What Grades and Achievement Tests Measure

Citation for published version (APA):

Document status and date:
Published: 22/11/2016

DOI:
10.1073/pnas.1601135113

Document Version:
Publisher's PDF, also known as Version of record

Please check the document version of this publication:
• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
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Download date: 16 Sep. 2023
What grades and achievement tests measure

Lex Borghans,a,b Bart H. H. Golsteyn,a James J. Heckman,†d,1, and John Eric Humphriesc

*Department of Economics, Maastricht University, 6200 MD Maastricht, The Netherlands; †Research Centre for Education and the Labour Market, Maastricht University, 6200 MD Maastricht, The Netherlands; ‡Department of Economics, The University of Chicago, Chicago, IL 60637; and §The American Bar Foundation, Chicago, IL 60611

Contributed by James J. Heckman, September 19, 2016 (sent for review January 22, 2016; reviewed by Armin Falk and Patrick Kyllonen)

Intelligence quotient (IQ), grades, and scores on achievement tests are widely used as measures of cognition, but the correlations among them are far from perfect. This paper uses a variety of datasets to show that personality and IQ predict grades and scores on achievement tests. Personality is relatively more important in predicting grades than scores on achievement tests. IQ is relatively more important in predicting scores on achievement tests. Personality is generally more predictive than IQ on a variety of important life outcomes. Both grades and achievement tests are substantially better predictors of important life outcomes than IQ. The reason is that both capture personality traits that have independent predictive power beyond that of IQ.

IQ | achievement tests | grades | personality traits

The paper proceeds as follows. The first section briefly reviews the literature. The second section describes the data. The third section decomposes grades and scores on achievement tests into IQ and personality. The fourth section examines the predictive power of IQ and personality on a variety of important life outcomes (we make no causal claims in this paper).

Brief Overview of the Literature

Achievement tests, like the Armed Forces Qualification Test (AFQT), are often used as proxies for cognitive ability (12–14). A Appendix, Appendix S1 lists 50 papers that use AFQT scores as proxies for intelligence. Grades are also used as proxies for intelligence (1, 2).

Previous research studies relationships between IQ and personality1, between grades and IQ (a review of the literature is in ref. 18), and between personality and grades. Ref. 22 relates the High School Personality Questionnaire and the Culture Fair Intelligence Test to scores on standardized achievement tests and finds that conscientiousness and IQ predict scores on achievement tests. Ref. 23 surveys studies.

Significance

Grades and scores on achievement tests are widely used as measures of cognition. This paper examines these measures and their constituent parts. We establish that, on average, grades and achievement tests are generally better predictors of life outcomes than “pure” measures of intelligence. The reason is that they capture aspects of personality that have been shown to be predictive in their own right. All of the standard measures of “intelligence” or “cognition” are influenced by aspects of personality, albeit to varying degrees, depending on the measure. This result has important implications for the interpretation of studies using scores on achievement tests and grades to explain differences in outcomes and for the use of standard cognitive measures to evaluate the effectiveness of public policies.


Reviewers: A.F., University of Bonn; and P.K., Educational Testing Service. The authors declare no conflict of interest.

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1To whom correspondence should be addressed. Email: jjh@uchicago.edu.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1601135113/-/DCSupplemental.

†Ref. 15 gives an overview of this literature. Scores on IQ tests have been related to personality (16). In related work, ref. 17 shows that less conscientious men perform better when they are offered incentives in IQ tests, and ref. 11 shows that conscientious and emotionally stable people do not spend more time answering IQ questions when rewards are higher, whereas people who score lower on these traits do.

