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Intelligence of adolescents is related to their parents' educational level but not to family income

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ABSTRACT

Parental educational level and family income have been related to individual differences in intelligence. However, large and representative samples are hardly available. Here two samples of young and old adolescents totaling 3233 boys and girls completed an intelligence battery comprising abstract, numerical, verbal, mechanical, and spatial reasoning subtests. Parents' educational levels, family incomes, and adolescents' general intelligence (g) were simultaneously related using SEM (structural equation modeling) analyses. The main findings show that (1) parental education strongly predicts family differences in income, (2) family income is not related to adolescents' intelligence, and (3) parents' education predicts adolescents' intelligence regardless of family income. Because it is widely acknowledged that personal intelligence is the best predictor of educational differences, the next causal chain is endorsed: brighter parents reach higher levels of education, which allows approaching better occupations, and, therefore, they can create families with higher incomes. Adolescents from more affluent families tend to be brighter because their parents are brighter, not because they enjoy better family environments.

1. Introduction

There is a wide range of individual differences in general cognitive ability (intelligence) (Deary, Penke, & Johnson, 2010; Gottfredson et al., 1997; Jensen, 1998; Mackintosh, 1998). Indeed, as highlighted by Murray (2008) (a) abilities vary, and (b) half of the children are below average. These two related facts have extraordinary implications for everyday life, so efforts aimed at understanding the origin of these differences should be welcome.

Intelligence differences are caused by genetic and non-genetic factors (Bouchard, 2009; Flynn, 2007). Genes account from 40% of the intelligence variance in childhood and up to 80% in adulthood. Haworth et al. (2009) reported a large scale study (11,000 twin pairs from four countries) showing that genetic influences on general cognitive ability increase linearly from childhood to adolescence to young adulthood (.41, .55, and .66, respectively). Shared environment declines from .33 to .16, whereas non-shared environment declines from .26 to .19. The increased relevance of genetic factors during school years "*leads to an active view of experiences relevant to cognitive development, including educational experiences, in which children make their own environments that not only reflect, but also accentuate, their genetic differences*" (Haworth et al., 2009, p. 7).

Beyond this influence of genes over intelligence differences, it is acknowledged that non-genetic factors are also involved. Thus, for instance, parental SES is usually considered to be causally related to children's intelligence. Kemp (1955) reported the results obtained from the analyses of 50 British schools. A correlation of .52 was obtained between intelligence and SES. Li (1975) re-analyzed one longitudinal dataset reported by Jencks (1972) using path-analysis. The standardized regression weights from father's education and occupation to child IQ were .20 and .20, respectively. Furthermore, the correlation between father's education and occupation was .51. Parents' occupation, income, and education could influence the home environment in which children grow up. Therefore, children with higher SES parents would have greater intelligence tests' scores than children with lower SES parents, because the more favorable environment may improve general cognitive ability (Loehlin, 2000).

Nevertheless, SES usually combines distinguishable factors such as family income and parents' educational level. Colom and Flores-Mendoza (2007) analyzed three independent samples of participants comprising a total of 641 children from Brazil. These children belonged to families of largely different social classes. Family income and parents' educational levels were considered separately for predicting children's academic performance. Children's intelligence was also measured. Across the three samples, these

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were the main common findings: (a) the relationship between family income and their children's intelligence, as well as between parents' educational level and their children's intelligence, is small (approx. $r = .13$), (b) family income and parents' education do not predict children's scholastic achievement, (c) children's intelligence predicts their own scholastic achievement irrespective of family income and parents' education (approximately .50), and (d) family income and parents' educational levels are significantly related to each other (range from .45 to .51).

Also, Strenze (2007) reported a comprehensive meta-analysis regarding the relationships between three predictors (intelligence, parental SES, and academic performance) and three measures of socioeconomic success (educational level, occupational level, and income). Data from 85 datasets (135 samples) were used in the meta-analysis, and these were the main conclusions: (a) intelligence predicts career success (predictive validities of .56 for education, .43 for occupation, and .20 for income), (b) parental SES (considering several indicators like father's education, mother's education, father's occupation, and parental income) is related to career success as shown in correlations between father's education and education ($r = .50$), between father's occupation and occupation ($r = .35$), or between parental income and income ($r = .20$), and (c) academic performance is also related to career success as shown by correlations between academic performance and education ($r = .53$) or occupation ($r = .37$).

