



Short Communication

Cognitive ability and conscientiousness are more important than SES for educational attainment: An analysis of the UK Millennium Cohort Study

Michael O'Connell^{a,*}, Gary N. Marks^b^a School of Psychology UCD, Dublin, Ireland^b Social and Political Sciences, University of Melbourne, Parkville 3052, Victoria, Australia

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ABSTRACT

The influences on children's success in education remain a profoundly important topic of enquiry. The dominant view is that socioeconomic background (SES) is critical. This study examines the influences on student performance in the General Certificate of School Education (GSCE) taken at age 16 in England, Wales and Northern Ireland analysing data from the Millennium Cohort Study. The GSCE results of 8303 students were converted to a numerical score. Two psychological factors – cognitive ability and their level of conscientiousness – could explain almost as much of the variation in exam attainment as all measures, and far more than a model of socio-economic factors. The power of psychological traits in influencing key educational outcomes is underestimated.

1. Introduction

Educational attainment is a key influence on socioeconomic success, so its antecedents are of great interest. The origins of the substantial disparities in educational performance and attainments are widely discussed and investigated. One influential view attributes educational outcomes to exogenous, socio-economic factors, such as parents' education, occupational status, household income or wealth – (e.g., see [Burhan et al., 2017](#); [Shavit et al., 2007](#)). This paradigm is embedded in the OECD's influential PISA triennial assessments of 15-year-olds in key subject domains where students' socio-economic status (or what is referred to in PISA as ESCS – Economic Social and Cultural Status) is the key determining factor in student attainment, along with school structures, teachers, curricula, and other exogenous factors, see [OECD, 2018](#).

An alternative view shifts the locus of causality from social factors to individual traits, such as personality and cognitive ability. This paradigm is supported by the very substantial correlation between cognitive ability and educational achievement – with estimates often around 0.7 depending on the measure and the educational domain ([Kriegbaum et al., 2018](#); [Rindermann, 2018](#); [Walberg, 1984](#); [Zaboski et al., 2018](#)). Aside from intelligence, the other consistently replicated individual variable linked with educational performance is the personality trait of conscientiousness – [Almlund et al., 2011](#); [Andersen et al., 2020](#), [Vedel, 2014](#). As children mature into teenagers, and schooling becomes more formal, conscientiousness - characterised by the facets of carefulness,

thoroughness, and deliberation - is likely to become increasingly important in educational performance ([Andersen et al., 2020](#); [Poropat, 2009](#)).

The intellectual challenge presented by these competing paradigms is that seemingly both are supported by the data. Better performing children do tend to come from wealthier homes, and have parents with more education, working in jobs with higher status and earnings. But those children are also likely to have higher levels of cognitive ability and be more conscientious. Assessing the respective effects of both groups of factors requires comparison of the explanatory power of differing models. The picture that emerges when studies include both socio-economic and psychological factors in explaining educational disparities is that - contrary to the standard paradigm - psychological ones are far more powerful – see [Layte, 2017](#); [Maani & Kalb, 2007](#); [Marks, 2016](#); [Weber et al., 2013](#).

The aim of this paper is to contribute to the debate using newly available national exam results from a large representative sample in a longitudinal UK survey with high-quality measures.

2. Methodology

2.1. The dataset and participants

The Millennium Cohort Study (MCS) is a longitudinal study of the cognitive and socio-emotional development of UK children. The MCS is

* Corresponding author at: School of Psychology, Newman Building, UCD, Belfield, Dublin 4, Ireland.

E-mail address: michael.f.oconnell@ucd.ie (M. O'Connell).

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funded by the UK Economic and Social Research Council (ESRC), and several government departments. The sample was obtained through a stratified cluster design, and is nationally representative of UK children, with survey weights provided to adjust for non-response, and to enhance representativeness. The data are gathered in face-to-face interviews with children, parents, and teachers where applicable. The first wave of the survey was in 2000 when children were nine months old, and there have been six further waves, at ages 3, 5, 7, 11, 14, and 17. The first wave gathered data from 18,819 children. At age 17, the sample size had declined to 10,757 children, due mainly to attrition.

2.2. Measures

Univariate statistics (mean, standard deviation, skewness, and where relevant, reliability) are available for all variables used, in [Table 2](#).

