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Do smart parents raise smart children? The intergenerational transmission of cognitive abilities

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Abstract Complementing prior research on income and educational mobility, we examine the intergenerational transmission of cognitive abilities. We find that individuals' cognitive skills are positively related to their parents' abilities, despite controlling for educational attainment and family background. Differentiating between mothers' and fathers' IQ transmission, we find different effects on the cognition of sons and daughters. Cognitive skills that are based on past learning are more strongly transmitted between generations than skills that are related to innate abilities. Our findings are not compatible with a pure genetic model but rather point to the importance of parental investments for children's cognitive outcomes.

Keywords Cognitive abilities · Intergenerational IQ transmission · Skill formation

JEL Classification J10 · J24 · I20

1 Introduction

There is abundant evidence that societal inequality is related to the transmission of economic status between parents and children. The issues typically ad-

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dressed in this type of research are (a) income mobility (e.g., Solon 2002; Corak 2006; Oreopoulos 2003; Nicoletti and Ermisch 2007), and (b) educational attainment (e.g., Hertz et al. 2007; Heineck and Riphahn 2009). While it is a well-known fact that economic status is highly correlated across generations "..., we still know little about which factors are responsible for the strong correlation" (Liu and Zeng 2009: p. 76). However, understanding the underlying cause of the intergenerational transmission is crucial to develop useful redistributive policies. Complementing the research on income and educational mobility, there is a small economic literature that examines whether it is the transmission of cognitive abilities that drives intergenerational correlation patterns (Agee and Crocker 2002; Bowles and Gintis 2002; Blanden et al. 2007; Black et al. 2009). It seems plausible that smarter parents raise smarter children, but the intergenerational transmission of cognitive abilities is still an under-researched topic in the field of economics. Cognitive abilities play a substantial role for education (Heckman and Vytlacil 2001) and income (Hanushek and Woessmann 2008) so that a strong intergenerational transmission of cognition could translate into higher persistence in educational and earnings inequalities. We therefore investigate the determinants of cognitive abilities and compare the influence of parents' abilities, other family background variables, and education.

Our analysis complements the two recent Scandinavian studies by Black et al. (2009) for Norway and Björklund et al. (2009) for Sweden, which are based on large-scale nationally representative datasets but restricted to intergenerational IQ elasticities between fathers and sons. In our data from the German Socio-Economic Panel Study (SOEP), we have both men *and* women, which allows investigating possible gender differences in IQ transmission and computing overall transmission effects from both parents. Our analysis is hence the first to examine separate transmission effects of fathers' *and* mothers' cognitive skills on their adult sons' *and* daughters' abilities using a representative dataset.

Second, we examine whether intergenerational IQ transmission behaves differently according to the type of cognitive ability: Our data enable us to employ measures from two ultrashort IQ tests. In particular, we compare the association between parents' and their children's fluid intelligence (cognitive speed) and crystallized intelligence (verbal fluency). While the former is related to individuals' innate abilities, the latter is based on learning (Cattell 1987). The use of objective ability measures has the advantage of a lower risk of measurement error, which may affect intergenerational analyses on income and education, as earnings and schooling information is mostly self-reported.[1]

[1] Bowles and Gintis (2002: 12) note that "for the commonly used Armed Forces Qualification Test (AFQT), for example—a test used to predict vocational success that is often used as a measure of cognitive skills—the correlation between two test scores taken on successive days by the same person is likely to be higher than the correlation between the same person's reported years of schooling or income on two successive days."

Finally, our rich dataset enables us to control for a large number of family background and childhood variables so that we can, to some extent, account for early life stage conditions, which are critical for individuals' cognitive development (Shonkoff and Phillips 2000; WHO 2007; Ermisch 2008).

The literature considers two main channels for the transmission of cognitive abilities between generations. On the one hand, cognitive skills may be transmitted by the inheritance of genes, or "nature" (e.g., Plomin et al. 1994), as parents pass their genetic endowment on to their biological children. Cognitive skills may, on the other hand, be transmitted by a positive productivity effect of parental education, or "nurture" (e.g., Sacerdote 2002; Plug and Vijverberg 2003; Ermisch 2008).[2] Higher parental investment by more able parents could lead to better health and education of their offspring, which may translate into higher cognitive skills. Findings from recent research on income and educational mobility suggest the importance of both nature and nurture (e.g., Björklund et al. 2007). As our data do not allow to clearly identify separate effects, we tentatively approximate the nature vs. nurture elements by comparing the transmission of the two types of cognitive abilities, which vary in their degree of dependence on innate abilities. We also refer to recent research by Cunha and Heckman (2007), who lay out the theoretical framework for individuals' ability development, the "technology of skill formation".[3] They point out that the assumed separability of nature and nurture is obsolete, as the mechanisms interact in more complex ways.[4]

