The intergenerational transmission of cognitive and non-cognitive abilities[a]

by

Erik Grönqvist[b], Björn Öckert[c] and Jonas Vlachos[d]

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Abstract

We study the intergenerational transmission of cognitive and non-cognitive abilities between parents and sons using population-wide enlistment data. Conscripts are evaluated at the same age and with comparable methods across cohorts, and we correct for measurement error bias in fathers' ability measures by using their brothers' abilities as instruments. The "uncle instrument" is supported by a host of validity tests. This strategy also enables us to predict mothers' abilities. Our results suggest that previous estimates of intergenerational ability correlations are biased downwards; in particular for non-cognitive skills. When this bias is corrected for, the non-cognitive correlation is close to that of cognitive abilities. Using predicted abilities, we further find the mother-son cognitive ability correlation to be stronger than the father-son correlation. Finally, educational attainment and labor market outcomes of both sons and daughters are found to be strongly related to both parents' cognitive and non-cognitive abilities.

Keywords: Intergenerational ability correlations, cognitive ability, non-cognitive ability, measurement error bias
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[b] Institute for Labour Market Policy Evaluation (IFAU) and Department of Economics, Uppsala University. Email: erik.gronqvist@ifau.uu.se
[c] Institute for Labour Market Policy Evaluation (IFAU) and Department of Economics, Uppsala University. Email: bjorn.ockert@ifau.uu.se
[d] Department of Economics, Stockholm University, IFN and CEPR. Email: jonas.vlachos@ne.su.se

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1 Introduction

A growing literature recognizes the importance of not only cognitive abilities but also of non-cognitive abilities—or personality traits—for labor market outcomes (e.g. Bowles, 2001; Heckman et al., 2006; Lindqvist and Vestman, 2010). It is vital to understand how economic outcomes are transmitted over generations in order to guide policies aiming at enhancing intergenerational mobility and reducing inequality. However, despite the growing mass of research on non-cognitive abilities (Borghans et al., 2008), the role of parents in shaping such personality traits is still far from fully understood. One fundamental problem when studying the relation between parental abilities and the abilities of their offspring is that abilities are likely to be measured with error. As is well known, such measurement error will induce attenuation bias that leads to an under-appreciation of the influence that parents have on their children (Black and Devereux, 2010). This is particularly problematic when comparing the intergenerational transmission of cognitive and non-cognitive skills as the measurement problems are likely to be more severe for non-cognitive, not the least since the measurement methods for cognitive abilities are relatively well-developed. Hence, measurement error may potentially lead to unfounded beliefs that parental influences are less important for non-cognitive than for cognitive abilities.

In this paper we make use of military enlistment records for 37 cohorts of Swedish men, where fathers' and sons' abilities are evaluated at the same age (approximately at age 18) and where the evaluation methods are comparable over time. This enables us to estimate intergenerational correlations in both cognitive and non-cognitive abilities using the same sample of individuals. Moreover, we introduce a new strategy to correct for measurement error bias in the fathers' abilities by using the ability evaluations of uncles as instruments. The brother correlation in skills ensures a strong first stage[1] and the exclusion restriction that uncles do not have a direct effect on the skills of their nephews is supported by a series of validity checks. For example, we find close to identical results when using alternative evaluations of the fathers' own abilities at an earlier age for a subset of fathers as when using the uncles' abilities as instruments.

[1] The brother correlation in cognitive and non-cognitive abilities in our data is 0.45 and 0.30 respectively.

Furthermore, our strategy enables us to predict mothers' abilities by using the ability evaluations of their brothers, thus bringing both parents into the analysis.

Without adjusting for measurement error, we find a father-son correlation of 0.35 for cognitive and 0.21 for non-cognitive abilities. This is much in line with previous findings: Black et al. (2009) and Björklund et al. (2010) find intergenerational correlations in cognitive abilities of between 0.35 and 0.38, while the meta-study by Plomin and Spinath (2004) reports a correlation of 0.4. As for non-cognitive abilities, the meta-study by Loehlin (2005) reports an intergenerational coefficient of about 0.15, while Dohmen et al (2008) find coefficients of between 0.15 and 0.25. Anger (2010) finds correlations ranging from 0.12 to 0.22 between parents and their young adult children.[2] When we do adjust for measurement error in father's abilities, however, the intergenerational correlation increases to 0.48 for cognitive abilities and to 0.43 for non-cognitive abilities.[3] Our study thus suggests that the substantial difference in estimated intergenerational correlations between cognitive and non-cognitive abilities found in the previous literature to a large extent is due to a higher degree of measurement error in non-cognitive abilities. This is unlikely to be a unique feature of our data.

We next derive predicted cognitive and non-cognitive ability measures also for mothers using the enlistment evaluations of their brothers; i.e. maternal uncles. To do so, we use auxiliary data to adjust the brother correlations in the first stage relation for gender-specific sibling correlations in both cognitive and non-cognitive abilities. When using predicted abilities for both parents—thus simultaneously adjusting for the measurement error—we find mother-son correlations in cognitive abilities to be somewhat stronger than father-son correlations, while the influence of both parents is essentially the same for non-cognitive abilities. Previous studies on the relative ability correlations between mothers and fathers have produced inconclusive results, most

[2] These studies all use different measures of non-cognitive abilities and personality traits. For example, Dohmen et al. (2008) study risk taking and trust attitudes while the results in Loehlin (2005) and Anger (2010) are related to the 'big five' personality traits: openness, conscientiousness, extraversion, agreeableness, and neuroticism. Anger also studies the internal and external locus of control. A related paper by Wilhelm et al (2008) reports that intergenerational attitudes for charitable giving ranges from 0.26 to 0.31 for religious giving and 0.08 to 0.14 for secular giving.

[3] Note that Bowles and Gintis (2002) argue that the intergenerational correlation in cognitive ability lies between 0.42 and 0.72 when taking measurement error into consideration.

likely due to quite small sample sizes yielding imprecise estimates.[4] With the large sample at our disposal, the estimates we report are estimated with a high degree of precision. Since both generations are evaluated at approximately age 18, another advantage of our data is that parental abilities are not influenced by experiences shared by parents and children. This also prevents any direct impact on parents assessed abilities by their children.

Finally, we find a strong association between predicted parental abilities and educational and labor market outcomes for both sons and daughters. Parents' cognitive abilities are relatively more important for educational outcomes while their non-cognitive abilities are relatively more important for earnings and labor force participation. Previous findings regarding the labor market effects of cognitive and non-cognitive abilities for men (Lindqvist and Vestman, 2011) are thus likely to apply to women as well.[5] These results provide support for recent findings suggesting that the transmission of non-cognitive skills can explain a substantial part of the intergenerational correlation in economic outcomes. For example, in a small sample of US children Osborne-Groves (2005) finds that personality traits can explain 11 percent of the earnings transmission, the same number as Blanden et al. (2007) find in a study of 3300 UK children using a measure of non-cognitive skills. Hirvonen (2009) finds that a combination of sons' education, cognitive and non-cognitive skills, as well as a health indicator (BMI) can account for most of the intergenerational correlation in income. In the same vein, Björklund et al. (2010) find that indicators of parental patience can explain a substantial part of sibling income correlations.

In sum, this paper makes four distinct contributions: we compare intergenerational correlations in cognitive and non-cognitive ability using a large and representative sample of men who are evaluated using the same methods and at the same age; we correct for measurement error bias using the ability evaluations of uncles; we predict

[4] Using representative but relatively small samples, Anger and Heineck (2009) and Anger (2010) report mother-son, mother-daughter, father-son, and father-daughter correlations for a number of cognitive and non-cognitive ability dimensions.

[5] Lindqvist and Vestman (2011) use the same type of enlistment data as we do. They find that a one standard deviation increase in the cognitive and non-cognitive skills measure is associated with 6 and 9 percent higher wages, respectively. Further, non-cognitive skills are strongly related to future labor force participation and the probability of living in poverty.

mothers' abilities using the ability evaluations of maternal uncles; and we estimate the importance of the transmission in abilities from both parents for outcomes later in life, both for sons and daughters.

2 Data

If called upon, all Swedish men are by law obliged to go through the military enlistment.[6] In most cases, the enlistment takes place the year men turns 18. Up until the late 1990s, over 90 percent of all men in each cohort went through the whole enlistment procedure; only the physically and mentally handicapped were exempted.[7] Since then, the need for conscripts has declined and as a consequence the enlistment has become less comprehensive.

The enlistment consists of a series of physical, psychological and intellectual tests and evaluations. The evaluation of cognitive ability consists of several subtests of logical, verbal, and spatial abilities, as well as a test of the conscript's technical understanding. The design of the test has been subjected to minor revisions in 1980, 1994 and 2000, but throughout the period it tests for the same four underlying abilities. The raw test results on these four subtests are combined to a discrete variable of general cognitive ability ranging from 1 to 9, which has been found to be a good measure of general intelligence (Carlstedt, 2000). We standardize this composite measure of general cognitive ability by enlistment year.

