive effect, just as cognitive ability and conscientiousness; all three are statistically highly significant. The next model includes the interaction between SES and ability. The interaction coefficient is 0.0038 and statistically significant on the 1% level. This is interesting as it means that the positive influence of ability on grades increases the higher the SES of the family. To depict this graphically Figure 2 has been created. It shows the predicted grades depending on the cognitive ability of the child for three SES categories (2 standard deviations below the average; the average SES; and 2 standard deviations above the average). It becomes obvious that ability works differently for different SES groups. While there is no difference at all for pupils with low ability, the effects increase with growing ability (scissor effects). For the group of pupils with the highest ability, the effects of SES are quite large. In other words: high SES pupils make much more of their superior cognitive abilities than low SES ones. Of course, this can have many reasons (potentially, teachers grade high SES students better due to their academic habitus or better behavior in class). At this point, the causes cannot be explained in detail but might be worthwhile to consider in subsequent studies.

For the two other models, no statistically significant interaction effects are found. This means that SES and conscientiousness or ability and conscientiousness do not compensate for each other.

4. Discussion

The main finding is that the replication study using German data comes to the same conclusions as the original one. When grades are the dependent variable, it is clear that both cognitive ability and personality traits exceed the influence of SES as their relative influence is more than twice as large. The school track itself has only a very little additional influence, however, there are certain caveats. First, the total share of explained variance is lower in the replication by about ten percentage points. This is interesting as even more control variables are included. One explanation might be that the German grades are not standardized at all and highly dependent on the respective schools or even teachers. The GCSE in the original study has as a higher degree of standardization as questions are given by exam boards. Even though multiple exam boards exist, at least a few thousand of the pupils receive the same questions. This is very different from the German system where each teacher designs the tests and assigns grades. Another explanation is that the cognitive score of the mother is not available in the replication study, yet this has probably only a minor impact. This variable correlates highly with both filial cognitive scores and parental education, rendering the share of additional provided explanatory power small. We also see this in the original study where the influence of maternal cognitive ability (t = 3.86) is minor in relation to the filial ability (t = 25.84) or the household income (t = 5.11). As maternal performance also correlates with maternal education, there should be no bias present in the replication results. Regarding the distribution of the share that is explained by the different parts, note that not a perfect comparison with the original study is possible as the replication study quantifies the additional marginal share. This proves statistically that cognitive ability and personality traits are partially independent and contribute both. However, their overall influence is clearly larger than the influence of SES. Overall, these results suggest that the original findings are stable, even in a different context.

Regarding the extension of the original study, the replication provides more insight by adding two models. First, regarding the track placement after primary school, the model explains about 36% of the total variance where SES and cognitive ability contribute equally. Here, personality traits add very little. This is interesting, as the selection is officially intended to be on ability. Therefore, one would expect an even greater influence of cognitive ability. However, it becomes clear that parents also have other means to affect placement (for example, by ignoring the recommendation given by the class teacher in grade four) (Bittmann, 2021b). At this point, it is rather unclear why personality