Our results indicate a significant transmission of both types of cognitive abilities from parents to their children. An increase in the age-standardized cognitive ability test score of parents by one point is associated with a 0.45-point increase in coding speed and 0.5-point increase in word fluency of their children. That is, although we control for more individual and family background variables, the IQ transmission in our study is stronger than the correlations found by Black et al. (2009) for Norway and by Björklund et al. (2009) for Sweden, where a one-point increase in father's ability is associated

[2]We do not neglect that the individual's environments, including peers, grandparents, and neighborhood, may also play a role in the development of cognitive and non-cognitive abilities. However, it is plausible to assume that the two channels mentioned mainly affect the critical early life-cycle cognitive development.

[3]According to this framework, the technology varies with the periods of development. In the first stages, the primary care givers (in most cases the individual's parents) form the environment in which initial conditions, i.e., the individual's abilities endowment, can thrive. In later stages, there is interaction with parents, the larger family, with friends and in school that affects individuals' abilities and how these evolve.

[4]Research in neuroscience however emphasizes that genes are the predominant determinant of IQ transmission (e.g., Toga and Thompson 2005).

with an increase in the son's ability by about one third of a point. Our results point to maternal effects inasmuch as mothers' skills are more important than fathers' test scores for sons and daughters. In addition, when differentiating between males and females, we find evidence for an own-gender effect with respect to fluid intelligence, as fathers' coding speed is correlated with the abilities of their sons only, and mothers' speed of cognition is more strongly associated with the abilities of their daughters. Furthermore, we find a stronger intergenerational transmission of word fluency, which is based on past experience, than of coding speed. Altogether, our findings are not compatible with a pure genetic model but rather point to the importance of parental investments for the cognitive outcomes of children.

2 Literature review

So far, the main part of the economic literature on cognitive abilities concentrates on the determination of earnings. A large number of studies reveal substantial returns to cognition, providing evidence for a positive relationship between abilities and earnings (e.g., Cameron and Heckman 1993; Green and Riddell 2003; Bronars and Oettinger 2006; Anger and Heineck 2010), which also holds when taking into account individuals' background characteristics and non-cognitive skills (Heckman et al. 2006; Mueller and Plug 2006; Cebi 2007; Heineck and Anger 2010). Hanushek and Woessmann (2008) provide a broad overview of the literature on cognitive skills, emphasizing the importance of a population's cognitive abilities for economic growth.

While the number of studies on returns to cognitive abilities is growing, there is far less economic research on the determinants of cognition and on intergenerational mobility with respect to cognitive abilities. As outlined above, intergenerational research in economics so far concentrates heavily on the analysis of income mobility and the transmission of education.[5] The topic is however not new in psychology: Bouchard and McGue (1981) review psychological studies on correlations of cognitive abilities within family groupings. They report that "... the higher the proportion of genes two family

[5] Another strand of literature combines the analysis of income mobility with cognitive skills. Bowles and Gintis (2002) identify cognitive abilities as one of the causal channels of intergenerational transmission of economic status. Blanden et al. (2007) show that parental income is strongly associated with children's cognitive abilities, which in turn significantly affect their earnings later in life. By comparing earnings correlations of parents with biological children and those with adopted children, Liu and Zeng (2009) reveal the importance of genetic ability for the intergenerational transmission of earnings in the USA.

members have in common the higher the average correlation between their IQ's" (Bouchard and McGue 1981: p. 1055) and also point to considerable environmental effects on the formation of cognitive skills. Furthermore, they did not find evidence for sex-role effects or maternal effects in their reviewed studies. The IQ correlation between parents and their children usually found in the literature ranges between 0.42 and 0.72 (Bouchard and McGue 1981; Plomin et al. 2000). However, the datasets used by many (mostly psychological) studies are based on a small number of observations and/or lack representativeness. As one of the few economic studies, Agee and Crocker (2002) analyze the importance of parents' discount rates and mean parental IQ for their child's cognitive development using US data on 256 children in the first or second grade. They control for a number of the child's background variables and find that a one-point increase in parental IQ is associated with an increase in the child's verbal IQ by one quarter of a point and with an increase in the child's full-scale IQ by one third.