Our measure of non-cognitive abilities is based on a standardized psychological evaluation aimed at determining the conscripts' psychological capacity to fulfill the requirements of military duty and armed combat. Central to this are the abilities to cope with stress and to contribute to group cohesion. A conscript is given a high score if considered to be emotionally stable, persistent, socially outgoing, willing to assume responsibility, and able to take initiatives. Motivation for doing the military service is,

[6] This discussion of the enlistment data draws heavily on an interview with Johan Lothigius, chief psychologist at the National Service Administration, carried out by Erik Lindqvist (August 25, 2004). We are grateful to Erik for sharing his notes with us. See also Lindqvist and Vestman (2010) for additional details of the enlistment procedure.

[7] The consequences of refusing the enlistment include fines and being round up by the police, and ultimately imprisonment in up to one year (1994:1809 Lag om totalförsvarsplikt, kap 10).

however, explicitly not a factor to be evaluated. The evaluation is performed by a certified psychologist who conducts a structured interview with the conscript. As a basis for the interview, the psychologist has information about the conscript's results on the tests of cognitive ability, physical endurance, muscular strength, as well as grades from school and the answers on questions about friends, family, hobbies etc. The interview follows a specific, and secret, manual that states topics to discuss and also how to grade different answers. Grades are given on four different sub-scales which are transformed to a discrete variable of non-cognitive ability ranging from 1 to 9. Also this measure is standardized by enlistment year. The correlation between cognitive and non-cognitive abilities across individuals is 0.35.

This evaluation instrument was developed based on the experiences from the Korean War, adapted to Swedish circumstances. The experiences of Swedish UN peacekeeping troops have also been important. The instructions for the instrument remained unchanged up until 1995, when it was subject to minor revisions.

Data on enlistment files have been collected from administrative records kept by the Military Archives of Sweden and the National Service Administration. The original sample consists of all Swedish men born between 1950 and 1987, and includes information on date of the enlistment, results on the cognitive ability tests and the psychologist's rating of the non-cognitive skills. Information from Statistics Sweden on biological parents has then been used to link fathers and sons, as well as mothers and siblings.[8]

A few restrictions on data have been imposed in the main analysis. First, all men included in our sample must have a valid enlistment record and have enlisted the year they turned 18, 19 or 20 years of age. Since over 90 percent of all men were enlisted up to about year 2000, this is a minor concern for most of the period studied. From then on, however, the share of men who were called to the enlistment fell dramatically. For individuals born in the mid 1980s, only 70 percent were enlisted. Thus, for individuals

[8] In principle all individuals born in Sweden since 1932 can be linked to their mother and father. The qualification is that they are residents in Sweden in 1961 and later. For immigrants the coverage is much lower, but as only Swedish citizens are allowed (and obliged) to attend the enlistment this is a minor concern

born towards the end of our sampling window, the selective enlistment might potentially pose a problem. We will return to this issue in section 4.5.

Second, since we use uncles' abilities as instruments for the father's abilities, we restrict the sample to sons with at least one uncle. In addition, by requiring that both the father and the uncle have enlisted before 1980 we guarantee that they have undertaken the same version of the cognitive ability test. Further, to avoid that uncles share more of the same environment with their nephews than with their brothers, we require the age difference between fathers and uncles to be at most seven years.[9]

Subject to these restrictions, our main regression sample consists of more than 50 000 observations (sons). *Table 1* shows descriptive statistics for sons, fathers and paternal uncles in our sample.[10] As noted above, men are typically enlisted when they are 18 years old. There is some evidence that the sons in our sample have slightly higher cognitive and non-cognitive skills than the population on average, while their fathers have slightly lower cognitive and slightly higher non-cognitive skills. This pattern is likely to be caused by the age restrictions in the enlistment data (individuals born 1950 to 1987) which implies that the fathers in our sample are somewhat younger than fathers in the population as a whole. Paternal uncles are slightly younger than the fathers, since there is no requirement that uncles need to have children. They also have somewhat lower cognitive scores than fathers, possibly due to birth order effects (Black et al., 2007).

Table 1. Descriptive statistics

	Sons	Fathers	Paternal uncles
Variables:			
Year of birth	1981.31	1954.64	1955.46
	(3.91)	(2.52)	(2.68)
Age at draft	18.21	18.51	18.44
	(0.35)	(0.56)	(0.56)
Cognitive ability at 18	0.09	-0.03	-0.09
	(0.93)	(0.97)	(1.00)

[9] As will be discussed later, we will also predict abilities for both parents using the enlistment evaluations of both paternal and maternal uncles. The restrictions on this sample will be slightly different as we require the relevant data to be available for both parents.
[10] For fathers with more than one enlisted brother, we use the evaluation of the brother closest in age.

Non-cognitive ability at 18	0.05	0.07	-0.02
	(0.97)	(0.98)	(0.99)
n	50,214	40,277	39,599

Notes: Standard deviations are in parentheses. The cognitive and non-cognitive ability measures have been standardized by year of draft in the entire population.

3 Methodological considerations

As the aim of this paper is to describe how cognitive and non-cognitive abilities are transferred from one generation to another we would ideally like to estimate the following simple regression model:

$$Y_j^{*son} = \alpha + \beta Y_j^{*father} + \varepsilon_j, \qquad (1)$$

where Y_j^{*son} represents the true cognitive or non-cognitive ability for the son in family *j*, $Y_j^{*father}$ is the corresponding true ability for the father and ε_j is an error term. The parameter β is the intergenerational correlation in true cognitive or non-cognitive abilities between fathers and sons.[11]

A problem for this study—and essentially all other studies on the subject—is that the observed measures of cognitive and non-cognitive abilities will typically only proxy for the true underlying abilities. There are two potential sources of measurement errors in the observed abilities, both of which may bias the estimates of the intergenerational correlations towards zero. First, the evaluation instrument can only test for a subset of the traits characterizing the underlying ability, and individuals may have good or bad realizations with respect to the specific items included in the test. To exemplify, consider the verbal subtest for word comprehension in the cognitive ability test. Such a test can only cover a small sample of all possible words, and the individual may have good or bad luck with the specific words included in the test. It can also be that the general type of words considered in the test lies outside the domain of his proficiency. Hence, the test may not fully capture the underlying ability it aims to measure. Second,

[11] The slope coefficient in a univariate regression with standardized variables equals the correlation coefficient.

some individuals perform particularly well or bad in the test taking situation; e.g. due to nervousness or because they are highly motivated. Some individuals will also perform particularly badly on the test day, e.g. due to illness or outside stress.

To illustrate how the two types of measurement errors may affect our estimates, assume that the observed ability for individual *i* in family *j*, Y_j^i, can be expressed as linear function of the true latent ability, a test specific measurement error and an individual specific measurement error:

$$Y_j^i = Y_j^{*i} + \lambda_j^i + \eta_j^i , \tag{2}$$

where Y_j^{*i} is the true latent ability for individual *i* in family *j*, λ_j^i is the test specific measurement error and η_j^i is the individual specific measurement error. Under the assumption that both types of measurement errors are classical, i.e. independent random variables, the OLS estimate of the intergenerational correlation in true abilities can be expressed as:

$$plim\, \beta^{OLS} = \beta \frac{V\left(Y_j^{*\,father}\right)}{V\left(Y_j^{father}\right)} . \tag{3}$$

This is the usual measurement error bias expression, where the estimate of the intergenerational correlation is attenuated by the ratio between the variance of fathers' true and the observed abilities. The attenuation term is typically known as the reliability ratio. In this setting, however, a more appropriate term would be the "reliability-validity ratio", since it reflects not only how well the evaluation instrument measures what it measures (reliability), but also to what extent it captures what it is supposed to measure (validity).

Using proxy variables for the true latent ability of fathers is particularly problematic for our purposes, since the extent of measurement error may differ between the cognitive and non-cognitive ability measures. In particular, we suspect the measurement error problem to be more severe for measures of non-cognitive skills than of cognitive skills, as the methods for testing cognitive abilities are more developed. The downward bias of the OLS estimates of intergenerational correlations in non-cognitive skills may thus be greater than that of cognitive skills, leading us to draw incorrect conclusions of the relative importance of the intergenerational transmission of different types of skills.