2.2.1. GCSE exam results

In wave 7, at age 17, the MCS asked respondents to report their GCSE grades. The GCSE (General Certificate of Secondary Education) is a set of academic qualifications based on state examinations in a variety of subjects taken typically at age 16. The GCSE is taken in state schools in England, Wales, and Northern Ireland. However, in Scotland, the Scottish Qualifications Certificate is used, with a different grading system. Therefore, the analysis is only based on the GCSE results, and does not include the Scottish cohort in the MCS, or those who took other alternatives to the GCSE. GCSE data were available for 8303 respondents, or 77% of the sweep 7 cohort. Of these, 4190 were male (50.5%) and 4113 were female (49.5%). Typically, a student takes nine GCSEs in nine subjects, and there are nine possible grades. These grades were transformed into numbers (0–9), and each student's performance summed. The mean GCSE score was 45.1, and the scores were normally distributed, with over 99% of the sample scoring between 0 and 100.

2.2.2. Cognitive measures

2.2.2.1. Child's cognitive ability. The MCS included cognitive ability tests at waves 2, 3, 4, 5 and 6 ([Rosenberg et al., 2020](#)). A single unrotated principal component score was extracted for each participant based on ten cognitive ability tests – see below. In a principal component analysis, the components are calculated as linear combinations of all the original variables, and the goal is to explain as much variance as possible with each successive component. The first component explains maximum variance (highest eigenvalue), and thus represents the best account of the data.

Wave 2, age 3 – Bracken School Readiness Composite Standard Score, BAS naming-Vocabulary T-Score.

Wave 3, age 5 – iPattern Construction T-score, Naming Vocabulary T-score, Picture Completion T-score.

Wave 4, age 7 – Word Reading Standard Score, Pattern Construction T-score, Maths7 Standardised Age Score.

Wave 5, age 11 – Verbal Sims Standard Score.

Wave 6, age 15 – Word Activity (Recognition) Score out of 20.

Data were available for 5938 respondents for all ten cognitive measures.

2.2.2.2. Maternal cognitive ability. Most mothers (N = 7359), but only a minority of fathers participated in a cognitive ability test, in sweep 6. Therefore, only the maternal score – taken when the child was fifteen – was included in the analysis. This was a Word Activity Test, scored out of 20.

Table 1

Distribution of highest educational level of higher educated parent (N = 4524).

Level	Educational equivalent	N	%
1	Low achievement in lower secondary school	294	6.5
2	High achievement in lower secondary school	918	20.3
3	Completion of higher secondary school	737	16.3
4	Higher secondary school and some post-secondary qualifications	1861	41.1
5	Completion of foundation degree level at university or higher	714	15.8

2.2.3. Socio-economic status (SES) measures

2.2.3.1. Household income. A derived variable from each survey wave measuring weekly household income based on net earnings, benefits, and pensions was provided by the MCS. This was adjusted for family size (by the MCS) using the OECD equivalence scale of a value of 1 for the first adult, 0.7 for each adult after that and 0.5 for each child in the household. To avoid the potential distortion of household income based on any single sweep, the mean of sweeps 6 and 7 were calculated, and was then standardised. N = 7481.

2.2.3.2. Highest parental education. The MCS provided a measure of highest educational attainment of either parent based on a scale from 1 to 5 (lowest to highest). The data from wave 6 were used. [Table 1](#) presents the percentage of highest educated parent at each level.

2.2.3.3. Highest parental occupational status. The MCS recorded the job status of both parents using the SOC-2000 coding scheme. These were recoded into categories ISCO-88, and the ISCO-88 categories were assigned a ISEI occupational status score. The ISEI is a worldwide scale that transforms narrow occupation roles into a numerical scale based on the transmission of educational qualifications into earnings through occupation. It maximizes the importance of occupation ([Ganzeboom & Treiman, 1996](#)). The highest occupation status of either parent was assigned. N = 5692, and the minimum score was 16, and maximum was 88.

2.2.4. Personality measures

In wave 7 of the MCS, the “Big Five” personality traits - Openness (N = 8203), Conscientiousness (N = 8200), Extraversion (N = 8191), Agreeableness (N = 8210), Neuroticism (N = 8163) - of the cohort, aged 17, were assessed with five three-item scales. As can be seen in [Table 2](#), the reliability scores for four of the five traits were low, between 0.6 and 0.7 – ideally these should be above 0.7 ([DeVellis, 2003](#)), but [Pallant \(2010; 97\)](#) notes that “for scales with fewer than ten items, it is common to find quite low Cronbach values. E.g. 0.5”.