A study that is closely related to the literature on intergenerational IQ transmission is carried out by Brown et al. (2009) who use the British National Child Development Study to investigate the link between parental abilities in literacy and numeracy as a child and their children's performance in reading and mathematics. They find evidence for the relationship between parents' performance in mathematics and an even stronger link between reading skills during their childhood and the performance of their children. Furthermore, their results support the importance of parenting style for the transmission of literacy skills, while genetic effects seem to be the driving force behind the transmission of numeracy skills. However, as literacy and numeracy are direct outcomes of schooling, it may be preferable to use IQ test scores as a more general measure of cognitive abilities.

Two recent studies by Black et al. (2009) and Björklund et al. (2009) are exceptional inasmuch as they investigate the relationship between cognitive abilities of fathers and sons using IQ test scores from large-scale, nationally representative datasets from Norway and Sweden. Black et al. (2009) employ composite IQ test scores based on three subtests conducted at age 18 and find a strong intergenerational transmission of IQ scores for fathers and their sons: A one-point increase in the father's ability is associated with an increase in the son's ability by about one third of a point. Björklund et al. (2009) find similar intergenerational correlations in IQ of about one third and complement their analysis with sibling correlations. Their estimates for brothers are close to one half, which leads them to conclude that 50% of the variation in IQ can be attributed to family and community background factors.

Beyond the importance of using representative data, it is relevant to analyze data that represents the whole population, i.e., both fathers and mothers and their sons and daughters. We contribute to the small economic literature on the intergenerational transmission of cognitive skills by providing evidence on both men and women and investigate gender differences in the transmission of cognitive skills. To the best of our knowledge, we are the first to use a representative dataset to examine separate transmission effects of fathers' and mothers' cognitive skills on their adult sons' and daughters' abilities. In contrast to many other studies that use cognitive ability test scores of children who are still in school (e.g., Agee and Crocker 2002; Heckman et al. 2006), we have the advantage of observing adult children who completed their schooling degree. Therefore, contemporaneous feedback effects between cognitive skills and education can be excluded. The data we use furthermore allows for the inclusion of family background and childhood characteristics and for the differentiation between two types of abilities, fluid and crystallized intelligence.

3 Data and methodology

Our data are drawn from the German SOEP. The SOEP is a representative longitudinal micro database that provides a wide range of socioeconomic information on private households and individuals in Germany since 1984 (for more detailed information on the SOEP, see Wagner et al. 2007). The wave 2006 provides information on cognitive abilities for respondents who were surveyed with a computer-assisted personal interview (CAPI): Out of 22,665 persons who were interviewed in 2006, about one third was CAPI respondents and hence asked to participate in the ultrashort IQ tests. Out of these potential test participants, 22% refused to take either of the tests, which leads to a total of 5,790 participants. In order to be able to use the test scores of the word fluency test (outlined below), we excluded 328 non-Germans from our study, since individuals with migration background may have insufficient language skills and may therefore be disadvantaged compared to native speakers when taking the test. Furthermore, we excluded 129 respondents who are still in school in order to avoid feedback effects between cognitive skills and education. We further dropped 12 observations with zero test scores in both tests from our sample because we interpret a value of zero scores as refusal. This results in a sample of 5,321 respondents with valid information on either of the two IQ tests.

Within this sample of test takers, we then identified parent–child pairs in order to link test scores across generations. This however leads to the most severe reduction in sample size, as we had to restrict the sample to respondents for whom we have parental information from the parents' interviews.[6] For only

[6]Matching parents' information to their children is possible for (grown up) children who lived at some point of time during the survey years (1984–2006) in the same household as the parents. Only then are mother and father identifiers available. This requirement naturally excludes relatively old respondents from our sample, since these were less likely to be observed in the same household as their parents during the survey years (54% of the individuals in our sample live in the same household as their parents: 49% of females and 57% of males).

715 test-taking participants could either the mother or the father be identified as active SOEP respondent in any year.[7] Moreover, our analysis requires that parents, too, were SOEP respondents in 2006 (622 participants), with a CAPI interview (568 participants), and participated in the cognitive ability tests (520 participants). Dropping cases with missing information on educational or family background and on childhood environment reduces the sample by another 16 observations. We end up with a final sample of 504 observations of adult children (228 daughters and 276 sons) who took part in at least one of the tests and who could be matched to at least one of their parents with valid information on IQ test scores. Our sub-sample of individuals for which there is information on both parents' cognitive ability tests comprises 275 observations. Despite the severe restrictions on the sample, selection does not seem to be a major problem for the interpretation of the results (see the discussion on representativeness in the Appendix).