One way of dealing with measurement errors is to find an instrument for the noisy variable; that is, to find a variable that is strongly related to the variable of interest but without any direct effect on the outcome variable (see e.g. Ashenfelter and Krueger, 1994). We propose using the ability of paternal uncles as an instrument for the ability of fathers to correct for measurement error bias in the estimated intergenerational correlations. This amounts to estimating the following first stage relation:[12]

$$Y_j^{father} = \pi + \rho Y_j^{uncle} + u_j , \tag{4}$$

where ρ is the correlation between fathers' and uncles' observed abilities. In other words, we exploit brothers' ability correlation in order to address the measurement error problem. Under the assumption that uncles do not have a direct impact on their nephews' abilities, the uncle's ability is a valid instrument for the father's ability. Hence, we are able to correct for the measurement error bias, and thus capture the intergenerational correlation in the true latent abilities:

$$plim\hat{\beta}_{IV} = \frac{\mathrm{cov}(Y_j^{son}, Y_j^{uncle})}{\mathrm{cov}(Y_j^{father}, Y_j^{uncle})} = \beta \frac{\mathrm{cov}(Y_j^{*\,father}, Y_j^{*\,father})}{\mathrm{cov}(Y_j^{*\,father}, Y_j^{*\,father})} = \beta. \tag{5}$$

There are a few concerns that could invalidate the interpretation of our IV estimates as the intergenerational transmission of true abilities. First, it is not obvious that the exclusion restriction holds; uncles can have a direct influence on their nephews, or they could share some family factor with their nephews not shared by the father. In such a case, the IV-estimate would overestimate the true transmission in abilities. Second, the measurement error may not be classic. In particular, the brothers' measurement errors

[12] Note that the uncle's ability may also be measured with an error.

could potentially be correlated. For instance, brothers may share the same motivation for writing the test (i.e. to do the military service), or the design of the test may fit the knowledge shared between brothers particularly good or bad. To exemplify with the word comprehension test again; the test may cover a sub sample of words that are more or less frequently used in the brothers' family. If this would be the case, the IV-estimate is likely to underestimate the intergenerational correlation in true skills. In Section 4.2 we will address these and related concerns about the validity of the instrument.[13]

Like all IV-estimators, the "uncle instrument" exploits the variation in the variable of interest (father's ability) that is driven by the instrument (uncle's ability), and identifies a local average treatment effect (Imbens and Angrist, 1994). In principle, it is possible that the intergenerational transmission of the abilities that are shared between fathers and their brothers may differ from the intergenerational transmission of fathers total abilities. Thus, any difference between the OLS and the IV estimates may not only be driven by measurement errors in the measures of fathers' abilities, but can also be due to the fact that the estimators exploit different parts of the variation in fathers' abilities.

In order to gain more insight to the local average treatment effect captured by the uncle instrument we temporarily put the error problem aside. We can then think of abilities as having different sources; either produced by genes or the environment. In particular, we model the production of abilities as a function of both genes (G) and environment (E), $Y^* = Y_S^{*G} + Y_{NS}^{*G} + Y_S^{*E} + Y_{NS}^{*E}$, where some parts are shared (S) between brothers while others are not (NS), and where there are no complementarities between the different components. See Appendix B for details.

If we assume that the intergenerational transmission of fathers' abilities determined by genes (environment) is the same regardless of whether the genes (environment) are shared between brothers or not, the transmission of abilities over generations will be a sum of the intergenerational transmission of the genetic and the environmental component weighted by the relative share of the variation in fathers abilities that comes

[13] In the event that a part of the test specific measurement error is correlated over generations, both the OLS and the IV estimate will be biased upwards. We believe this is less of a problem, since the test used in the parental generation is different from the one used in the sons' generation.

from these two sources.[14] The IV-estimate of the intergenerational transmission using the uncle instrument will reflect the average treatment effect in the population if (i) the shared parts of brother's abilities have the same relative genetic and environmental determinants as the non-shared parts, or (ii) the intergenerational transmission is the same for the genetic and environmental components. In section 4.2 we will discuss whether it is likely that the different estimators are measuring the same underlying parameter or not.

4 Father-son correlations

We start this section by presenting the results for intergenerational correlations in cognitive and non-cognitive abilities between fathers and sons with and without correction for measurement error. The main result is that correcting for measurement error results in substantially higher intergenerational correlations in both cognitive and non-cognitive abilities. The attenuation bias is particularly severe for non-cognitive abilities and once corrected for, the intergenerational correlation in personality traits is close to that of cognitive abilities. In Section 4.2, we present a number of consistency checks validating the use of the uncle instrument. We also discuss whether the OLS and the IV estimates capture the same parameter.

4.1 Correlations with and without correcting for measurement error

In this section, we estimate baseline intergenerational correlations with and without corrections for measurement error. In the first column of *Table 2*, we see that the correlation between fathers' and sons' cognitive abilities is 0.35. This is close to what Black et al. (2009) have found for Norway and Björklund et al. (2009) for Sweden.[15] In the second column, we estimate the father-son correlation for non-cognitive abilities and find it to be 0.21, which is in line with previous findings in the literature.[16] In the third and forth columns, we correct the estimates for attenuation bias by using the ability

[14] Absent of the measurement error we have that $p\lim \hat{\beta}_{OLS} = \beta^G \left(V(Y_S^{*G}) + V(Y_{NS}^{*G})\right) / V(Y^*) + \beta^E \left(V(Y_S^{*E}) + V(Y_{NS}^{*E})\right) / V(Y^*)$, see Appendix B

[15] Since we use essentially the same data as Björklund et al. (2009) the similarity of our results is unsurprising.

[16] The meta-study by Loehlin (2005) finds the intergenerational coefficient for non-cognitive abilities to be around 0.14. Dohmen et al. (2008) find the coefficient for risk taking and trust attitudes to be between 0.15 and 0.25.

evaluations for the son's uncle (the father's brother) as instruments for the father's abilities.[17]

Correcting for measurement error leads to a substantial increase in the intergenerational correlations of both ability measures. The estimate for cognitive ability increases from 0.35 using OLS to 0.48 using IV, implying that the reliability ratio of the cognitive ability measure is 0.73. For non-cognitive ability, the estimate increases from 0.21 using OLS to 0.43 using IV, which means that the reliability ratio of the non-cognitive ability evaluation is 0.50.[18]

One concern is that the surprisingly high father-son correlation in non-cognitive ability may be spuriously driven by cognitive ability, as the cognitive ability is omitted in the regression in column four. Similarly, the estimated correlation in cognitive ability in column three might be upwardly biased due to the omission of non-cognitive abilities. In columns five and six, however, we find that the point estimates are only slightly reduced – to 0.44 for cognitive abilities and to 0.39 for non-cognitive abilities – when controlling for the other ability type with the relative size being unchanged. Furthermore, these point estimates are not statistically different from the ones in columns three and four.

The larger measurement error in non-cognitive than in cognitive ability evaluations is not surprising as the concept of cognitive ability is more precisely defined and measurement methods more developed. That a substantial part of the differences in intergenerational correlations between cognitive and non-cognitive abilities can be explained by a higher degree of measurement error in the non-cognitive ability dimension is thus unlikely to be a unique feature of this study. Rather, the results suggest that previous estimates of intergenerational correlations in non-cognitive abilities have been quite severely downwardly biased due to measurement error.

[17] In table 2 we only use the sample of father-son pairs for which uncles with enlistment records are available. However, the OLS estimates in columns one and two are essentially unchanged when using all father-son pairs available. This suggests that no selection problems arise when using the uncle sample.

[18] In the "first stage"-regression we find a brother correlation of 0.45 in cognitive abilities, which is very close to the brother correlations found by Björklund et al. (2009). The corresponding brother correlation for non-cognitive abilities is 0.30.

Table 2. Intergenerational correlations in cognitive and non-cognitive abilities

	OLS		IV			
Dependent variable:	Son's cognitive ability	Son's non-cognitive ability	Son's cognitive ability	Son's non-cognitive ability	Son's cognitive ability	Son's non-cognitive ability
Independent variable:						
Father's cognitive ability	0.349	.	0.479	.	0.445	0.043
	(0.004)	.	(0.009)	.	(0.014)	(0.015)
Father's non-cognitive ability	.	0.210	.	0.425	0.069	0.394
	.	(0.005)	.	(0.015)	(0.019)	(0.021)
n	50,214	50,214	50,214	50,214	50,214	50,214

Notes: All estimates come from separate regressions. The ability measures have been standardized by year of draft. Standard errors adjusted for clustering on the father are in parentheses. In the IV-specification, the father's ability is instrument by the uncle's ability, and the sample is restricted to sons who have at least one uncle.

4.2 Can we trust the uncle instrument?

Whether our IV-estimates are to be trusted crucially depends on whether the exclusion restriction that we impose on the instrument holds. If uncles have a direct effect on their nephews' abilities—either by a direct influence, through shared environment, or shared genetic factors—using the test results of the uncle as an instrument may be inappropriate. While the exogeniety of the instrument is an assumption that by definition cannot be tested, we can perform several consistency checks corroborating the exogeniety of the uncle instrument.

Testing for a direct influence of the uncle

In order to avoid the son and his uncle to be sharing the same environment, we restrict the sample to uncles who are at most 7 years younger than the father; this means that the typical uncle in our data is always more than 11 years older than his nephew. Table 1 shows that the average uncle is more than 25 years older than his nephew, reducing much of the shared time- and age-specific environmental influences.