Family income and parents' educational levels are undoubtedly related to their offspring's intelligence. Besides, there are several studies underscoring the impact of SES over human development, with particular emphasis on how family income relates to children and adolescents' development and their cognitive and educational outcomes (e.g. Almeida, 1989; Bos et al., 1999; Duncan & Raudenbush, 1999; Maynard & Murnane, 1979). Also, recent studies (Duncan, Ziol-Guest, & Kalil, 2010; Milligan & Stabile, 2009; Ratcliffe & McKernan, 2010) highlight that children growing up in poverty are less successful over the life course than their counterparts from higher-income families. Furthermore, the heterogeneity of income measures (e.g. father's education, mother's education, highest educational level, father's occupation, mother's occupation, family current income, or composite measures derived from those variables) has long prevented researchers and policy makers from reaching a consensus on family income effects over child development (Dahl & Lochner, 2008). Income appears to have some impact on education and IQ among children, probably greater among economically disadvantaged families (e.g. Conger & Donnellan, 2007; Dahl & Lochner, 2008).

Nevertheless, Kuncel, Ones, and Sackett (2010) critically reviewed findings derived from the analysis of these sorts of relationships, underscoring that confusion and weak data are widespread. Problems of interpretation derive from three main sources: (a) small-sample individual studies, (b) restricted samples, and (c) flawed criterion measures. Therefore, it is crucial to obtain data from large scale studies of representative samples. Further, there is a lack of data from continental Europe with respect to the variables of interest (Strenze, 2007). Here we consider some of the discussed variables using two independent large and representative samples of young and old adolescents from Portugal totaling 3233 participants. Intelligence was measured by a battery composed by five reasoning subtests (abstract, numerical, verbal, mechanical, and spatial). Indices of socio-economic status were considered, such as parental education (father's and mother's educational level) and family income (regarding occupation class categories – see below). It is predicted that adolescents' intelligence scores will be genuinely associated with the educational level of their parents, because the latter can be considered a proxy estimate of their intelligence and relatives share genes influencing general cognitive ability.

2. Method

2.1. Participants

Two independent samples of students from third cycle of elementary school and from secondary school were analyzed. The first sample comprised 1714 young adolescents (mean age = 13.5, SD = .96, range from 12 to 15 years, 828 boys and 886 girls), whereas the second sample included 1519 old adolescents (mean age = 16.9, SD = .88, range from 16 to 19 years, 736 boys and 783 girls). All participants were involved in a larger study for the standardization of the Reasoning Tests Battery (RTB; Almeida, 2003; Almeida & Lemos, 2007). The samples were obtained randomly; state schools were selected based on the principle of randomness, considering previous stratification by regions in the country, school grade and gender within the class group at the school level. Representativeness was also fulfilled and according to the annual school census of the Department of Assessment and Foresight and Planning – Ministry of Education – samples gather 6 per cent of the Portuguese student population in the considered school levels. Schools' Executive Councils, and when necessary (students less than 16 years old) students' carers provided written informed consent.

The school system in Portugal considers three cycles in elementary school and one cycle in secondary school. This study takes students from the 3rd cycle of elementary school, equivalent to junior high school in other countries (7th – 9th grades), and secondary school (10th – 12th grades), when students choose from among several curricular options in order to follow different graduation areas in higher education or professional specialization. The first school level corresponds to the first sample mentioned above, whereas the second level matches the second sample.

2.2. Measures

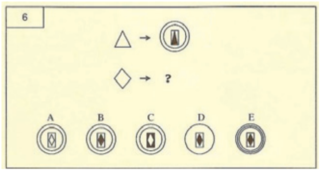
As noted before, intelligence was measured by the Reasoning Tests Battery (RTB). The young adolescents completed the battery version designed for the first level (third cycle of elementary school) and the old adolescents completed the battery version designed for the second level (senior high school battery).