3.1 Measures of cognitive ability

Since fully fletched IQ tests cannot be implemented in a large-scale panel survey, two ultrashort tests of cognitive ability were developed for the SOEP (Lang et al. 2007; Schupp et al. 2008) and implemented in the year 2006: a symbol correspondence test (SCT) and a word fluency test (WFT). Both tests correspond to different modules of the Wechsler Adult Intelligence Scale (WAIS), which altogether comprises 14 modules, seven on verbal IQ and seven on performance IQ (Groth-Marnat 1997; Kline 1999).

The SCT was developed after the symbol digit modalities test (Smith 1995) and corresponds to a sub-module in the non-verbal section of the WAIS. It is conceptually related to the mechanics of cognition or fluid intelligence, meaning that it comprises general and largely innate abilities. The SCT hence refers to the performance and speed of solving tasks that are related to new material. The test was implemented by asking respondents to match as many numbers and symbols as possible within 90 s according to a given correspondence list, which is permanently visible to the respondents on a screen.

The WFT as implemented in the SOEP is similar to a sub-module in the verbal section of the WAIS and has been developed after the animal-naming

[7] As usual in survey-based datasets, it is not possible in the SOEP to identify biological parents with full certainty. Available birth biographies for men and women allow identifying 70% of biological (or adoptive) fathers and 80% biological (or adoptive) mothers in our sample. The identification of the remaining parents was based on children files, which include pointers to the mother and to the partner of the mother, and on the relationship of the child to the head of the household. This implies that the probability of identifying non-biological parents is higher among these children due to the more frequent presence of stepparents or new partners of the biological parent who act as social parents. Additional regressions, in which we restrict our sample to children for whom biological (or adoptive) parents could be identified ($n = 347$), yield virtually the same results.

task (Lindenberger and Baltes 1995): respondents name as many different animals as possible within 90 s. Using the distinction of fluid and crystallized intelligence (Cattell 1987), the WFT is conceptually related to the pragmatics of cognition or crystallized intelligence, such as verbal knowledge. Crystallized intelligence concerns the fulfillment of rather specific tasks, which improve with knowledge and skills acquired in the past.[8]

Both WFT and SCT as implemented in the SOEP produce outcomes, which are relatively well-correlated with test scores of more comprehensive and well-established intelligence tests: Lang et al. (2007) carry out reliability analyses and find test–retest coefficients of 0.7 for both WFT and SCT.[9] This means that despite the short duration of the tests (90 s), they perform very well compared to longer tests typically used in the psychology literature. Since age is a strong confounding factor for IQ and IQ tests (Lindenberger and Baltes 1995), we employ age-standardized scores from both tests in the following analyses.[10]

3.2 Control variables

Our main independent variables of interest are the ability test scores of individuals' parents. Ideally, we would like to include both the mother's and the fathers' test score in each estimation. However, out of 504 individuals for whom we have either the test score of the father or that of the mother only 275 individuals could be linked to both parents' test scores. We therefore did not differentiate between fathers and mothers in the first instance but—similar to Bouchard and McGue (1981)—use the average of the parents' test scores in order to maximize the number of observations. In a second step, we rerun our estimates for the subsample of individuals for whom we have the cognitive ability information for both parents in order to distinguish the effect of the father from the influence of the mother. Similar to the dependent variables, all parental test scores are age-standardized.[11]

Other potential determinants of cognitive abilities derive from family context, childhood environment (for instance, Agee and Crocker 2002), and

[8] It might be argued that the time constraint of 90 s interferes with the concept of crystallized intelligence inasmuch as factors like working memory come into play. Working memory however is related to executive function and thus to fluid intelligence rather than crystallized intelligence only. It should therefore be kept it mind that the WFT scores may be a mixture of fluid and crystallized intelligence.

[9] If at all, the random component to cognition test scores in our data may lead to a downward bias in the estimates of IQ correlations.

[10] Age-standardized test scores are generated by calculating the scores' standardized value for every year along the age distribution.