2.3. Imputation of data

As most measures had missing values, imputation of values was employed, using the ‘Fully Conditional Specification MCMC’ command in SPSS 26. A visual review of the missing values in SPSS revealed no strongly monotonic patterns; however, this imputation method can be used with arbitrary (monotonic or non-monotonic) patterns of missing data. No imputation was used on the GCSE scores (as this was the dependent variable), or on either the occupational status measure or the cognitive measures, as the missing cases were well over 30%. Following imputation, N = 4528. Weights were applied. The non-imputed sample was 50.5% male, mean family income = £423, job status = 47.0, and parental education of 3.12. The imputed sample was 50.3% male, mean family income = £481, parental job status = 47.6, and parental education = 3.39.

Table 2
Correlation matrix of continuous measures, imputed data (on variables with less than 20% missing cases).

Measure	1	2	3	4	5	6	7	8	9	10	11
1. GCSE exam score	1										
2. Child cognitive score	0.47**	1									
3. Mother cognitive score	0.27**	0.40**	1								
4. Highest parent educate	0.25**	0.25**	0.38**	1							
5. Highest parent occup.	0.21**	0.19**	0.34**	0.41**	1						
6. Household income	0.29**	0.32**	0.42**	0.45**	0.35**	1					
7. Pers. – Openness	0.11**	0.12**	0.07**	0.08**	0.05**	0.06**	1				
8. Pers. – Conscientious	0.19**	0.08**	0.00	0.04*	0.03	0.07**	0.16**	1			
9. Pers. – Extraversion	-0.02	-0.01	-0.02	0.01	0.05**	0.07**	0.18**	0.15**	1		
10. Pers. – Agreeableness	0.09**	0.00	0.01	0.03*	0.05**	0.03*	0.20**	0.29**	0.14**	1	
11. Pers. – Neuroticism	0.07**	0.04*	0.05**	-0.01	-0.02	-0.01	0.01	0.01	-0.30**	0.01	1
Mean	45.1	0	11.2	3.12	47.0	423	14.3	14.2	13.6	16.7	11.8
Standard deviation	22.5	1.0	4.4	1.26	19.3	172	3.8	3.3	3.9	3.1	4.8
Skewness	0.61	-0.37	-0.08	-0.24	0.46	0.29	-0.33	-0.40	-0.39	-0.99	0.12
Cronbach's alpha	NA	0.73	NA	NA	NA	NA	0.68	0.60	0.67	0.63	0.79

N = 4528. Pooled r scores based on five imputations.
 Descriptives in last four rows based on raw (non-imputed) data.
 * p < .05.
 ** p < .01.

Table 3
Comparison of five regression models. Dependent measure - GCSE exam scores. Imputed datasets (imputation used for variables with less than 20% missing values). R squared values based on pooled scores of five imputations. Variable coefficients are b values and corresponding t scores based on five pooled imputations. N = 4528. * indicates p < .001.