Despite this age difference, uncles could still have a direct influence on their nephews. We test for this by using a sub-sample of "absent uncles", defined as uncles who have either died or emigrated from Sweden prior to the birth of their nephew. The reasoning is as follows: If uncles have a direct effect on their nephews, IV estimates based on the ability evaluation for absent uncles—who have had no or very limited contact with their nephews—should be lower than for the average uncle.

Despite the drastic reduction in sample size, column two in *Table 3* first shows that the OLS estimates for cognitive and non-cognitive skills are essentially unchanged compared to the estimates based on the full sample. More importantly, the IV estimates for the absent uncle sample are, if anything, larger than the IV estimates based on the full sample of observations. It should be noted, however, that the standard errors of these IV estimates are large and we cannot reject the possibility that the IV estimates for the different samples are equal. Still, we find no evidence suggesting that the IV estimates for absent uncles are smaller than the estimates based on the full sample. This indicates that uncles do not have a direct influence on their nephew's abilities.

Table 3. Intergenerational correlation in abilities – alternative restrictions and instruments

Instrument:	Uncle's ability				Father's ability at 13
Sample:	All	Dead or emigrated uncle	Dead grandfather *or* grandmother	Dead grandfather *and* grandmother	All
Model:	**Panel A. Cognitive abilities**				
OLS	0.349	0.339	0.330	0.299	0.322
	(0.004)	(0.050)	(0.012)	(0.056)	(0.023)
IV	0.479	0.584	0.471	0.415	0.423
	(0.009)	(0.113)	(0.026)	(0.117)	(0.031)
Statistic:					
Reliability ratio	0.730	0.580	0.700	0.721	0.764
	(0.017)	(0.141)	(0.046)	(0.244)	(0.078)
Model:	**Panel B. Non-cognitive abilities**				
OLS	0.210	0.226	0.200	0.178	0.212
	(0.005)	(0.059)	(0.014)	(0.061)	(0.024)
IV	0.425	0.616	0.420	0.711	0.412
	(0.015)	(0.176)	(0.043)	(0.248)	(0.161)
Statistic:					
Reliability ratio	0.497	0.366	0.477	0.250	0.515
	(0.021)	(0.142)	(0.058)	(0.123)	(0.209)
n	50,214	296	5,780	257	1,889

Notes: All estimates come from separate regressions. The ability measures have been standardized. Standard errors adjusted for clustering on the father are in parentheses. The reliability ratios have been calculated by dividing the OLS-estimates by the IV-estimates, and the standard errors have been computed by means of the delta-method.

Even if uncles do not influence their nephews directly, they do have a shared environment through the grandparents. Grandparents may have an influence on both their sons and their grandsons, for example by spending time with their grandchildren. Hence, there may be an association between the uncle and his nephew, not shared with the father, potentially biasing the IV estimates of the father-son correlation upwards. In order to test for this we utilize sub-samples of children with "absent grandparents", where the direct contact with the grandparents is broken. If there is an association between children and their uncles—not shared by the father—via the grandparents, the IV estimates based on a sample of sons with absent grandparents should be lower relative to the OLS estimates than for the full sample.

We first use a sample of children where *either* the grandmother *or* the grandfather died before their grandson was born. In column three in *Table 3*, we find that the IV estimates for cognitive and non-cognitive skills to be essentially unchanged as compared with the original estimates. In column four we instead use the small sample where *both* the grandmother and the grandfather died before their grandson was born. For this sample, the IV estimate for cognitive ability is slightly smaller, while the estimate for non-cognitive ability is larger, than for the full sample, but these differences are not statistically significant. It is important to note that the OLS estimates also differ somewhat from the estimates based on the full sample, most likely due to this sample being a highly selected one. It is therefore useful to study the reliability ratios rather than the IV estimates. If the original IV estimates were upward biased due to a direct influence by grandparents on their grandchildren, we would expect the reliability ratios for the absent grandparents sample to be higher than for the full sample. We find no indication of this and the same also holds true for the absent uncle sample. This means that we find no sign of an independent association between the uncle and the nephew through the influence from the grandparents.

So far we have considered the case where the uncle instrument could be invalid through either a direct influence from the uncle or through a shared environment. A third possibility is that there is a genetic component shared by the uncle and the nephew, but not by the father. In order to test for this possibility we consider a trait that has a large genetic component and for which measurement error is limited; namely stature. In the absence of such a shared genetic component between uncles and nephews, we expect the OLS and IV estimates to be close to identical. Indeed, in *Table 4* we find the OLS estimate of the father-son correlation in height to be 0.48, whereas the IV estimate is 0.50. As measurement error is not completely absent even for our measure of height, this slight difference can be explained by attenuation bias.[1] Alternatively, it can be due to a small direct influence of the uncle on his nephew's stature. Either way, we feel reassured that any direct effect from the uncle through a shared genetic component is at most marginal.

Table 4. Instrument validity check: Intergenerational correlations in height

	OLS		IV
Dependent variable:	Son's Height	Son's Height	Son's height
Independent variable:			
Father's height	0.483	0.477	0.500
	(0.004)	(0.005)	(0.008)
Uncle's height	.	0.012	.
	.	(0.005)	.
n	52,973	52,973	52,973

Notes: The height has been standardized by year of draft. Standard errors adjusted for clustering on the father are in parentheses. In the IV-specification, the father's height is instrument by the uncle's height, and the sample is restricted to sons who have at least one uncle.

Using the fathers abilities at age 13 as an instrument

As a final validity check we exploit two alternative instruments for the father's abilities. For a sample of fathers we have alternative measures of cognitive and non-cognitive abilities at age 13. These data originates from the longitudinal study *Evaluation Through Follow-up* (EFT) administrated by the department of education at Gothenburg University and consists of a 10 percent sample of individuals born in 1953. Within the EFT surveys, individuals were given cognitive ability tests reflecting some of the very same abilities as measured during the enlistment: verbal, logical, spatial, and technical

[1] Apart from coding errors, rounding can induce some noise to the measure as height is reported in integer centimeters. Further, there is a slight variation of the age at the draft between 18 and 19 years of age, height also differs somewhat over the course of the day, and conscripts may stretch more or less when being measured.

abilities. Even though the cognitive tests at age 13 and 18 are not identical, they are supposed to reflect the same underlying cognitive abilities.

The EFT data does not include any direct measurement of non-cognitive abilities. It does however contain schooling information that captures non-cognitive skills. More specifically the EFT data contains information on father's grade point average (GPA) in non-theoretical subjects in the 6th grade and survey information on educational aspirations and social interaction at age 13.[2] In particular we use the residual of these measures after regressing them on the measure of cognitive ability—thus netting out any cognitive ability captured by this schooling information—as instruments of the father's non-cognitive ability at age 18. By using fathers' cognitive ability scores and schooling information at age 13 as instruments for their own cognitive and non-cognitive abilities at age 18, we avoid the concerns that may be raised against the uncle instrument; i.e. that uncles have a direct influence on their nephews. The sample for which these abilities at age 13 are available is however substantially smaller than the full enlistment sample.

The top panel of column five in *Table 3* presents the OLS and the IV estimates when using the father's own cognitive ability test at age 13 as an instrument for his cognitive ability at age 18. We first see that both the OLS and the IV estimates when using the EFT sample are similar, though slightly smaller, as compared to using the uncle instrument in the enlistment sample. More importantly, the reliability ratios for the specifications based on the uncle instrument and the father's early cognitive ability instrument are very similar. The two instruments thus provide the same correction of the measurement error bias. In the bottom panel of column five where the father's non-cognitive ability is instrumented with schooling information at age 13, the OLS and the IV-estimates are essentially the same as when using the uncle instrument. Again the reliability ratio is very similar as when using the uncle instrument. In neither case is difference in the reliability ratios, when using ability measures at age 13 and the uncle's abilities as instruments, close to reaching statistical significance. All this is reassuring

[2] The survey question on educational aspirations contain information on the number of years of schooling required for the preferred profession at age 30, while the question on social interaction captures the extent to which the student spend time outside school alone or with friends.

and further convinces us that uncles indeed have a limited direct effect on their nephews' abilities, and hence that their ability evaluations can be used as instruments.

Do OLS and IV capture the same transmission?

The uncle instrument exploits only the variation in the father's abilities that is shared between brothers, and a potential problem is that the intergenerational transmission of this part of the variation in father's abilities may be different from the overall transmission of father's abilities. In section 3 we argued, based on a very simple and admittedly restrictive ability production function, that the OLS and IV estimates would capture the same parameter if either the shared parts of brother's abilities have the same relative genetic and environmental determinants as the non-shared parts, or if the intergenerational transmission is the same for the genetic and environmental components. By having access to two alternative instruments for the same skill we can address whether any of these requirements are plausible.