[11] Note that the parents' ability test scores have been age-standardized using all individuals with available test score information because there were too few persons in some of the age groups within the sample. The higher number of observations further allowed to age-standardize the test scores for males and females separately.

educational background.[12] Schooling effects are accounted for by including the following dummies for educational degrees: dropout/unknown schooling degree, high school/no college, and college/university degree; other secondary/intermediate degree is used as the reference category. We further take into account that cognitive abilities may be affected by family size (Black et al. 2010b) and therefore include the number of brothers and sisters in our estimations. In addition, we distinguish between first- and later-born children in our dataset: Birth order has been shown to negatively affect children's IQ scores (Black et al. 2010a), although Black et al. (2009) did not find strong evidence of a large impact of birth order on intergenerational IQ transmission. Additional family background variables we use are whether a child has been raised by a single parent and dummy variables for educational degrees of both mother and father: secondary school, intermediate school degree and upper degree, with no schooling degree as reference category. We further include a set of childhood area dummies: childhood in a town, city, urban area, or unknown childhood area, where childhood in a rural area serves as reference category. This is to control for individuals' childhood environment, which will partially capture socioeconomic conditions (health, nutrition, educational provision, etc.) that are critical to cognitive development. Complementing that, we use individuals' body height—which has been shown to be a significant predictor of cognitive skill outcomes (Case and Paxson 2008; Heineck 2009)—as a composite indicator of health and nutritional conditions in early childhood development.

Furthermore, we use the following characteristics of the adult children as additional controls in robustness checks: work experience, unemployment experience, marital status, and region of current residence (East Germany, North, Middle, and South). To take into account the potential effects from physical or mental health, we control for the health status of an individual by adding a dummy variable for disability. However, this is not our preferred specification, as we are aware that these variables are potentially endogenous.

3.3 Descriptive evidence

The raw cognitive ability test scores, educational degrees, and the other variables used in the regression analyses are summarized in Table 1. Note that the average test scores of mothers and fathers are clearly below the test scores of the children, especially for coding speed. This can be partially explained by the so-called *Flynn effect*, which indicates a rise in average cognitive ability test scores for the last three generations (Flynn 1994). Another reason is that

[12] Although formal education in part depends on early cognitive ability, it has been shown that additional years of schooling increase IQ later in life (Falch and Sandgren 2010).

Table 1 Summary statistics: IQ test scores, education, and family background

Variable	Daughters				Sons			
	Mean	(SD)	Min	Max	Mean	(SD)	Min	Max
Speed test score	32.54	(9.57)	10	53	32.37	(10.47)	5	60
Word fluency test score	26.54	(10.20)	6	82	25.88	(10.71)	1	74
Age	25.68	(7.01)	17	58	26.43	(8.21)	17	64
No school degree	0.13	(0.34)	0	1	0.14	(0.35)	0	1
Other secondary degree	0.51	(0.50)	0	1	0.62	(0.49)	0	1
High School, no college	0.26	(0.44)	0	1	0.17	(0.38)	0	1
College/University degree	0.10	(0.30)	0	1	0.06	(0.23)	0	1
Height (in cm)	167.75	(6.46)	150	186	180.59	(6.77)	163	200
Single parent	0.10	(0.30)	0	1	0.12	(0.32)	0	1
First born	0.47	(0.50)	0	1	0.46	(0.50)	0	1
Number of brothers	0.90	(1.21)	0	7	1.05	(1.13)	0	6
Number of sisters	0.90	(0.99)	0	6	0.86	(1.05)	0	7
Childhood area: rural	0.32	(0.47)	0	1	0.32	(0.47)	0	1
Childhood area: town	0.18	(0.38)	0	1	0.18	(0.39)	0	1
Childhood area: city	0.14	(0.35)	0	1	0.22	(0.42)	0	1
Childhood area: urban	0.24	(0.43)	0	1	0.18	(0.38)	0	1
Childhood area: missing	0.11	(0.32)	0	1	0.10	(0.30)	0	1
Mother's information								
Speed test score	25.46	(9.11)	4	44	26.46	(9.07)	2	49
Word fluency test score	25.69	(9.88)	7	56	25.57	(10.52)	2	71
No school degree	0.07	(0.26)	0	1	0.08	(0.27)	0	1
Second. degree	0.46	(0.50)	0	1	0.53	(0.50)	0	1
Intermediate degree	0.38	(0.49)	0	1	0.28	(0.45)	0	1
Upper degree	0.08	(0.28)	0	1	0.12	(0.32)	0	1
Father's information								
Speed test score	25.78	(9.64)	2	50	25.49	(9.74)	2	45
Word fluency test score	25.04	(10.94)	1	71	24.09	(11.47)	1	54
No school degree	0.08	(0.28)	0	1	0.11	(0.31)	0	1
Second. degree	0.53	(0.50)	0	1	0.55	(0.50)	0	1
Intermediate degree	0.25	(0.43)	0	1	0.21	(0.41)	0	1
Upper degree	0.14	(0.35)	0	1	0.14	(0.35)	0	1
Individuals	228				276			