	Model fit	Predictor	b	b: [95% CI]	t	Sig. t
Model 1 – Personality	Rsq = 0.053	(Constant)	19.02	[13.02, 25.01]		
		Gender	-0.12	[-1.51, 1.26]	-0.17	0.864
		Personality - Openness	0.52	[0.32, 0.72]	5.19	<0.001*
		Personality – Conscientiousness	1.22	[0.10, 1.45]	10.55	<0.001*
		Personality – Extraversion	-0.23	[-0.41, -0.04]	-2.42	=0.015
		Personality – Agreeableness	0.16	[-0.08, 0.41]	1.30	=0.195
Model 2 – SES	Rsq = 0.105	Personality – Neuroticism	0.48	[0.32, 0.63]	5.98	<0.001*
		(Constant)	33.13	[30.00, 36.26]		
		Gender	0.26	[-1.08, 1.61]	0.38	0.704
		Household income: Standardised	4.76	[3.92, 5.60]	11.10	<0.001*
		Highest parental education	2.36	[1.68, 3.05]	6.75	<0.001*
Model 3 – Cognitive	Rsq = 0.254	Highest parental work status	0.11	[0.07, 0.14]	5.25	<0.001*
		(Constant)	38.32	[35.50, 41.15]		
		Gender	0.20	[-1.03, 1.43]	0.32	0.750
		Maternal cognitive test score	0.69	[0.52, 0.85]	8.01	<0.001*
Model 4 - Psychological	Rsq = 0.285	Child cognitive test scores	10.99	[10.23, 11.75]	28.47	<0.001*
		(Constant)	14.81	[9.21, 20.42]		
		Gender	0.08	[-1.13, 1.29]	0.13	0.894
Model 5 - All	Rsq = 0.301	Personality - Openness	0.05	[-0.12, 0.23]	0.60	0.551
		Personality – Conscientiousness	1.03	[0.83, 1.23]	10.10	<0.001*
		Personality – Extraversion	-0.12	[-0.28, 0.05]	-1.42	0.157
		Personality – Agreeableness	0.31	[0.09, 0.53]	2.79	=0.005
		Personality – Neuroticism	0.38	[0.25, 0.52]	5.48	<0.001*
		Maternal cognitive test score	0.70	[0.54, 0.87]	8.34	<0.001*
		Child cognitive test scores	10.58	[9.83, 11.33]	27.63	<0.001*
		(Constant)	12.40	[6.66, 18.15]		
		Gender	0.21	[-0.98, 1.41]	0.35	0.730
		Personality - Openness	0.05	[-0.12, 0.23]	0.62	0.535
		Personality – Conscientiousness	1.00	[0.80, 1.20]	9.94	<0.001*
		Personality – Extraversion	-0.15	[-0.31, 0.01]	-1.87	0.062
Personality – Agreeableness	0.28	[0.07, 0.49]	2.60	0.011		
Personality – Neuroticism	0.40	[0.26, 0.53]	5.80	<0.001*		
Household income: Standardised	2.03	[1.25, 2.81]	5.11	<0.001*		
Highest parental education	1.03	[0.41, 1.66]	3.24	=0.001		
Highest parental work status	0.07	[0.03, 0.10]	3.79	<0.001*		
Maternal cognitive test score	0.35	[0.17, 0.53]	3.86	<0.001*		
Child cognitive test scores	9.95	[9.20, 10.71]	25.84	<0.001*		

3. Results

The correlation matrix for the measure of interest, GCSE score, and ten potentially associated measures is presented in Table 2. The strongest correlation with GCSE score was child cognitive test score (r = 0.47). Other variables with moderate to high associations were

household income, maternal cognitive score, highest parental education value, highest occupation index, and the personality measure of ‘conscientiousness’. Higher GCSE score is associated with higher child cognitive scores, higher parental education, occupational status and family income, more openness in personality, greater conscientiousness, more agreeableness, more neuroticism, higher maternal cognitive score,

and higher parental occupational status. Extraversion was not significantly related to GCSE score.

Table 3 presents estimates from five different regression models along with the t-values as indicators of the strengths of individual coefficients, and the overall explanatory power (Rsquared value). Gender was included in each model as a dichotomous variable, but was not associated with any significant difference in GCSE score.

3.1. Models

Personality: The Rsquared value for gender and the five personality measures was just over 5% with conscientiousness having the highest t-value (10.55).

SES: The Rsquared value for gender plus household income, highest parental education and highest parental occupational status was close to 11% with household income having the highest t-value (11.10).

Cognitive: The cognitive model had far more explanatory power than had the SES model (25.4% compared to 10.5%). Child's cognitive score had the largest t-value (28.47).

Psychological: The Rsquared was 28.5%. Child's cognitive score and conscientiousness had the largest effects (27.63, 10.10).

All measures: The Rsquared for the final model comprising all measures was 30.1%. Child's cognitive score and conscientiousness had the strongest effects (t-values = 25.84, 9.94), stronger than any of the SES measures.

4. Discussion

The key result was a multivariate analysis of performance of a representative sample of sixteen-year-olds in a UK state exam comparing several models. The optimal model for educational attainment includes cognitive ability and conscientiousness. SES measures have much weaker effects.

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. Given their small effects, it does not make sense to pursue improvements in educational attainment by using SES as a lever. This route to reducing educational attainment has been overemphasised both in research and policy. It may be timely to consider reducing educational disparities through more effective, targeted and pragmatic sets of interventions. In the case of cognitive ability, this might involve using intelligence as a diagnostic tool to find the right educational approach and level for schoolgoers. In the case of conscientiousness, it is plausible that stressing values associated with the component elements of the trait – carefulness, thoroughness, diligence and deliberation – can help young people engage more successfully with educational goals.

CRediT authorship contribution statement

Michael O'Connell is the first author.

Any errors arising from the use, analysis and interpretation of the Millennium Cohort Study data are the responsibility of the first author.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.paid.2021.111471>.

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