The RTB is composed of five reasoning subtests: (a) abstract reasoning (25 figural analogies and 5 min of administration time), numerical reasoning (20 numerical series and 10 min of administration time), verbal reasoning (25 verbal analogies and 4 min of administration time), mechanical reasoning (25 mechanical problem-solving items and 8 min of administration time), and spatial reasoning (20 spatial orientation and cubes rotation series and 9 min of administration time). The RTB is modeled after the well known Differential Aptitude Test Battery (DAT) (Bennett, Seashore, & Wesman, 1990). Figure 1 shows examples of items from these subtests. Reliability indices have been estimate by test–retest and internal consistency methods. The coefficients obtained are appropriate, varying from .63 (mechanical reasoning) to .84 (numerical reasoning). Factor analysis suggests a common or general factor explaining 56% of the variance (Almeida & Lemos, 2007).

Parents' educational level was also registered. Students filled out an identification sheet, which included the information of the school grade completed by their parents. The levels (from lower to higher) were (1) first cycle, (2) second cycle, (3) third cycle, (4) secondary, (5) bachelor, (6) course degree, and (7) master or PhD. Table 1 shows the number of fathers and mothers from both samples of adolescents within each category.

Finally, two categories of family income are considered: below and above average. A standardized job's classification framework was applied, establishing as below average students whose parents

Example of an Abstract Reasoning item from the Junior High School Battery

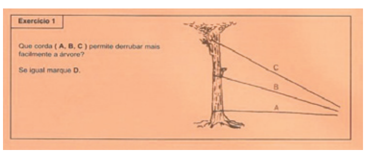


Example of a Numerical Reasoning item from the Senior High School Battery

Example of a Verbal Reasoning item from the Junior High School Battery

Doctor is to patient as salesman is to...
A. Marketer B. Collector C. Merchandise D. Customer E. Trader

Example of a Mechanical Reasoning item from the Junior High School Battery



Which string (ABC) will break down more easily the tree? If equal check D.

Example of a Spatial Reasoning item from the Senior High School Battery

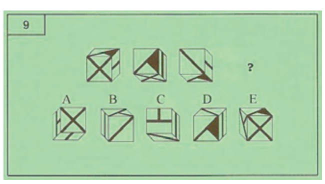


Fig. 1. Example items from the administered intelligence battery.

Table 1
Number of parents within each educational level for both samples.

Parents' educational levels	Sample of young adolescents		Sample of old adolescents	
	Fathers	Mothers	Fathers	Mothers
1. First cycle	364	350	413	413
2. Second cycle	254	286	252	258
3. Third cycle	358	347	272	278
4. Secondary	316	342	277	290
5. Bachelor	27	26	40	27
6. Course degree	241	254	201	205
7. Master, PhD	26	19	9	14
Total	1586	1624	1464	1485

are included in the next categories: trades people, personal and household services, agriculture and fishery (smallholders), non-qualified jobs, or unemployed. Above average students include parents corresponding to one of the following categories: managers, business executives, intellectual and scientific professionals, or technical professionals. For the sample of young adolescents, 964 families were below the national average and 660 families were above average. For the older sample, 825 families were below average and 630 families were above average.

2.3. Procedure

A team of psychologists was specifically trained for the administration of the intelligence battery by means of a training course lasting 8 h. The battery was administered in small groups of no more than 25 students at their classrooms and strictly adhered to conditions specified in the test's manual.

3. Results

First, a measurement model was tested for both samples using confirmatory factor analysis (CFA). In this model, a general factor of intelligence (*g*) predicts the five measures comprised in the battery: abstract, numerical, verbal, mechanical, and spatial reasoning. Model fit was excellent in both samples: young adolescents [$\chi^2_{(5)}$ = 15.7, CMIN/DF = 3.1, RMSEA = .033, CFI = .99] and old adolescents [$\chi^2_{(5)}$ = 14.4, CMIN/DF = 2.9, RMSEA = .035, CFI = .99]. Figure 2 shows the regression weights.

All values depicted in Fig. 2 are above .50, but it must be noted that not very large figures are found. For the young adolescents, abstract, numerical, and verbal reasoning show the largest values (>.65). For the old adolescents (values in parenthesis) spatial and numerical reasoning show the largest values (>.65). Mechanical reasoning shows the lowest weight for the young adolescents (.57), whereas verbal reasoning shows the lowest weight for the old adolescents (.50).

Secondly, a general factor score (*g*) was computed for every participant after a principal axis factoring (PAF). The standardized scores were converted to the IQ scale with a mean of 100 and a SD of 15. These scores were used for comparing adolescents from both samples along the educational levels of their parents. Figure 3 shows the results for fathers (the same pattern emerges for mothers). Clearly, the higher the educational level of the parents, the better the *g* score of their offspring.