2†Ref. 19 and 20 give an overview of this literature. Ref. 19 concludes that conscientiousness is the greatest Big Five predictor of grades (followed at some distance by openness by openness to experience). Conscientiousness predicts academic performance almost as well as intelligence. Ref. 20 evaluates how adolescent measures of the Big Five predict academic performance—finding that openness and conscientiousness are particularly important. Ref. 21 investigates the relationship between verbal and mathematical Scholastic Aptitude Test (SAT) scores and the Big Five. It finds that openness to experience relates to SAT verbal scores. Ref. 7 has an extensive review.
related self-regulation and scores on standardized achievement
tests, course grades, and high school achievement. It shows that
self-regulation is more predictive of course grades than scores on
standardized achievement tests and suggests that this may be the
reason why course grades are more predictive of certain later-life
outcomes than achievement tests. Ref. 24 reports that both self-
discipline and IQ predict performance on achievement tests. Ref.
25 reports that self-control (a facet of Big Five conscientiousness)
and IQ (measured by Raven Matrices) predict scores on the
English/language arts and mathematics standardized achievement
tests. Our analysis builds on and extends this research by
analyzing the effects of cognition and personality on grades,
achievement tests, and a variety of important life outcomes.
We report results from samples pooled across genders.

Data
Table 1 summarizes the availability of measures in the four
datasets that we analyze. Although details and point estimates vary and some data contain only partial information, consistent patterns emerge across all four datasets.

Stella Maris is a Dutch high school at which we collected
Raven’s IQ, scores on achievement tests [the Differential
Aptitude Test (DAT)], grades, and measures of personality.
For this sample, we have no measure of adult outcomes. The
British Cohort Study (BCS) followed a cohort of children born
in one week in April of 1970 until 2016. It has information on
grades, IQ, scores on achievement tests, personality, and a
variety of adult life outcomes. The National Longitudinal
Survey of Youth 1979 (NLSY79) sampled American children
aged 14–21 y old in 1979 and followed them ever since that
time. It has an achievement test (the AFQT) and scores on
different IQ tests across students, which we equate to produce
a common IQ score. It has limited measures of personality but
rich data on adult outcomes. The National Survey of Midlife
Development in the United States (MIDUS) is a survey of
It has rich data on IQ, personality, and adult outcomes, but lacks
information on achievement scores or grades. No single dataset
produces definitive evidence. It is the consilience of the evidence
across the diverse datasets that justifies the conclusions of this paper.3

Grades, Achievement Tests, and Personality
This section summarizes the correlations among the dimensions
of human capabilities that we study. It also analyzes the extent to
which personality predicts achievement test scores and grades
above and beyond IQ.
Table 2 displays the correlations among the available mea-
sures of cognition and personality in our four datasets. Notice
that the correlations between IQ and grades as well as between
IQ and achievement tests are far from perfect. The same is
true of the correlations between grades and achievement tests.
Personality is positively correlated with grades and achievement
test scores. Grades, achievement tests, and IQ capture different
aspects of human capabilities.
Figs. 1, 2, and 3 display the predictive power of personality
and IQ on grades and scores on achievement tests as measured
by the adjusted $R^2$. 4 The results from the Stella Maris data in
Fig. 1 indicate that scores on the Raven’s Progressive
Matrices test explain more of the variance in achievement
scores (DAT) than the personality measures. However, per-
sonality traits explain a substantial fraction of the variance in
the DAT, even when Raven IQ scores are included in
regressions. In the Stella Maris data, grades, data are mostly related
to personality traits. Scores on the Raven test do not predict
overall grades.
Fig. 2 decomposes achievement tests and grades using data
from the BCS. The results show that IQ and personality
measured at age 10 y old predict scores on various achievement
tests at ages 10 and 16 y old and grades at age 16 y old.
The NLSY data in Fig. 3 show that IQ explains more of
the variance in the AFQT scores and grades than the only available
personality variables—self-esteem and locus of control—but
both personality measures are predictive. Note, however, that
the measures of personality in the NLSY are only a subset of the
wide array of personality traits typically used by psychologists
(ref. 7 has a summary of these measures).