Table 3. Interaction regression models

	No interactions	SES x Ability	SES x Consc.	Ability x Consc.
Overall SES	0.094***	-0.28*	0.088	0.094***
	[0.07,0.12]	[-0.52,-0.05]	[-0.00,0.18]	[0.07,0.12]
Cognitive ability	0.018***	0.018***	0.018***	0.016**
	[0.02,0.02]	[0.02,0.02]	[0.02,0.02]	[0.01,0.03]
Female child	0.080**	0.080**	0.080**	0.080**
	[0.03,0.13]	[0.03,0.13]	[0.03,0.13]	[0.03,0.13]
Migration background	-0.080**	-0.086***	-0.080**	-0.080**
	[-0.13,-0.03]	[-0.14,-0.03]	[-0.13,-0.03]	[-0.13,-0.03]
Age in 2015	-0.087***	-0.092***	-0.087***	-0.087***
	[-0.13,-0.04]	[-0.14,-0.04]	[-0.14,-0.04]	[-0.13,-0.04]
Single parent	-0.066	-0.065	-0.066	-0.066
	[-0.13,0.00]	[-0.13,0.00]	[-0.13,0.00]	[-0.13,0.00]
Living in East Germany	0.23***	0.23***	0.23***	0.23***
	[0.16,0.30]	[0.16,0.30]	[0.16,0.30]	[0.16,0.30]
Neuroticism	-0.017	-0.016	-0.017	-0.017
	[-0.05,0.01]	[-0.05,0.01]	[-0.05,0.01]	[-0.05,0.01]
Openness	-0.0011	-0.0016	-0.0012	-0.0013
	[-0.03,0.02]	[-0.03,0.02]	[-0.03,0.02]	[-0.03,0.02]
Agreeableness	-0.012	-0.010	-0.012	-0.012
	[-0.05,0.03]	[-0.05,0.03]	[-0.05,0.03]	[-0.05,0.03]
Conscientiousness	0.19***	0.19***	0.19***	0.13
	[0.17,0.22]	[0.16,0.22]	[0.17,0.22]	[-0.14,0.40]
Extraversion	0.0060	0.0081	0.0060	0.0060
	[-0.02,0.04]	[-0.02,0.04]	[-0.02,0.04]	[-0.02,0.04]
Academic track	-0.0046	-0.0066	-0.0045	-0.0048
	[-0.06,0.05]	[-0.06,0.05]	[-0.06,0.05]	[-0.06,0.05]
Overall SES x Cognitive ability		0.0038**		
		[0.00,0.01]		
Overall SES x Conscientiousness			0.0020	
			[-0.03,0.03]	
Cognitive ability x Conscientiousness				0.00060
				[-0.00,0.00]
Constant	2.19***	2.20***	2.19***	2.39***
	[1.34,3.04]	[1.36,3.05]	[1.34,3.05]	[1.12,3.67]
Observations	4607	4607	4607	4607

Source: NEPS SC3. Imputed data (M = 20). Unstandardized coefficients. 95% confidence bands in brackets. The dependent variable is grades.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

traits contribute very little. Potentially, the *parental* personality contributes more, as usually the parents decide the track placement and not the children. It must also be kept in mind that reverse causality might be an issue for this specific analysis (as the track placement happens after grade 4 but personality traits were measured in grade 7). When cognitive ability is inspected, SES and all control variables explain about 16% of the total variation, which means that the major share is unexplained and must be due to other, for example, genetic or random influences. The influence of SES is however apparent as it explains about half of it (ca. 47%). Finally, interaction terms were included to test whether some variables can compensate for each other. As the results have shown, this assumption is only valid for the interaction of SES and ability. SES has the largest influence in the group of the most able students in the sample and grades clearly diverge. The reasons for these differences were not recovered given the scope of the current paper, yet seem relevant starting points for further research. Understanding why teachers grade pupils of high SES better only when their abilities are very high appears to be an worthwhile research project.