Source: SOEP 2006

all ability tests have been conducted in the same year (SOEP wave 2006), and differences between parents and children can be explained by cognitive decline at old age (Lindenberger and Baltes 1995).[13] As outlined above, we therefore employ age-standardized test scores to assess the dimension of intergenerational transmission of cognition independent of age effects.

Figure 1 displays the distributions of children's age-standardized scores for both cognitive ability measures by gender and schooling level. The graphs

[13] It is striking that there is only a minor difference between parents' and children's word fluency test scores. This is in line with the notion in psychology that crystallized intelligence remains fairly stable, whereas cognitive speed declines at old age.

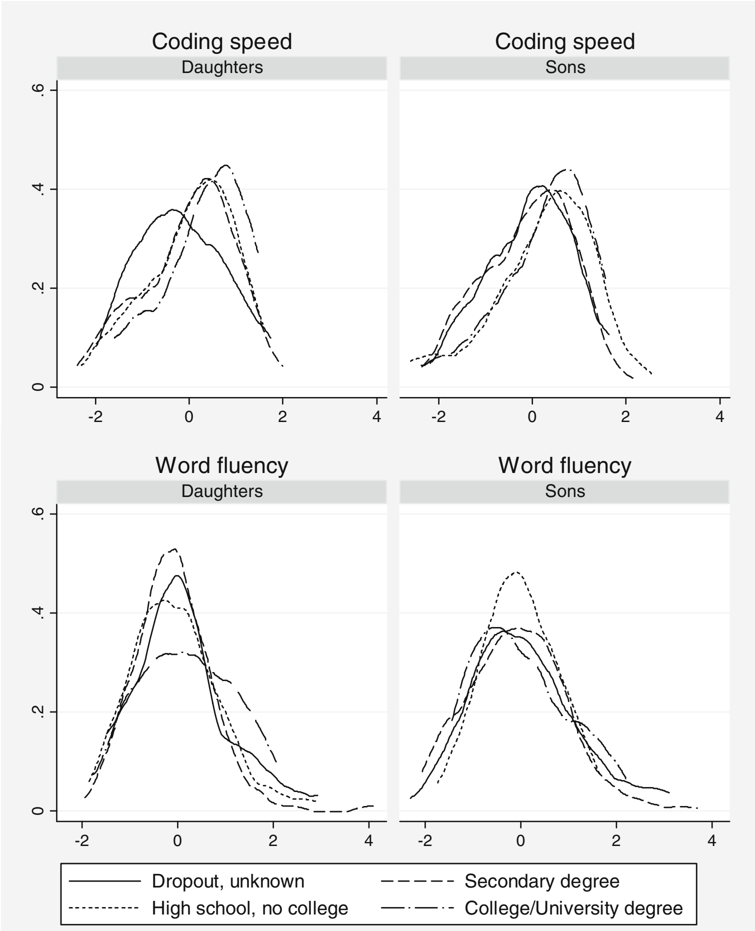

Fig. 1 Distributions of age-standardized coding speed test scores and word fluency test scores by gender and schooling. Source: SOEP 2006

show that coding speed is left-skewed for both sons and daughters. It is apparent that both males and females with more years of schooling achieve higher speed test scores. Gender differences are clearly visible with respect to verbal fluency. Whereas female college/university graduates did better than daughters with other educational degrees, the gap between highly educated and less educated sons is less obvious for the WFT. Averaged over all individuals, there are no male–female differences for children with respect to the cognitive abilities test scores. The obvious relationship between education and post-school cognitive abilities points to the importance of controlling for education when estimating the intergenerational transmission of cognitive abilities.

3.4 Estimation methods

In the following, we examine the determinants of cognitive abilities using ordinary least squares (OLS) regressions. The estimated functions are based on the form

$$\boldsymbol{y}_i = \boldsymbol{x}_i^{'}\boldsymbol{\beta} + \boldsymbol{c}_i^{'}\boldsymbol{\gamma} + \boldsymbol{u}_i \tag{1}$$

where y_i are individual i's age-standardized cognitive ability test scores, $\boldsymbol{x}$ is a vector of individual characteristics, $\boldsymbol{c}$ is the vector that includes parental characteristics and their age-standardized intelligence test scores, $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ are the corresponding parameter vectors to be estimated, and u_i denotes the idiosyncratic error term.