As we discuss in Appendix B, the father's early ability instrument exploits all the variation in father's cognitive abilities as determined by genes (it is the same individual), and all the environmental determinants up to the age 13. It does however not exploit the variation in the environmental determinants of father's ability between the ages 14 and 18. However, if the environmental factors during this age period have limited impact on the father's abilities at age 18, the early father's ability instrument will in essence exploit all the determinants for father's ability at age 18 and the instrument will capture the same parameter as do OLS.

Since the uncle instrument and the early ability instrument produce very similar estimates of the intergenerational correlation in both cognitive and non-cognitive skills, our simple ability production model suggests that the uncle instrument must capture the same parameter as the OLS. The reason is that the IV-estimates when using the uncle instrument and the early ability instrument can only give the same estimates in two distinct cases. One possibility is that the shared and non-shared part of brothers abilities have the same relative genetic and environmental determinants and that environmental factors between ages 14 and 18 have limited impact on abilities at enlistment. Alternatively, the transmission rate of father's cognitive abilities is the same, no matter if the underlying source is genes or environment. According to the discussion in

Appendix B, the OLS and the IV capture the same underlying abilities in both these cases.

Motivational factors

A final issue is that subjects may vary in their motivation to perform well at the enlistment; even if there are both those who are highly and poorly motivated at the enlistment it is easier to underperform. Hence, we are typically worried that some are systematically underperforming in the hope to escape the military service, something that would weaken the estimated transmission in abilities. In *Table A.3* we therefore re-estimate our IV estimates (with the uncle instrument), truncating the fathers' ability distribution (2 to 4 percent) in the upper and lower tails. The analysis in column two shows the IV estimates when removing individuals with the lowest score on either the cognitive or non-cognitive test, i.e. those scoring 1 on the original 1 to 9 scale used by the military when aggregating test results. When trimming the lower tail of the distribution, the father-son correlation for cognitive abilities raises to 0.50 and the correlation for non-cognitive ability rises to 0.45. If we instead remove individuals with the highest score on either test the father-son correlation also increases slightly in both ability dimensions (column three). When trimming both the upper and lower tails of the distribution (column four), we find that the estimated father-son correlations increases even further: to 0.51 and 0.48 for cognitive and non-cognitive ability respectively. Since the measured intergenerational transmission in abilities increases symmetrically when we truncate the upper and lower tails of the ability distribution, we interpret this as the intergenerational correlation in skills being lower in the tails due to a mean reversion across generations, rather than there being individuals in both tails who are systematically over- and underperforming. As it is virtually impossible to over-perform at these tests by other means than by chance, we do not think this is a major problem in our analysis.[3]

A similar issue is whether there is a joint motivational factor across brothers towards the enlistment process. This would mean a systematic measurement error, shared

[3] Another case in point here is that the intergenerational correlation between fathers at age 13 (the EFT evaluation) and sons at age 18 (the enlistment evaluation) is 0.333. For the same sample, the intergenerational correlation is 0.339 when the enlistment evaluation is used for both fathers and sons.

between brothers, which would overstate the brother correlation in the first stage regression, and thus bias the IV estimates downwards. The fact that the IV estimates when using the father's early ability instrument yields the same results as when using the uncle instrument reassures us that a systematic motivation component in the measurement error is at most a limited problem. After all, the test taken at age 13 is set in a very different environment and is taken for a very different purpose than the enlistment test.

Through all the consistency tests performed we find no indication of a direct effect from the uncle to his nephew, either through a direct influence, a shared environment or through a common genetic component. We find no evidence of a systematic measurement error induced by motivational factors and we find that virtually the same IV estimates for the father-son correlation when using an alternative instrument. We also argue that the IV and OLS estimates are likely to capture the same underlying parameter. Hence, we feel confident that the ability of uncles is a valid instrument when estimating the intergenerational correlation in abilities.

5 Correlations using both parents

So far we have only studied father-son correlations even though both parents presumably are important for the transmission of abilities to their children. This is due to data limitations that we share with many other studies on intergenerational ability correlations. Our next step is therefore to generalize our methodological strategy and bring mothers into the analysis by predicting mothers' abilities using the enlistment records of their brothers. We find that both parents' abilities are strongly and independently correlated with their sons' abilities; in particular, the mother-son correlation in cognition is somewhat stronger than the father-son correlation. In Section 5.2 we find that educational and labor market outcomes for both sons and daughters are strongly related to the cognitive and non-cognitive abilities of both parents.

5.1 Bringing mothers into the analysis

Whether or not the inclusion of mothers is important crucially depends on the degree of assortative mating. If mothers' and fathers' abilities are highly correlated, using ability measures for one parent would be sufficient to estimate the full intergenerational correlation between parents and sons.

Rather than relying on such an assumption, we here use the idea behind the uncle instrument to predict abilities for both parents using the first stage relation; that is, we use enlistment ability measures of both paternal and maternal uncles. For fathers we can again use the usual two stage procedure, by first estimating the sibling correlation between brothers in equation (4) and plugging the predicted value of fathers' abilities into equation (1). Since we do not observe mothers' abilities we cannot obtain a direct estimate of the first stage equation for mothers. However, if we had an estimate of the sibling correlation between brothers and sister at age 18, $\hat{\rho}_{18}^{brother-sister}$, from some other source, we could still predict the abilities of mothers from maternal uncles as:

$$\hat{Y}_j^{mother} = \hat{\pi} + \hat{\rho}_{18}^{brother-sister} Y_j^{maternal uncle} \tag{6}$$

We could then plug $\hat{Y}_i^{mother}$ into the second stage relation (1).[4] To perform this exercise, we need an estimate for $\hat{\rho}_{18}^{brother-sister}$. If ability correlations between siblings of opposite sexes were the same as correlations between same-sex siblings, deriving the implied ability scores for mothers using their brothers' abilities would be a trivial exercise. Rather than just assuming that sibling correlations display such a pattern, we use alternative sources of data to produce an estimate of the gender specific sibling correlations.

To produce these gender specific sibling correlations, we scale the brother correlations from equation (4) by a factor equal to the relative sister-brother to brother-brother correlation for each assessed ability. These relative correlations are estimated using sources of data where we can observe both men and women. More specifically, we construct the estimate of the brother-sister correlation to be used in the first stage prediction of mother's abilities as follows:

[4] Note that we do not have any estimate of the π-parameter, but this term will be captured by the estimated constant in the second stage regression.

$$\hat{\rho}_{18}^{brother-sister} = \hat{\rho}_{18}^{brother} \frac{\hat{\rho}_{18,k}^{brother-sister}}{\hat{\rho}_{18,k}^{brother}} \quad , k=13, 16. \tag{6}$$

For cognitive skills we have ability evaluations at age 13 from the EFT-study for a sample of both boys and girls. Using these data we first regress sisters' cognitive ability at age 13 on their brothers' cognitive ability at the enlistment at age 18 to obtain the brother-sister correlation $\hat{\rho}_{18,13}^{brother-sister}$. Next, we obtain $\hat{\rho}_{18,13}^{brother}$ by regressing the cognitive ability at age 13 of one brother on his brother's cognitive ability at the enlistment. Relating the brother-sister correlation to the brother correlation then gives us the scaling factor for cognitive ability. In the first column of *Table A.1*, we find the sibling correlation in cognitive abilities between men for whom we have an ability evaluation at age 13 and their brothers' cognitive enlistment evaluation to be 0.42. In column two, we estimate the same relation between women's cognitive ability at age 13 and their brothers' enlistment evaluation at age 18. The estimate is 0.38, somewhat lower than between brothers. The relative correlation in cognitive abilities for siblings of different gender compared to same sex siblings is thus 0.92.

Estimating gender differences in non-cognitive sibling correlations is somewhat trickier as we do not have any direct measure of non-cognitive abilities for women at our disposal. What we do have, however, is the GPA from the last year of compulsory school in Sweden, i.e. the year the students' turns 16. These grades are supposed to reflect how well students perform relative to national standards and grade setting is aided by standardized national achievement tests in Swedish, English, and Mathematics. GPA records are available from 1988 and we standardize them by year. The GPA-results are used by students to apply for upper-secondary education and they reflect both cognitive and non-cognitive abilities.[5] In order to obtain a scaling factor for non-cognitive abilities—and an additional estimate of the scaling factor for cognitive

[5] The partial regression coefficients from regressing an individual's GPA at age 16 on his cognitive and non-cognitive ability at the draft, show that both cognitive and non-cognitive skills are highly, and independently, correlated with the GPA.

abilities—we regress boys' and girls' GPA scores on their brothers' enlistment evaluations. This gives us $\hat{\rho}_{18,16}^{\,brother}$ and $\hat{\rho}_{18,16}^{\,brother-sister}$, respectively.