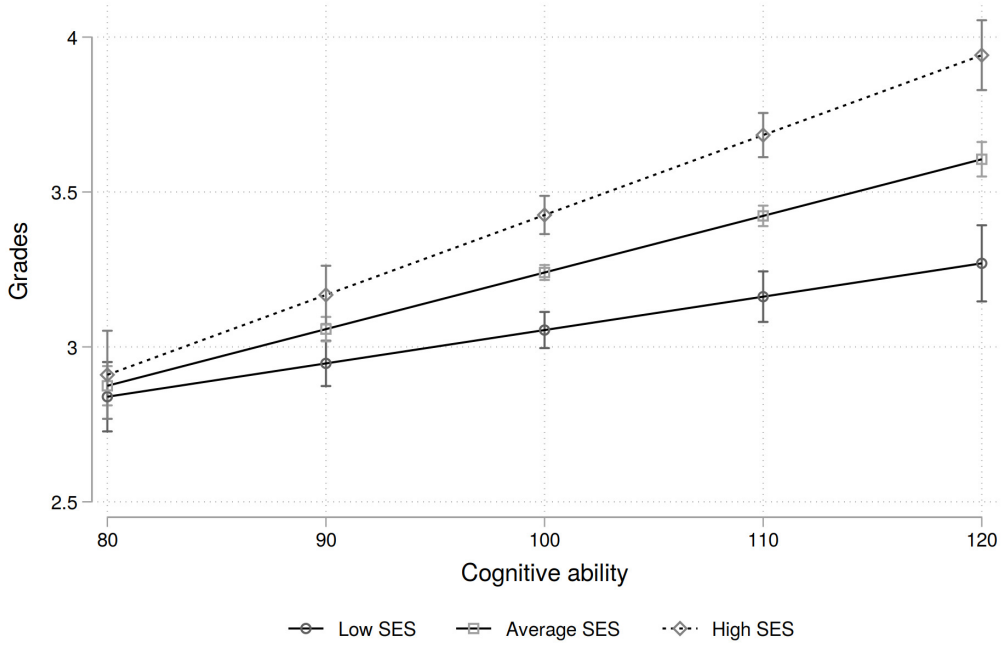

Figure 2. Predicted grades by SES and cognitive ability (interaction model)

Source: NEPS SC3. Imputed data (N = 4,607; M = 20). Included are 95% confidence bands.

To conclude the main finding, researchers might have good empirical arguments to focus more on personality and ability instead of SES for explaining attainment.

As always, there are limitations that come with observational data. Even by including relevant controls, spurious correlations can never be ruled out and hence the findings presented here cannot be interpreted as purely causal. Of course, this is a general problem as no experiment will be able to resolve these questions as SES cannot be "assigned" by a research team (especially when grades are of interest as this is a process that evolves over the course of a school year due to the pupil-teacher interactions in class). As the current findings are in line with the original study there are hopefully no severe biasing factors that might lead to wrong conclusions. Readers are advised to interpret all results with caution and not overgeneralize the conclusions.

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Competing Interests

None.

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Ethical Statement

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. Informed consent was obtained from all patients for being included in the study.

Data Accessibility Statement

The data are provided by the Leibniz Institute for Educational Trajectories and can be accessed online after registration as a researcher, see: https://www.neps-data.de/Data-Center/Data-Access. The specific dataset used in the analyses is accessible under doi:10.5157/NEPS:SC3:11.0.1.

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References

Andersen, S. C., Gensowski, M., Ludeke, S. G., & John, O. P. (2020). A stable relationship between personality and academic performance from childhood through adolescence. An original study and replication in hundred-thousand-person samples. *Journal of Personality*, *88*(5), 925–939. https://doi.org/10.1111/jopy.12538

Azen, R., & Budescu, D. V. (2006). Comparing Predictors in Multivariate Regression Models: An Extension of Dominance Analysis. *Journal of Educational and Behavioral Statistics*, *31*(2), 157–180. https://doi.org/10.3102/10769986031002157

Azur, M. J., Stuart, E. A., Frangakis, C., & Leaf, P. J. (2011). Multiple imputation by chained equations: What is it and how does it work?: Multiple imputation by chained equations. *International Journal of Methods in Psychiatric Research*, *20*(1), 40–49. https://doi.org/10.1002/mpr.329

Baltes, P. B., Staudinger, U. M., & Lindenberger, U. (1999). LIFESPAN PSYCHOLOGY: Theory and Application to Intellectual Functioning. *Annual Review of Psychology*, *50*(1), 471–507. https://doi.org/10.1146/annurev.psych.50.1.471