Third, *g* scores for the young and old adolescents were computed according to their family income. Figure 4 shows the results: adolescents with below average family incomes show smaller *g* scores (98) than adolescents with above average family incomes (between 103 and 105). Therefore, the average difference in general intelligence approaches half a standard deviation.

Fourth, to clarify the simultaneous relationship among parents' educational level, family income, and adolescents' intelligence, a SEM analysis was computed. The general model assumes that parents' educational level predicts family income. Further, adolescents' intelligence, defined according to the measurement model depicted in Fig. 2, is predicted directly by family income and indirectly by parents' educational level. Fit indices are excellent for both samples: young adolescents [$\chi^2_{(18)}$ = 46.6, CMIN/DF = 2.6, RMSEA = .030, CFI = .99] and old adolescents [$\chi^2_{(18)}$ = 37.5, CMIN/DF = 2.1, RMSEA = .027, CFI = .99].

Figure 5 shows the results for both samples. It can be seen that (a) parents' education predicts family income with high values (around .60 on average), (b) family income does not predict adolescents' intelligence (.03), and (c) parents' education predicts adoles-

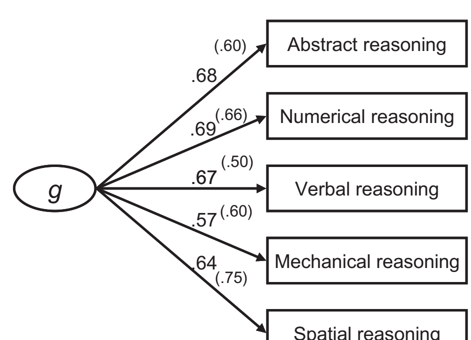


Fig. 2. Measurement model (CFA) for both samples (weights for the old adolescents in parenthesis).

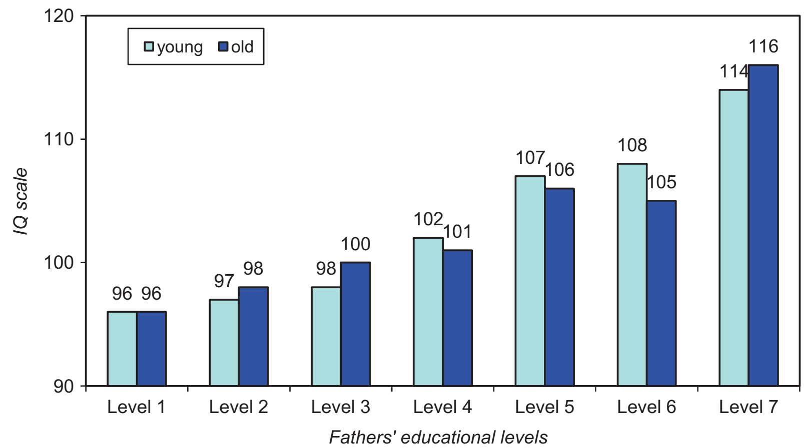


Fig. 3. General intelligence scores for young and old adolescents according to their fathers' educational level [(level 1) first cycle, (level 2) second cycle, (level 3) third cycle, (level 4) secondary, (level 5) bachelor, (level 6) course degree, and (level 7) master or PhD]. See Table 1 for number of parents within each educational group.

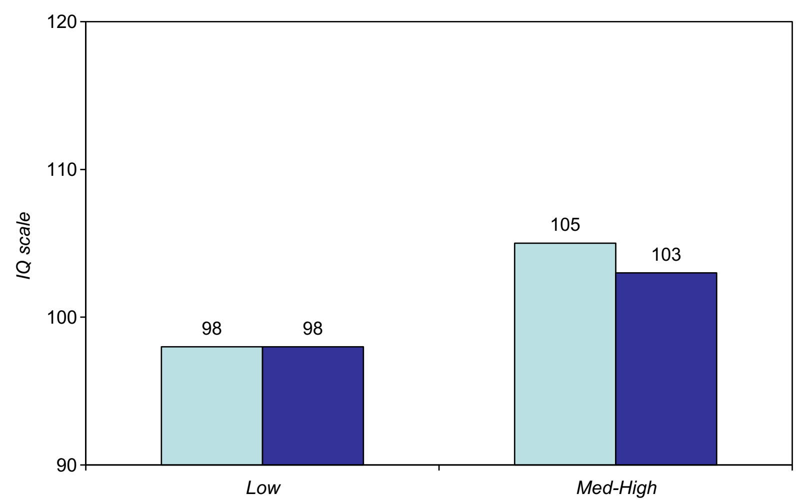


Fig. 4. General intelligence scores for young and old adolescents according to their fathers' income levels. For the young sample, 964 families were below average and 660 families were above average. For the old sample, 825 families were below average and 630 families were above average.