The predictive power of personality and IQ for grades and
scores on achievement tests is considerably lower in the Stella

Table 1. Data analyzed

<table>
<thead>
<tr>
<th>Datasets</th>
<th>Achievement tests</th>
<th>Grades</th>
<th>Personality measures</th>
<th>Adult outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stella Maris (Dutch high school students)</td>
<td>✓</td>
<td>✓</td>
<td>✓ (Big Five; grit)</td>
<td>NA</td>
</tr>
<tr>
<td>BCS (children born in one week in 1970 followed until 38 y old)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>NLSY79 (prospective survey of youth 14–21 y old in 1979; currently followed)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>MIDUS (survey in adult life; baseline 24–34 y old in 1995; follow-up 2004–2006)</td>
<td>✓</td>
<td>NA</td>
<td>✓ (Self-esteem; locus of control)</td>
<td>✓</td>
</tr>
</tbody>
</table>

Details on each dataset and their measures are provided in SI Appendix, Appendices S2–S5. NA, not available.

*Self-esteem, locus of control, disorderly activity, antisocial behavior, introversion, and neuroticism.

3Across datasets, the survey instruments differ somewhat. The definitions are given in SI Appendix.
4More information about the datasets can be found in SI Appendix, Appendices S2–S5.

5The study has not been reviewed by an internal review board. There is no need for this
because: (i) three of the four datasets we use are publicly available (BCS, NLSY, MIDUS),
and (ii) the Stella Maris project does not belong to the regimen of the Dutch Act on
medical research involving human subjects. The Stella Maris data were collected at Stella
Maris high school with full cooperation of the school. Before the data collection started,
all students received a letter with information about the types of questions that were
going to be asked. Informed consent was not explicitly asked for because only noninva-
sive questions were asked. It was mentioned to students that participation was volun-
tary. In case they did not want to participate, they could indicate this before the data
collection started or at any time during the process. One student indicated not to be
interested in participating.

6SI Appendix locations of the source regressions for Figs. 1, 2, and 3 are given in the notes
of each figure.

Table 2. Correlations (Pearson correlations)

<table>
<thead>
<tr>
<th>Correlations</th>
<th>Stella Maris</th>
<th>BCS</th>
<th>NLSY</th>
<th>MIDUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho$ (IQ, achievement)</td>
<td>0.378</td>
<td>0.509</td>
<td>0.698</td>
<td></td>
</tr>
<tr>
<td>$\rho$ (IQ, grades)</td>
<td>0.112</td>
<td>0.338</td>
<td>0.464</td>
<td></td>
</tr>
<tr>
<td>(Achievement, grades)</td>
<td>0.316</td>
<td>0.379</td>
<td>0.610</td>
<td></td>
</tr>
<tr>
<td>$\rho$ (IQ, personality)</td>
<td>0.195</td>
<td>0.451</td>
<td>0.291</td>
<td>0.189</td>
</tr>
<tr>
<td>(Achievement, personality)</td>
<td>0.294</td>
<td>0.446</td>
<td>0.410</td>
<td></td>
</tr>
<tr>
<td>(Grades, personality)</td>
<td>0.257</td>
<td>0.433</td>
<td>0.305</td>
<td></td>
</tr>
</tbody>
</table>

$P$ values are presented in SI Appendix, Appendix S6.
Maris data compared with the other datasets. The predictive power of personality and IQ for grades and scores on achievement tests is considerably lower in the Stella Maris data compared with the other datasets, which is probably due to the restriction on range in that dataset. The sample is constructed from the two highest tracks (of three possible tracks) at that secondary school.

Some basic patterns emerge across all datasets. Personality predicts grades and scores on achievement tests. IQ is weighted more heavily in predicting achievement scores than in predicting grades. Note that most of the variance in both measures remains unexplained. The reason may be, in part, because of measurement error. However, it is also likely that important determinants of these measures are missing in our datasets.

**Decomposing the Contributions of IQ and Personality to Life Outcomes**

Using the BCS, the NLSY, and the MIDUS, we determine how much of the variation in numerous important life outcomes is explained by IQ and personality traits. We also consider the relative predictive power of grades and scores on achievement tests compared with IQ. The outcomes studied include wages and measures of health among other items. We build on the analyses in refs. 4, 5, 7, and 26.