In essence, we thereby follow Todd and Wolpin (2003) who lay out a general modeling framework for the production function for cognitive achievement (of children) that comprises family inputs, schooling inputs—and in our case also post-schooling inputs—and initial endowment. In order to yield consistent estimates, we have to assume that further unobservables, which might affect individuals' cognitive skills, are not related to the vectors of regressors. That is, we assume that our model is correctly specified. We however are aware of possible biases because of misspecification and because of measurement error. Measurement error may arise in the IQ tests per se and because we are using proxy information for inputs—parental education may for example stand for the time that parents read to their children when they are young. A common approach to deal with such biases would be the use of IV strategies. Unfortunately, our data do not allow using either IV strategies or the value-added approach or family fixed effects, which, according to Todd and Wolpin (2003), should be preferred to the simple cumulative specification. In additional analyses, we however use averaged and factorized test scores and further apply Leamer's extreme bounds approach (Leamer and Leonard 1983; Klepper and Leamer 1984),[14] which to some extent will give us an insight about the reliability of our OLS estimates.

As mentioned above, we estimate the intergenerational transmission of cognitive ability test scores for different subsamples. In a first step, our estimates are based on all individuals for whom we have either maternal or paternal test scores in order to maximize the number of observations. We use the average of the parents' test scores, when test scores of both parents are available, and maternal (paternal) test scores, when only the test scores for the mother (father) are available. We then distinguish the effect of the mother from the effect of the father in a second step and rerun the regressions for the subsample of individuals for whom we have the cognitive ability information for both parents. In a third step, we run separate regressions for males and

[14] We are grateful to one of the referees for pointing us to this method.

females to distinguish the effect that mothers' and fathers IQs have on their daughters from the effect on their sons.

We include covariates as outlined above and, in addition, a gender dummy in the regressions that are based on the merged male–female sample. We furthermore carry out a number of robustness checks, which we will address while going through our results in the following section.

4 Results

The following tables display intergenerational associations in cognitive abilities allowing for different individual characteristics, family background, and childhood environment. In the most basic specification, we regress children's cognitive ability test scores on their education, since schooling has been found to be an important determinant of post-school cognitive skills (Falch and Sandgren 2010). We then add the parents' IQ test scores to the regression to investigate whether parental test scores have explanatory power in addition to schooling.[15] As could be expected, the regression results indicate a positive relationship between education and both types of ability test scores (Table 2, columns 1 and 3), although the explained variation is very small.[16] Particularly, individuals with a college or university degree attain significantly higher speed test scores compared to their counterparts with lower secondary schooling. This positive association however vanishes once parents' cognitive skills are included. The coefficient for parents' speed test score is highly statistically significant (Table 2, column 2).[17] It implies that an increase in parents' ability by one age-standardized SCT score increases the child's coding speed by 0.45 points, which roughly corresponds to five units in the SCT. The intergenerational link is equally statistically significant and even stronger for the WFT (Table 2, column 4): A one-point increase in the age-standardized WFT score of parents is associated with a 0.49-point increase for their children, which corresponds to approximately six units in the WFT. Note further that the test score of parents are not only highly statistically significant after controlling for

[15] Pure correlations of age-standardized ability test scores between parents and their children are about 0.45 for the SCT and 0.46 for the WFT.

[16] We cross-checked this result using the initial sample of 5,321 observations before merging the data to the respondents' parents. Regressing the IQ test scores on gender and educational attainment for the larger sample yields only slightly higher R^2 values as compared to our final sample. This may seem unexpected at first glance, but note again that the tests aim at measuring individuals' intelligence and not achievement. This might be behind this first low explained variation.

[17] Adjusting the standard errors to account for heteroskedasticity and for intra-family correlation does not affect the results.