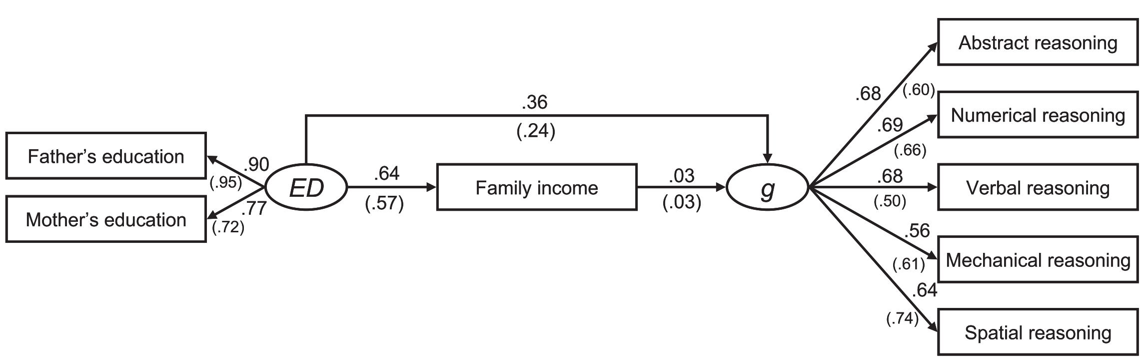


Fig. 5. SEM (structural equation model) testing the simultaneous relationship among parental educational level, family income, and adolescents' general intelligence.

cents' intelligence irrespective of family income (around .30 on average).

Finally, several SEM were computed to analyze each subtest comprised in the intelligence battery. Two scores for each subtest were considered: (a) raw score and (b) scores controlling for general intelligence (*g*). These latter scores represent variance unpredicted by the *g* score. As noted above, Fig. 2 indicates that there is a significant amount of variance unpredicted by *g*. Figure 6 depicts the generic SEM, while Table 2 shows the regression weights for parental educational level and family income in both samples.

For all the subtests parental education predicts adolescents' cognitive performance differences. The values are a bit greater for the young adolescents, but they are all significant ($p < .01$). However, family income is not related to any subtest. Interestingly,

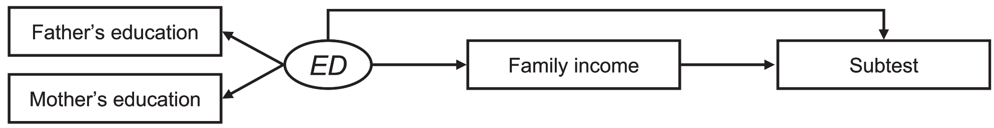


Fig. 6. Generic SEM testing the simultaneous relationship among parental educational level, family income, and adolescents' performance on the subtests, both including and excluding general intelligence (*g*). See Table 2 for obtained weights.

Table 2
Regression weights for parental educational level and family income obtained from the SEM model depicted in Fig. 6. Values are for the five subtests including and excluding (non-*g*) the general factor of intelligence (*g*).

Measures	Young adolescents ($N = 1714$)		Old adolescents ($N = 1519$)	
	Parents' education	Family income	Parents' education	Family income
Abstract reasoning	.23**	.01	.15**	.03
Numerical reasoning	.24**	.01	.14**	.01
Verbal reasoning	.28**	.06	.15**	.00
Mechanical reasoning	.18**	.01	.16**	.02
Spatial reasoning	.22**	.02	.15**	.04
Non-g abstract	−.02	−.02	.01	.01
Non-g numerical	−.01	−.02	−.02	−.01
Non-g verbal	.05	−06	.05	−.02
Non-g mechanical	−.02	−.01	.03	.00
Non-g spatial	−.01	.00	−.05	.02

** $p < .01$.

when the general factor of intelligence (*g*) is removed from the subtests (non-*g*) all the regression weights for parental education turn out to be non-significant and with values close to those corresponding to family income. Therefore, the *g* component of the intelligence measures accounts for their correlation with parents' educational levels. Subtests' specificity or unique variance is irrelevant.