Bittmann, F. (2021a). *Bootstrapping: An Integrated Approach with Python and Stata* (1st ed.). De Gruyter. https://doi.org/10.1515/9783110693348

Bittmann, F. (2021b). Academic track mismatch and the temporal development of well-being and competences in German secondary education. *Vienna Yearbook of Population Research*, *19*, 1–36. https://doi.org/10.1553/populationyearbook2021.res5.1

Bittmann, F., & Mantwill, O. (2020). Gute Leistung, gute Noten? Eine Untersuchung über den Zusammenhang von Schulnoten und Kompetenzen in der Sekundarstufe (Good Performance, Good Grades? An Analysis of the Relationship Between Grades and Competences in German Secondary Education). *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3724172

Blossfeld, H., & Roßbach, H. (2019). *Education as a Lifelong Process: The German National Educational Panel Study (NEPS)* (2nd ed., Vol. 3). VS Verlag für Sozialwissenschaften.

Boudon, R. (1974). *Education, opportunity, and social inequality: Changing prospects in western society*.

Brand, J., Buuren, S., Cessie, S., & Hout, W. (2019). Combining multiple imputation and bootstrap in the analysis of cost-effectiveness trial data. *Statistics in Medicine*, *38*(2), 210–220. https://doi.org/10.1002/sim.7956

Breen, R., & Goldthorpe, J. H. (1997). Explaining Educational Differentials: Towards a Formal Rational Action Theory. *Rationality and Society*, *9*(3), 275–305. https://doi.org/10.1177/104346397009003002

Budescu, D. V. (1993). Dominance analysis: A new approach to the problem of relative importance of predictors in multiple regression. *Psychological Bulletin*, *114*(3), 542–551. https://doi.org/10.1037/0033-2909.114.3.542

Cowan, R., Donlan, C., Shepherd, D.-L., Cole-Fletcher, R., Saxton, M., & Hurry, J. (2011). Basic calculation proficiency and mathematics achievement in elementary school children. *Journal of Educational Psychology*, *103*(4), 786–803. https://doi.org/10.1037/a0024556

Credé, M., Harms, P., Niehorster, S., & Gaye-Valentine, A. (2012). An evaluation of the consequences of using short measures of the Big Five personality traits. *Journal of Personality and Social Psychology*, *102*(4), 874. https://doi.org/10.1037/a0027403

Damian, R. I., Su, R., Shanahan, M., Trautwein, U., & Roberts, B. W. (2015). Can personality traits and intelligence compensate for background disadvantage? Predicting status attainment in adulthood. *Journal of Personality and Social Psychology*, *109*(3), 473–489. https://doi.org/10.1037/pspp0000024

Ganzeboom, H. B. (2010). A new International Socio-Economic Index (ISEI) of occupational status for the International Standard Classification of Occupation 2008 (ISCO-08) constructed with data from the ISSP 2002-2007. *Annual Conference of International Social Survey Programme, Lisbon, 1*. http://www.harryganzeboom.nl/Pdf/2010%20-%20Ganzeboom-ISEI08-ISSP-Lisbon-(paper).pdf

Heilmann, K., Hinrichs, R., Herke, M., Richter, M., & Rathmann, K. (2021). Die Bedeutung der „Big Five"-Persönlichkeitsmerkmale für die subjektive Gesundheit und Lebenszufriedenheit im Jugendalter: Ergebnisse des Nationalen Bildungspanels (NEPS). *Das Gesundheitswesen*, *83*(01), 8–16. https://doi.org/10.1055/a-1068-2280

Husén, T. (1975). *Social Influences on Educational Attainment*. Research Perspectives on Educational Equality.