As can be seen in the third column of *Table A.1*, male students' GPA-results are strongly related to their brother's cognitive and non-cognitive ability evaluations at the enlistment.[6] The same is true for female students even though the point estimates differ slightly. By comparing the relative size of point estimates of the importance of brothers' cognitive abilities for the GPA, we find the correlation in cognitive abilities between brothers and sisters to be 0.92 (0.310/0.337) relative to that between brothers. This is close to identical to the relative sibling correlations in cognitive abilities obtained from the estimates in columns one and two. Similarly, the relative sibling correlation in non-cognitive abilities from columns three and four is found to be 0.93 (0.113/0.122).[7]

Based on these estimates, we assume that the scaling factor (the brother-sister correlation relative to the brother-brother correlation) is 0.92 for cognitive abilities and 0.93 for non-cognitive abilities. Using these estimates of the relative gender correlations, we calculate the brother-sister correlation at age 18 in the first-stage relation (6) for both cognitive and non-cognitive abilities. We then predict the cognitive and non-cognitive abilities for both fathers and mothers using the abilities of paternal and maternal uncles with enlistment records.[8]

When estimating the intergenerational correlation of both fathers and mothers on their sons, we require that enlistment records are available for both paternal and maternal uncles. This reduces the sample size to around 25,000 sons. In the first column of *Table 5*, we estimate the father-son correlation in cognitive ability using the fathers' predicted ability. Since we are using predicted values, attenuation bias due to

[6] We include the brother's cognitive and non-cognitive ability measures simultaneously, since GPA reflects both types of abilities. However, the relative correlations for brother-brother and brother-sister are more or less unchanged when entering each ability separately.

[7] There is no consensus regarding the relative correlation in personality traits between same-sex and different-sex siblings. For example, Eaves et al (1999) report opposite-sex correlations in personality traits to vary substantially relative to brother correlations. The relative correlations are 0.61 (*Psychoticism*), 0.94 (*Extraversion*), 1.05 (*Lie*), and 1.25 (*Neuroticism*). Lake et al (2000) find the opposite-sex correlation in *Neuroticism* to be 0.89 relative to the brother correlation in Australia, but 1.25 in the US. This wide range of estimates possibly reflects the fact these studies include a relatively low number of individuals and that the samples are non-representative of the general population.

[8] In the specifications where we include both fathers' and mothers' abilities, column three and six in Table 5, we also need to derive a scaling factor for the mother's brothers-in-law correlation. It can be noted that this scaling factor also becomes 0.92 and 0.93 for cognitive and non-cognitive abilities, respectively.

measurement error is corrected for. The estimated father-son correlation is 0.51, where the slight difference to the IV estimates in the previous section is due to the somewhat different sample. In column two, we see that the estimated mother-son correlation in cognitive ability is even higher, 0.59. The third column shows that the partial correlations for fathers' and mothers' abilities are both somewhat reduced when entered jointly into the regression, indicating some degree of positive assortative mating. Consistent with the bivariate results, the partial correlation between mothers and sons is higher (0.43) than the partial father-son correlation (0.34) when both parents' abilities are entered jointly.

Table 5. Father-son and mother-son correlations

Dependent variable:	Son's cognitive ability	Son's cognitive ability	Son's cognitive ability	Son's non-cognitive ability	Son's non-cognitive ability	Son's non-cognitive ability
Independent variable:						
Father's cognitive ability	0.508	.	0.339	.	.	.
	(0.014)	.	(0.017)	.	.	.
Mother's cognitive ability	.	0.587	0.430	.	.	.
	.	(0.015)	(0.019)	.	.	.
Father's non-cognitive ability	.	.	.	0.459	.	0.333
	.	.	.	(0.021)	.	(0.027)
Mother's non-cognitive ability	.	.	.	.	0.463	0.292
	.	.	.	.	(0.023)	(0.030)
n	25,100	25,100	25,100	25,100	25,100	25,100

Notes: The regressions also include an intercept. The ability measures have been standardized by year of draft. The father's abilities have been predicted by using the father's brother's abilities. The mother's abilities have been predicted by using the mother's brother's abilities, and the relative sibling correlations in Table A1. Standard errors adjusted for clustering on the father are in parentheses.

For non-cognitive abilities, the mother and father correlations are more similar. The father-son correlation in non-cognitive abilities is 0.46 (column four), the same as the mother-son correlation in column five. When entered jointly, the father-son correlation is 0.33 whereas the mother-son correlation is 0.29.

We can sum up the results in this section by concluding that mother-son correlations in cognitive abilities are higher than father-son correlations, while the mother-son and father-son correlations are similar for non-cognitive abilities. Although there is a limited amount of research on intergenerational ability correlations that differentiates between the influence of paternal and maternal abilities, these findings for cognitive abilities are broadly consistent with previous findings. Using a relatively small but representative sample from the German Socio-Economic Panel, Anger and Heineck (2009) and Anger (2010) find no clear pattern regarding size of the relative correlations between children and their respective parents. For example, they find mother-son correlations in cognitive speed to be higher than father-son correlations but when using word fluency as an alternative indicator of cognitive ability the pattern is reversed. A meta-study by Bouchard and McGue (1981) does not report any noteworthy gender differences in cognitive ability correlations between parents and children. Regarding non-cognitive abilities, the meta-study by Loehlin (2005) reports mother-child correlations in personality traits and attitudes to be somewhat higher than father-child correlations.

5.2 Parental abilities and long run outcomes of children

In the previous section we derived predicted values for both parents' abilities and estimated the intergenerational correlations between parents and their sons. In this section, we use these predicted abilities to estimate the relation between parental abilities and the educational and labor market outcomes among their children; i.e. both sons and daughters. In particular, we are interested in the influence of parental abilities on their children's compulsory school achievement, total years of education, annual earnings, and labor force participation. These estimates will capture a composite effect of the influence from of two components. The first is the direct ability payoff on the skills transmitted from parents to children. The second is the indirect effects of parental abilities on their children's labor market prospects or educational success, including factors such as residential choice, help with homework, professional networks and so on.

We perform this analysis separately for sons and daughters, thus allowing mothers' and fathers' abilities to have different impact on male and female offspring. Such differences can be due to either a gender specific transmission of parental abilities to their children or that the same ability has different payoffs for men and women. While there is evidence that the same ability can have different payoffs for women and men,[1] much less is known concerning the relative importance of paternal and maternal ability transmission.[2] Our findings in the previous section indicate that the mother-son correlation in cognitive ability is stronger than father-son correlation but unfortunately our data does not allow us to perform the same analysis for daughters. Educational and labor market outcomes are, however, available both for sons and daughters.

The data restrictions are somewhat different in this part of the analysis. We only require the children to have a paternal uncle and a maternal uncle with a valid enlistment record. We can therefore predict cognitive and non-cognitive abilities also for fathers and mothers born before 1950. Further, in order for these long-term outcomes to be representative for life success, we require the labor market and educational outcomes to be observed when sons and daughters are between 30 and 40 years old.

In *Table 6* we present the results for sons (Panel A) and for daughters (Panel B). In the first column we see that both parents' cognitive abilities are strongly associated with child achievement in terms of the grade point average (GPA) at age 16. A one standard deviation increase in either parent's cognitive abilities is associated with about one third of a standard deviation increase in GPA. There is also a weaker relation between parental non-cognitive abilities and GPA. We find no obvious gender differences regarding the relation between parental abilities and school achievement.

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[1] Heckman et al. (2006) provides an analysis of gender specific payoffs of cognitive and non-cognitive abilities. Further, Mueller and Plug (2006) find that women with an antagonistic personality are at a substantial earnings disadvantage compared to women who are more agreeable. For men, this pattern is reversed. Nyhus and Pons (2005) report similar findings.

[2] There is a large literature discussing the relative impact of fathers' and mothers' educational attainment on child outcomes. The methodological challenge of this literature is to distinguish between the effects of the parents' abilities from the effects of the educational attainment, *per se* (e.g. Behrman and Rosenzweig, 2002; Currie and Moretti, 2003; Plug, 2004, Black et al, 2005).

Table 6. Intergenerational transmission of life success

	Achievement in 9th grade	Years of schooling	Earnings	P(employed)	ln(Earnings)
			Panel A. Men		
Father's cognitive ability	0.323	0.445	-788	-0.025	0.021
	(0.029)	(0.101)	(5934)	(0.016)	(0.013)
Father's non-cognitive ability	0.068	0.223	25930	0.044	0.042
	(0.041)	(0.143)	(8826)	(0.022)	(0.019)
Mother's cognitive ability	0.376	0.668	7088	0.009	0.015
	(0.031)	(0.109)	(7069)	(0.017)	(0.014)
Mother's non-cognitive ability	0.024	0.200	23440	0.041	0.041
	(0.046)	(0.158)	(9945)	(0.024)	(0.021)
n	13,846	9,288	9,288	9,288	7,272
			Panel B. Women		
Father's cognitive ability	0.332	0.572	7617	-0.003	0.050
	(0.029)	(0.105)	(4613)	(0.019)	(0.015)
Father's non-cognitive ability	0.078	0.281	24638	0.073	0.033
	(0.042)	(0.154)	(6815)	(0.027)	(0.022)
Mother's cognitive ability	0.306	0.347	993	-0.025	0.038
	(0.031)	(0.118)	(5047)	(0.020)	(0.016)
Mother's non-cognitive ability	0.086	0.279	7239	0.053	-0.008
	(0.046)	(0.173)	(7293)	(0.030)	(0.023)
n	13,275	8,538	8,538	8,538	4,970

Notes: The regressions also include an intercept. The ability measures have been standardized. The father's abilities have been predicted by using the father's brother's abilities. The mother's abilities have been predicted by using the mother's brother's abilities, and the relative sibling correlations in Table A1. Earnings are measured in SEK. P(Employed) is the probability to earn more than the minimum wage on a yearly basis (SEK 135,000), and is estimated using a linear probability model. ln(earnings) is restricted to individuals who earn more than the minimum wage on a yearly basis (SEK 135,000). The schooling and earnings estimates are restricted to individuals aged 30-40, and the models control for fixed effects for year of birth. Standard errors adjusted for clustering on the father are in parentheses.