4. Discussion

Here, two independent and large representative samples of the adolescent Portuguese population were considered. Their intelligence level was measured by means of a cognitive battery comprising abstract, numerical, verbal, mechanical, and spatial subtests (Almeida, 2003). Further, parental educational level and family income were also related to these intelligence scores. As noted before, parents were classified according to seven educational levels, and families were assigned to below and above average national income levels. The obtained results have several main points of interest.

First, adolescents' intelligence scores increase linearly along the parental educational level continuum. Figure 3 depicts this finding for the young and old adolescents. Intelligence scores change from 96 (lowest parental educational level) to 115 (highest parental educational level) for both samples, which means that the distance is greater than one standard deviation. This may lead one to argue that more educated parents are more prone than less educated parents to create family environmental conditions promoting intelligence development (Ceci & Williams, 1997). However, without appropriate controls the presumption that brighter parents have brighter children cannot be ruled out (Bouchard, 2009; Harris, 1995; Harris, 1998; Harris, 2006; Scarr, 1997). Bouchard and McGue's (2003) summary of the available evidence demonstrates that shared environmental influences are negligible. Therefore, for most psychological traits, parents and children are alike because of their shared genes: brighter children are raised in homes managed by brighter parents, but their advantage should not be attributed to home facilities.

Second, we tested the role of family income. Figure 4 shows adolescents from families of above national average income obtain higher general intelligence scores than adolescents from families of below average income. The mean difference is equivalent to half a standard deviation for the young adolescents and a bit smaller (five IQ points on average) for the old adolescents. Therefore, family income makes a difference regarding the measured intelligence differences. This finding could support statements claiming that affluence promotes the development of intelligence (Miller, 1997). However, family income differences may be a consequence of best occupations approached thanks to higher educational levels. Because intelligence is the best predictor of educational attainment (Deary, Strand, Smith, & Fernandes, 2007; Neisser et al., 1996) it can be presumed that higher intelligence promotes higher educational levels, best occupations, and greater incomes.

Third, the analysis of the simultaneous relationship among parental educational levels, family income, and adolescents' general intelligence by means of SEM reveals that educational levels of both parents predict family income with large values. For the young adolescents the regression weight is larger than .60, whereas for the old adolescents this weight approaches this figure. Discounting these values from family income shows that this latter variable is not related to adolescents' general intelligence differences. For both samples, the obtained weight is almost zero. Further, parents' education still predicts adolescents' intelligence once the correlation of the former with family income is removed: for the young adolescents the value is higher than for the old adolescents (.36 vs. .24).

Together, these results support the statement that the assessed intelligence differences are related to parental education, but not to their income levels themselves. Because parental education predicts with high values income differences, and because parental education predicts adolescents' intelligence differences irrespective of income level, it may be concluded that there is some hidden causal factor underlying those simultaneous relationships. Our best bet is that brighter parents raise brighter children.

This bet is further supported by the SEM analyses of the specific subtests of the intelligence battery. The comprehensive review made by Jensen (1998) demonstrates that *g* is the main ingredient comprised in the available intelligence measures. When *g* is removed from these measures, their significant relationships with a broad set of biological, psychological, and social correlates vanishes (Lubinski, 2004; Schmidt & Hunter, 2004). Here we have shown that adolescents' performance differences on the five subtests are no longer related to parental educational differences once *g* is removed, even when there is still a lot of variance unaccounted for by the general factor.

In summary, the findings derived from the analysis of the large datasets of representative samples considered in the present study are consistent with the general statement that intelligence differences can be accounted for by parental educational differences not by differences on their income levels. A causal chain is suggested: parental intelligence differences are behind the educational level they reach, and their educational differences facilitate approaching best occupations with higher incomes. The association between parental educational levels and adolescents' intelligence may be well attributed to the fact that parental education is a proxy of their intelligence levels (Gottfredson, 2004). Therefore, brighter parents raise brighter children.

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