Klein, D. (2014). *MIMRGNS: Stata module to run margins after mi estimate* [Stata]. https://ideas.repec.org/c/boc/bocode/s457795.html

Kulic, N., Skopek, J., Triventi, M., & Blossfeld, H.-P. (2019). Social Background and Children's Cognitive Skills: The Role of Early Childhood Education and Care in a Cross-National Perspective. *Annual Review of Sociology*, *45*(1), 557–579. https://doi.org/10.1146/annurev-soc-073018-022401

Luchman, J. N. (2015). *"DOMIN": Module to conduct dominance analysis*. Boston College Department of Economics. https://ideas.repec.org/c/boc/bocode/s457629.html

Marks, G. N. (2020). Is the relationship between socioeconomic status (SES) and student achievement causal? Considering student and parent abilities. *Educational Research and Evaluation*, *26*(7–8), 344–367. https://doi.org/10.1080/13803611.2021.1968442

Moenikia, M., & Zahed-Babelan, A. (2010). A study of simple and multiple relations between mathematics attitude, academic motivation and intelligence quotient with mathematics achievement. *Procedia - Social and Behavioral Sciences*, *2*(2), 1537–1542. https://doi.org/10.1016/j.sbspro.2010.03.231

O'Connell, M. (2019). Is the impact of SES on educational performance overestimated? Evidence from the PISA survey. *Intelligence*, *75*, 41–47. https://doi.org/10.1016/j.intell.2019.04.005

O'Connell, M., & Marks, G. N. (2022). Cognitive ability and conscientiousness are more important than SES for educational attainment: An analysis of the UK Millennium Cohort Study. *Personality and Individual Differences*, *188*, 111471. https://doi.org/10.1016/j.paid.2021.111471

Rammstedt, B., & John, O. P. (2007). Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German. *Journal of Research in Personality*, *41*(1), 203–212. https://doi.org/10.1016/j.jrp.2006.02.001

Rindermann, H. (2018). *Cognitive capitalism: Human capital and the wellbeing of nations*. Cambridge University Press. https://doi.org/10.1017/9781107279339

Shavit, Y., Arum, R., & Gamoran, A. (Eds.). (2007). *Stratification in Higher Education: A Comparative Study*. Stanford University Press. https://doi.org/10.1515/9780804768146

Sullivan, T. R., Salter, A. B., Ryan, P., & Lee, K. J. (2015). Bias and Precision of the "Multiple Imputation, Then Deletion" Method for Dealing With Missing Outcome Data. *American Journal of Epidemiology*, *182*(6), 528–534. https://doi.org/10.1093/aje/kwv100

Thaning, M., & Hällsten, M. (2020). The End of Dominance? Evaluating Measures of Socio-Economic Background in Stratification Research. *European Sociological Review*, *36*(4), 533–547. https://doi.org/10.1093/esr/jcaa009

Appendix

Table A1. Descriptive statistics

	Mean	SD	Skewness	Min	Max	Imputed %
Average grade	3.25	0.73	-0.10	0	5	26.3
Cognitive ability	100.0	10.00	-0.32	68.9	125.7	< 1
Academic track	0.48			0	1	19.4
Neuroticism	2.81	0.82	0.092	1	5	13.8
Openness	3.45	0.94	-0.20	1	5	13.3
Agreeableness	3.45	0.65	-0.31	1	5	14.6
Conscientiousness	3.24	0.86	-0.085	1	5	13.3
Extraversion	3.41	0.78	0.0088	1	5	14.3
Female child	0.48			0	1	< 1
Migration background	0.25			0	1	< 1
Age in 2015	15.0	0.51	0.81	12.6	18.1	< 1
Single parent	0.25			0	1	25.7
Log. HH income	7.29	0.46	0.16	5.42	10.8	30.5
Parental ISEI	46.9	14.9	0.17	16	88	26.9
Education Mother						
Low	0.30			0	1	34.4
Intermediate	0.29			0	1	34.4
HEE	0.16			0	1	34.4
Tertiary	0.26			0	1	34.4
Education Father						
Low	0.19			0	1	27.0
Intermediate	0.41			0	1	27.0
HEE	0.22			0	1	27.0
Tertiary	0.18			0	1	27.0

Source: NEPS SC3. Imputed data (N = 4,607; M = 20). HEE = Higher education eligibility. Shares not always add up to 1 due to rounding.