The results of our analysis of the BCS data plotted in Fig. 4 reveal that, for wages, years of schooling, body mass index, number of arrests, and life satisfaction, personality is at least as predictive as IQ. However, the variation explained by IQ and personality is relatively small. Consider, for example, the contribution to explained variance from a regression of log wages on IQ, personality, scores on achievement tests, and grades—reported in various combinations. Column 1 in Fig. 4 in the first block of columns (corresponding to wages) shows that IQ predicts wages, but the predictive power is small (around 1%). Column 2 in Fig. 4 shows that self-esteem, locus of control, antisocial behavior, and neuroticism, taken together, are more important determinants of wages. Both IQ and personality remain as important predictors in wage equations when both are included in a regression (column 3 in Fig. 4). The fourth column in Fig. 4 shows that achievement has more predictive power than IQ and personality alone. When IQ and personality are also included in a regression (column 5 in Fig. 4), achievement test scores remain an important predictor of wages, and IQ and personality also remain important predictors of wages. After controlling for scores on achievement tests, IQ loses around 60% of its predictive power. When grades are included, instead of achievement tests, the effect of IQ becomes negligible. A similar pattern arises across the other outcomes studied.

For the NLSY79, Fig. 5 parses the contributions of personality and IQ for a set of outcomes. Fig. 5 shows that IQ and personality only explain a small portion of the variance for all of the outcomes studied but that both are important predictors. IQ explains more of the variance than personality for log wages, any welfare, and physical health at age 40 y old, whereas personality explains more of the variance in mental health at age 40 y old and whether or not the individual voted in 2006. Achievement tests are better predictors of important life outcomes than IQ.

An analysis of the MIDUS data allows us to consider the predictive power of the Big Five personality traits for economic and health outcomes. Fig. 6 shows that the Big Five personality...
measures in the MIDUS data explain a much larger percentage of the variance than IQ for both wage and health outcomes.

The relative importance of IQ and personality measures varies across datasets. This variation is likely driven by differences in the measures used, the choice of measures, the populations considered, and the circumstances under which tests are taken. For example, in the NLSY79, IQ is a better predictor of log wages than personality, but in the BCS and the MIDUS data, personality measures are better predictors. The better and more comprehensive personality measures in the BCS and the MIDUS data compared with those available in the NLSY data likely explain why personality is a more predictive outcome in those data. The differences may also be driven by the availability of outcomes in each dataset, because different outcomes most likely place relatively more or less importance on IQ and personality. For example, in both the NLSY79 and the MIDUS, mental health depends relatively more on personality than physical health.\(^1\)

Despite variation across datasets, consistent patterns emerge. Personality is a powerful predictor for most life outcomes across all datasets. Grades and achievement test scores are more predictive of adult outcomes than IQ. In regression analyses reported in SI Appendix, Appendix S8, adding grades and test scores to models with IQ and personality produces greater predictive power for the outcomes studied. This larger explained variance is additional evidence that they capture relevant dimensions of human capability not captured by IQ and personality. A

\(^{1}\)Errors in the variables can explain some of our evidence. Surprisingly few studies of measurement error in our measures are available. For log wages, measurement error likely explains, at most, 25% of the variation (27).
grades and achievement

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ferences in the test scores
– Proc Natl Acad Sci USA

The Aptitude-Achievement Distinction: Proceedings of the 67(2):130

Handbook of the Economics of Education

We received valuable comments from two referees; (Cal-

Personality
– values of several sets of three regressions: (i) IQ and Personality
SI Appendix

show the full regressions supporting these decompositions.