Column two presents the relation between years of schooling and parental abilities. Again, parental cognitive abilities are relatively important compared to parental non-cognitive abilities, but the difference is less pronounced than for GPA. The association between parental cognitive abilities and educational outcomes is strong; having both a mother and a father with a one standard deviation higher cognitive ability is associated with about one additional year of schooling. We also find some interesting gender differences. A one standard deviation increase in mothers' cognitive abilities is associated with 0.67 additional years of schooling among sons but only 0.35 additional years among daughters; the difference being significant. Mothers' cognitive abilities are thus to be relatively more important for sons than for daughters. Our point estimates also suggest parental non-cognitive abilities to be slightly more important for daughters than for sons, even if this difference is not statistically significant.

In the third column of *Table 6*, we find that parental non-cognitive abilities are much more important for sons' annual earnings than parental cognitive abilities. A one standard deviation increase in fathers' non-cognitive abilities is associated with approximately 26,000 SEK higher annual earnings for their sons. As average earnings are 253,000 SEK, this is substantial. The point estimate for cognitive abilities is small, negative and far from statistically significant. The estimate for mothers' non-cognitive abilities is about the same magnitude as for fathers, while the association between earnings and maternal cognitive abilities is positive but not statistically significant. In the lower panel, we see that for daughters the point estimate for fathers' non-cognitive abilities is of the same magnitude as for sons' earnings. As daughters earn less than sons on average, 160,000 SEK, this is a strong association. Fathers' cognitive abilities have a weaker and only marginally statistically significant association with daughters' earnings. The association between maternal non-cognitive and—in particular—cognitive abilities and daughters' earnings is also weak and not statistically significant.

The fourth column shows that one of the reasons why non-cognitive abilities are so strongly related to earnings is because they are a predictor of labor force participation. This relation is strong for both sons and daughters, and from both fathers' and mothers' non-cognitive abilities. Among sons, a one standard deviation increase in either fathers' or mothers' non-cognitive abilities is associated with about a four percentage point higher probability of being employed. Among daughters, a one standard deviation increase in fathers' non-cognitive abilities increases the probability that daughters participate in the labor force by 7.3 percentage points. The corresponding figure for mothers is 5.3 percentage points. The relation between parental cognitive abilities and labor force participation is on the other hand weak.

In the final column, we estimate the relation between log earnings and parental abilities. This means that we only estimate these relations among sons and daughters with positive earnings. For sons, the relation between log income and the cognitive ability of their fathers and mothers is 0.21 and 0.15, respectively. The estimated correlation between sons' log income and parental non-cognitive abilities suggests an even stronger relation—0.042 for fathers and 0.041 for mothers—even if the difference is not significant. For daughters, on the other hand, parental cognitive abilities are more important than their non-cognitive abilities. The correlation between the log of daughters earnings the cognitive ability of their fathers and mothers is 0.050 and 0.038, respectively. The relation between log income among daughters and their parents' non-cognitive abilities is on the other hand weak; close to zero for mothers' abilities and non-significant for fathers'.

In sum, we find that both parents' cognitive and non-cognitive abilities are important for educational and labor market outcomes. Parental cognitive abilities are relatively important for schooling outcomes, while parental non-cognitive abilities are particularly important for labor force participation. These results are fully in line with the findings that Lindqvist and Vestman (2011) report for men, using their own cognitive and non-cognitive abilities. Our results thus suggest that these findings for men can be generalized to women. The most noteworthy gender difference is that among employed individuals, parental non-cognitive abilities appear relatively important for male earnings while parental cognitive abilities are relatively important for female earnings.

6 Selection issues

In this section we verify that our results are not sensitive to selection issues induced by the available sampling frame. Up until the late 1990's essentially all Swedish men underwent the whole enlistment procedure, thereby making selection an irrelevant problem of this study. However, as mentioned in section two, the demand for enlisted men went down thereafter and all men are no longer being enlisted. Even though no official documentation suggests that being enlisted is anything but random, this raises some concerns regarding the representativity of the sample. In order to investigate whether such potential selection biases our results we re-estimate the instrumented father-son correlations for different sub-samples. These estimates are reported in appendix *Table A.2*.

The first column includes the whole sample and shows, as before, a father-son correlation in cognitive abilities of 0.48. In the next column, we restrict the sample to sons being born prior to 1983, i.e. during a period for which selection is not a problem. The estimate for the restricted sample is slightly higher than in the full sample, 0.49. Columns three and four repeats this exercise for non-cognitive abilities and again we find the correlation in the full sample to be slightly lower than in the pre-1983 sample; 0.43 compared to 0.45. Thus, selection problems appear to be small even though they might cause us to slightly underestimate the true intergenerational ability correlations.

In the last two columns of *Table A.2*, we regress the sons' GPA at age 16 on their fathers' instrumented cognitive and non-cognitive abilities. In column five, this is done only for sons who were enlisted while column six includes both conscripts and non-conscripts. There is no difference in the estimated coefficients for fathers' cognitive abilities between the samples, but the estimate for non-cognitive abilities is somewhat higher for the full sample, 0.30, compared to the conscripts -only sample, 0.27. Even though there is some evidence that we underestimate the intergenerational correlations in the full sample, we can thus conclude that selection is a minor issue.

The main message of this paper is that previous studies have underestimated the true intergenerational ability correlations, in particular for non-cognitive abilities. The analysis in this section shows that the selection problems in our data are small and, if anything, makes us underestimate the true correlations slightly.

7 Conclusions

This paper makes several contributions to the literature on the intergenerational transmission of cognitive and non-cognitive abilities. The main methodological contribution is that we demonstrate that ability evaluations of a father's brother (a child's uncle) can be used as an instruments correcting for measurement error in the father's abilities. We find evidence of measurement error bias in both ability dimensions and once this bias is corrected for, the intergenerational transmission of non-cognitive abilities is almost as high as that of cognitive skills. This is in contrast to previous research indicating that the transmission of non-cognitive abilities between generations is substantially lower than that of cognitive abilities. That the measurement error is more severe when evaluating non-cognitive than cognitive abilities is unlikely to be a unique feature of our data.

As a second methodological contribution, we combine the ability evaluations of maternal uncles with gender specific estimates of sibling ability correlations to derive predicted abilities for mothers. Using these, we find a substantial intergenerational correlation between sons' and both parents' abilities. For cognitive abilities, the mother-son correlation is stronger than the father-son correlation while there is no substantive difference between parents for non-cognitive abilities.

We further find a strong relation between both parents' cognitive and non-cognitive abilities and several educational and labor market outcomes for both sons and daughters. Parental cognitive abilities are relatively important for schooling outcomes, while parental non-cognitive abilities are particularly important for labor force participation among both men and women. These results suggest that previous findings regarding the importance of cognitive and non-cognitive abilities for men (Lindqvist and Vestman, 2011) generalize to women.

There is a general perception that non-cognitive abilities are relatively malleable, and hence a more appropriate target for policy interventions than cognitive abilities (Carneiro and Heckman, 2003; Knudsen et al, 2006; Cunha and Heckman, 2008). Our finding that families play an important role in shaping both cognitive and non-cognitive abilities raises some doubts concerning this view. Before drawing any conclusion on these matters, however, more research is clearly needed. This study presents a descriptive analysis of intergenerational correlations and does not attempt to disentangle the mechanisms through which these correlations arise.[3] A more detailed understanding of these mechanisms may very well end up showing that the targeting of non-cognitive abilities is indeed the appropriate policy.

[3] These mechanisms are likely to include complex interactions between genetic and environmental factors. A recent study by Cesarini (2009) uses mono-zygotic and dizygotic twins, as well as different types of siblings to estimate the family component of—among other things—cognitive and non-cognitive abilities. Cunha and Heckman (2007) provide a perspective on the nature-nurture debate. Using a large sample of adopted children, Björklund et al (2006) find that pre- and postbirth parental characteristics interact when influencing child outcomes.