Table A2. Regression results

	Cognitive ability		School track		Grades	
	Beta (95% CI)	t	Beta (95% CI)	t	Beta (95% CI)	t
Female child	-1.46***	-5.32	0.044***	3.35	0.081***	3.35
	[-2.00,-0.92]		[0.02,0.07]		[0.03,0.13]	
Migration background	-2.08***	-6.20	0.070***	4.56	-0.079**	-2.98
	[-2.74,-1.42]		[0.04,0.10]		[-0.13,-0.03]	
Age in 2015	-2.62***	-9.11	-0.12***	-9.13	-0.089***	-3.65
	[-3.18,-2.05]		[-0.15,-0.10]		[-0.14,-0.04]	
Single parent	-0.63	-1.62	-0.049**	-2.89	-0.069*	-2.05
	[-1.40,0.14]		[-0.08,-0.02]		[-0.14,-0.00]	
Living in East Germany	0.56	1.19	0.045*	2.04	0.24***	6.62
	[-0.37,1.49]		[0.00,0.09]		[0.17,0.31]	
Log. equivalent HH income	0.86	1.90	0.098***	5.00	0.039	1.02
	[-0.03,1.76]		[0.06,0.14]		[-0.04,0.11]	
Parental ISEI	0.047**	3.17	0.0032***	4.26	0.0023*	1.98
	[0.02,0.08]		[0.00,0.00]		[0.00,0.00]	
Education Mother						
Low	Ref.		Ref.		Ref.	
Intermediate	1.85***	3.98	0.063**	2.95	-0.017	-0.48
	[0.93,2.77]		[0.02,0.10]		[-0.09,0.05]	
HEE	2.34***	4.37	0.12***	4.19	-0.021	-0.44
	[1.28,3.40]		[0.06,0.17]		[-0.12,0.07]	
Tertiary	3.03***	5.52	0.15***	5.65	0.015	0.28
	[1.95,4.10]		[0.10,0.21]		[-0.09,0.12]	
Education Father						
Low	Ref.		Ref.		Ref.	
Intermediate	2.43***	5.28	0.052*	2.48	0.041	1.11
	[1.52,3.34]		[0.01,0.09]		[-0.03,0.12]	
HEE	3.53***	6.43	0.13***	5.40	0.11*	2.46
	[2.45,4.61]		[0.08,0.18]		[0.02,0.19]	
Tertiary	4.34***	6.91	0.13***	4.43	0.18***	3.71
	[3.10,5.57]		[0.07,0.19]		[0.08,0.27]	
Neuroticism			-0.011	-1.21	-0.017	-1.17
			[-0.03,0.01]		[-0.05,0.01]	
Openness			0.011	1.48	-0.0032	-0.26
			[-0.00,0.03]		[-0.03,0.02]	
Agreeableness			-0.015	-1.37	-0.011	-0.56
			[-0.04,0.01]		[-0.05,0.03]	
Conscientiousness			0.025**	3.11	0.19***	13.49
			[0.01,0.04]		[0.17,0.22]	
Extraversion			0.017	1.79	0.0059	0.40
			[-0.00,0.04]		[-0.02,0.03]	
Cognitive ability			0.017***	24.29	0.018***	12.79
			[0.02,0.02]		[0.02,0.02]	
Academic track					-0.0052	-0.18
					[-0.06,0.05]	
Constant	128.0***	22.51	-0.46	-1.64	1.77***	3.45
	[116.82,139.15]		[-1.02,0.09]		[0.75,2.79]	
Observations	4607		4607		4607	

Source: NEPS SC3. Imputed data (M = 20). HEE = Higher education eligibility. Unstandardized coefficients. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Supplementary Materials

Response Letter

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