Fig. 6. Decomposing life outcomes into cognition and personality. MIDUS. Data from the MIDUS 1995–1996 and 2004–2006. For privacy, income is reported in 42 unique bins in the MIDUS data. We assign individuals the average of their income bin. Sixty-one individuals in the top bin of $200,000 or higher are excluded from the analysis. Cognitive ability is measured by the Brief Test of Adult Cognition by Telephone (BTACT), and personality is measured by the Big Five. Results are restricted to the main sample individuals who were interviewed in both MIDUS I and MIDUS II, have nonmissing BTACT and Big Five measures, and were between 30 and 60 y of age during MIDUS II, which leaves us with 2,298 observations. All health-related outcomes are from self-reported scales administered during the MIDUS II follow-up. The figure shows the adjusted R² values of several sets of three regressions: (i) life outcomes on IQ, (ii) life outcomes on the personality measures, and (iii) life outcomes on IQ and the personality measures. SI Appendix, Tables S8.1–S8.11 show the full regressions supporting these decompositions.

general message from our analysis is that additional dimensions of achievement remain to be discovered.

Conclusions and Implications for Policy

Cognitive skills predict life outcomes. This paper reinterprets the evidence on the relationship between cognitive skills and a variety of important life outcomes by analyzing the constituent components of widely used proxies for cognitive skills—grades and achievement tests. Measures of personality predict achievement test scores and grades above and beyond IQ scores. Analyses using scores on achievement tests and grades as proxies for IQ conflate the effects of IQ with the effects of personality. Both measures have greater predictive power than IQ and personality alone, because they embody extra dimensions of personality not captured by our measures.

Why do these findings matter? Achievement tests are widely used to measure the traits required for success in school or life. It is important to know what they measure to design effective policy and use these measures to evaluate schools and teachers (evidence of teacher effectiveness on personality and its consequences for high school graduation is in ref. 28). Understanding the sources of differences in the test scores and grades used to explain the black–white achievement gap (29), the male–female wage gap (30), and other gaps by social class directly points to what factors might be remediated (5). For example, personality or noncognitive skills are more malleable at later ages than IQ, and there are effective adolescent interventions that promote personality but are much less successful in boosting IQ (31, 32). The predictive power of grades shows the folly of throwing away the information contained in individual teacher assessments when predicting success in life.**

ACKNOWLEDGMENTS. We received valuable comments from two referees; Anja Achtziger; Thomas Dohmen; Angela Lee Duckworth; Brent Roberts; Wendy Johnson; Tim Kautz; Anna Sjögren; seminar participants at Institutet för Arbetsmarknads- och Utbildningspolitisk Utvärdering (Sweden), Institute for Social Research (2010), Institute for the Study of Labor (2009), Institute for Fiscal Studies (2009), Geary Institute (2009), Tilburg University (2009), and the University of Konstanz (2009); and conference participants at the 2011 American Economic Association in Denver, the 2011 IZA Conference on Cognitive and Noncognitive Skills in Bonn, three Spencer conferences at the University of Chicago (2009 and 2010), the Second Conference on Non-Cognitive Skills in Konstanz, Germany (2009), the 2009 European Summer Symposium in Labour Economics in Buch am Ammersee, Germany, the 2009 Meeting of the Association for Research in Personality in Evanston, IL, and the 2010 Society of Labor Economists/ European Association of Labour Economists in London. An appendix for this paper can be found at https://heckman.uchicago.edu/what-do-grades-mean. This research was supported by the American Bar Foundation; the Pritzker Children’s Initiative; the Buffett Early Childhood Fund; NIH Grants National Institute of Child Health and Human Development (NICHD) R37HD056572, NICHD R01HD057402, and National Institute on Aging R24AG048081; an anonymous funder; Successful Pathways from School to Work, an initiative of the University of Chicago’s Committee on Education; the Hymen Milgrom Supporting Organization; the Human Capital and Economic Opportunity Global Working Group, an initiative of the Center for the Economics of Human Development; the Institute for New Economic Thinking; a Tore Brownell Grant from the Handelsbanken Research Foundation, and a VIDI grant from The Netherlands Organization for Scientific Research.

**This conclusion echoes the wisdom of Tyler (33), one of the inventors of the modern achievement test who recognized the limitations of achievement tests and recognized the value of more comprehensive assessments. His original design for the National Assessment of Educational Progress (NAEP) included more comprehensive measures, including teacher assessments (34).