Our study suggests that successful policies may improve productivity not just for the current, but also for future generations. Apart from a better understanding of the mechanisms behind the intergenerational ability correlations, future research should therefore focus on analyzing how educational and other social interventions affect non-cognitive and cognitive abilities. As our data is very rich and covers a long time period, these issues are high on our research agenda.

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Appendix A: Tables

Table A.1. Sibling correlations

Dependent variable:	Brother's cognitive ability at 13	Sister's cognitive ability at 13	Brother's GPA at 16	Sister's GPA at 16
Independent variable:				
Brother's cognitive ability at 18	0.421	0.379	0.337	0.310
	(0.010)	(0.010)	(0.002)	(0.002)
Brother's non-cognitive ability at 18	.	.	0.122	0.113
	.	.	(0.002)	(0.002)
Statistics:				
Relative cognitive correlation	0.918		0.920	
	(0.032)		(0.007)	
Relative non-cognitive correlation	.		0.929	
	.		(0.020)	
n	9,179	8,882	292,073	278,474

Notes: All estimates come from separate regressions. The ability measures have been standardized. The sister's abilities have been weighted to reflect the brother's ability distribution. The standard error for the relative sibling correlation has been calculated by using the Delta method.

Table A.2. Intergenerational correlations, addressing sample selection of sons

Dependent variable:	Son's cognitive	Son's cognitive	Son's non-cognitive	Son's non-cognitive	Son's GPA at 16	Son's GPA at 16
Independent variable:						
Father's cognitive ability	0.479	0.491	.	.	0.327	0.327
	(0.009)	(0.013)	.	.	(0.014)	(0.012)
Father's non-cognitive ability	.	.	0.425	0.447	0.265	0.299
	.	.	(0.015)	(0.020)	(0.020)	(0.017)
Son's year of birth:						
Before 1988	X		X		X	X
Before 1983		X		X		
Son's draft status						
Drafted	X	X	X	X	X	X
Not drafted						X
n	50,214	28,369	50,214	28,369	48,808	72,018

Notes: The ability measures have been standardized by year of draft. The GPA at age 16 has been standardized by year of completion. The father's ability is instrument by the uncle's ability, and the sample is restricted to sons who have at least one uncle. Standard errors adjusted for clustering on the father are in parentheses.

Table A.3. Intergenerational correlations, addressing cheating, floor and ceiling effects

Dependent variable:	Son's ability	Son's ability	Son's ability	Son's ability
Independent variable:		Cognitive ability		
Father's ability	0.479	0.497	0.489	0.511
	(0.009)	(0.010)	(0.011)	(0.013)
		Non-cognitive ability		
Father's ability	0.425	0.452	0.448	0.482
	(0.015)	(0.017)	(0.017)	(0.020)
Trimming of fathers ability:				
Removing lower tail		X		X
Removing upper tail			X	X
n	50,214	48,876	48,167	46,829

Notes: The ability measures have been standardized by year of draft. The father's ability is instrument by the uncle's ability, and the sample is restricted to sons who have at least one uncle. The son's ability corresponds to the father's ability. Each estimate comes from a separate regression. Standard errors adjusted for clustering on the father are in parentheses.

Appendix B: Modelling the variation in the instrument

In section 3 and 4.2 we discuss whether the local average treatment effect captured by the uncle instrument reflects is representative of the average treatment effect captured by the OLS. In this appendix, we show that if the IV estimates using the uncle instrument and the father's earlier ability instrument give the same results, both instruments capture the same parameter as the OLS. We here abstract from the measurement error.

The uncle instrument

Consider that the production of the underlying latent ability is a linear function of genetic (G) and environmental factors (E), where some parts are shared (S) between brothers and some part are not shared (NS). Specifically, we characterize the latent ability of individual *i* belonging to family *j* as:

$$Y_j^{*i} = Y_{jS}^{*iG} + Y_{jNS}^{*iG} + Y_{jS}^{*iE} + Y_{jS}^{*iE},$$

where there are no complementarities across genetic and environmental components or between shared and non-shared components. If we further assume that the intergenerational transmission is the same for shared (non-shared) genetic (environmental) factors we can write the model of intergenerational transmission as:

$$Y_j^{*son} = \alpha + \beta Y_j^{*father} + \varepsilon_j = \alpha + \beta^G Y_{j,S}^{*father,G} + \beta^G Y_{j,NS}^{*father,G} + \beta^E Y_{j,S}^{*father,E} + \beta^E Y_{j,NS}^{*father,E} + \varepsilon_j,$$

where:

$$p\lim \hat{\beta}_{OLS} = \beta^G \frac{V(Y_{j,S}^{*father,G}) + V(Y_{j,NS}^{*father,G})}{V(Y_j^{*father})} + \beta^E \frac{V(Y_{j,S}^{*father,E}) + V(Y_{j,NS}^{*father,E})}{V(Y_j^{*father})}.$$

In effect, the transmission of abilities over generations will be a sum of the intergenerational transmission of the genetic and the environmental component weighted by the relative share of the variation in fathers' abilities coming from these two sources.

The uncle instrument, $Z_j^{*i,uncle}$, captures only the variation in the determinants of the latent ability that is shared between brothers; that is $Z_j^{*i,uncle} = Y_{jS}^{*iG} + Y_{jS}^{*iE}$. Using the uncle instrument thus yields:

$$p\lim \hat{\beta}_{IV}^{uncle} = \beta^G \frac{V(Y_{j,S}^{*father,G})}{V(Y_{j,S}^{*father,G}) + V(Y_{j,S}^{*father,E})} + \beta^E \frac{V(Y_{j,S}^{*father,E})}{V(Y_{j,S}^{*father,G}) + V(Y_{j,S}^{*father,E})}.$$

We see here that for the local average treatment effect—when using the uncle instrument—to capture the same effect as the OLS we must (i) either have that the shared parts of brother's abilities have the same relative genetic and environmental determinants as the non-shared parts:

$$\frac{V(Y_{j,S}^{*\,father,G})}{V(Y_{j,S}^{*\,father,G})+V(Y_{j,S}^{*\,father,E})}=\frac{V(Y_{j,S}^{*\,father,G})+V(Y_{j,NS}^{*\,father,G})}{V(Y_{j}^{*\,father})},$$

or (ii) that the intergenerational transmission is the same for the genetic and environmental components, $\beta^G=\beta^E$.

The fathers' early ability instrument

When we instead use fathers' own ability at age 13 as an instrument, we model the underlying latent ability as having three separate determinants: a genetic part; a part capturing all environmental influences on ability up to age 13; an part capturing additional environmental influences between age 13 and 18. We characterize the production function for abilities as a linear function without complementarities between the parts as:

$$Y_j^{*i}=Y_j^{*iG}+Y_{j13}^{*iE}+Y_{j13-18}^{*iE}.$$

If we assume that the intergenerational transmission of the environmental factors up to age 13 and between age 13 and 18 is the same, β^E, we have that:

$$p\lim\hat{\beta}_{OLS}=\beta^G\frac{V(Y_j^{*\,father,G})}{V(Y_j^{*\,father})}+\beta^E\frac{V(Y_{j,13}^{*\,father,E})+V(Y_{j,13-18}^{*\,father,E})}{V(Y_j^{*\,father})}.$$

The father's early ability instrument, $Z_j^{*i,13}$, utilizes a measurement of the father's ability at age 13. This instrument therefore captures all genetically determinants of the father's ability and all environmental determinants up to age 13; that is $Z_j^{*i,13}=Y_j^{*iG}+Y_{j13}^{*iE}$. Using the father's own ability as an instrument gives us:

$$p\lim\hat{\beta}_{IV}^{13}=\beta^G\frac{V(Y_j^{*\,father,G})}{V(Y_j^{*\,father,G})+V(Y_{j,13}^{*\,father,E})}+\beta^E\frac{V(Y_{j,13}^{*\,father,E})}{V(Y_j^{*\,father,G})+V(Y_{j,13}^{*\,father,E})}.$$

Now, for the OLS and the IV—when using the father's early ability instrument—to capture the same effect we either need (i) the environmental influence between ages 14 and 18 on the abilities measured at enlistment to be negligible, $V(Y_{j,14-18}^{*\,father,E})=0$, or (ii) the intergenerational transmission of the genetic and environmental components to be the same, $\beta^{G} = \beta^{E}$.

When does the IV represent the OLS?

The above discussion shows that if the IV estimates when using the uncle instrument and the father's own ability at age 13 are identical, the IV captures the same parameter as OLS. The reason is that, in our setting, the two instruments will only generate the same estimates under two different circumstances. First, this will occur if the intergenerational transmission of genetic and environmental factors is identical $\beta^{G} = \beta^{E}$. The second possibility for this to happen is that the environmental influence between ages 14 and 18 on the abilities measured at enlistment is negligible and the shared parts of brother's abilities have the same relative determinants as the non-shared parts. In either case, we have shown that the local average treatment effect when using either instrument represents the average treatment effect captured by the OLS.