Table 2 Intergenerational associations in cognitive ability

	Speed test		Word fluency test	
	(1)	(2)	(3)	(4)
Male	0.001	−0.041	−0.012	−0.010
	(0.089)	(0.080)	(0.087)	(0.077)
No school degree	−0.046	−0.156	0.157	0.048
	(0.133)	(0.120)	(0.128)	(0.114)
High School, no college	0.176	−0.007	0.043	−0.137
	(0.112)	(0.102)	(0.109)	(0.098)
College/University degree	0.341**	−0.028	0.203	−0.033
	(0.167)	(0.154)	(0.166)	(0.149)
SCT score parents		0.450***		
		(0.041)		
WFT score parents				0.489***
				(0.042)
Constant	−0.066	0.078	−0.071	0.024
	(0.079)	(0.072)	(0.077)	(0.068)
Observations	504	504	504	504
F test schooling degrees	2.154	0.582	0.873	0.851
Adjusted R^2	0.005	0.197	0.003	0.209

Standard errors in parentheses. Dependent variable: age-standardized test scores of the child's speed test/word fluency test. "SCT score parents" and "WFT score parents" refer to the average of parents' age-standardized test scores when test scores for both parents are available. Source: SOEP 2006

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

education, but they increase the explained part of the variance considerably compared to the first specification in which only schooling is controlled for.[18]

As outlined above, we are aware that our estimates may suffer from measurement error and misspecification. We therefore employ Leamer's extreme bounds approach (Leamer and Leonard 1983; Klepper and Leamer 1984) in additional regressions for which the results however differ only slightly from what we find with the conventional approach. Without showing it in detail, the minimum bound for the SCT regression is at 0.4296, the maximum is at 0.4569, so the range around the OLS coefficient of 0.45 is not large. We find a similar picture for the WFT with the OLS estimate at 0.49 and its extreme bounds ranging from 0.4604 to 0.5099. This in sum implies only a rather small bias because of measurement error and specification issues.

The positive association between parents' and their children's ability test scores in the basic specification could be driven by third variables, such as

[18]In order to compare these estimates with intergenerational transmission of educational attainment, educational degrees of parents and children are transformed into years of schooling. The transmission effect with respect to years of schooling, when only a gender dummy is included, amounts to 0.319 (SE, 0.046, adjusted R^2, 0.109). It slightly decreases to 0.277 (SE, 0.047, adjusted R^2, 0.160) when parental test scores are also taken into account. Detailed results are available from the authors upon request.

the family's social background, which correlate with IQ. We therefore take advantage of our rich dataset and include controls for family background and childhood environment in an extended specification. For the reasons described in the data section above, we add the number of brothers and sisters, whether the child is firstborn, has been raised by a single parent, parental education, childhood area dummies, and body height to the equation. In a further step, we check the robustness of the intergenerational transmission effect by adding labor-market-related variables and other factors, which might possibly affect individuals' cognitive skills. We in particular include work experience, unemployment experience, marital status, dummies for the region of current residence (North, Middle, South, and East Germany as the reference category), and disability status. However, note again that endogeneity might be more relevant in this specification.

Table 3 provides estimates of these extended specifications, including family background and childhood environment (Table 3, columns 1 and 4) as well as the controls related to labor market experience, marital status, region, and health (Table 3, columns 2 and 5). Interestingly, the estimates show barely any significant effects of the family background, childhood environment, and other control variables on children's cognitive abilities.[19] In contrast, the regressions show a very robust finding for parents' cognitive abilities, which is in line with the results by Brown et al. (2009), who find a robust transmission effect for reading and mathematics test scores in their study on the UK, independently of additional controls. Compared to the parsimonious specifications in Table 2, the coefficients remain almost unchanged at 0.442 for the SCT and at 0.495 for the WFT when controlling for the full set of background variables (Table 3, columns 3 and 6). Hence, although we account for more individual and family background variables, the IQ transmission revealed by our regressions is larger than the one found by Black et al. (2009) for Norway and by Björklund et al. (2009) for Sweden, where a one-point increase in the father's ability is associated with an increase in the son's ability by about one third. Our transmission effect is also stronger than the one revealed by Agee and Crocker (2002) who find that a one-point increase in parental IQ is related to an increase in the child's verbal IQ by one quarter and to an increase in full-scale IQ by one third in the USA. Likewise, our coefficients are higher than the ones found by Brown et al. (2009) for the transmission of reading skills (0.25) and numeracy skills (0.08) in the UK. In contrast, our estimates are in line with the correlations summarized by Bouchard and McGue (1981) from a sample of familial studies of IQ who report an average correlation of 0.5 between parents and their offspring.

[19] In three alternative specifications, we checked for differences between East and West Germany by including a dummy variable for (a) living in East Germany, (b) being born in the former GDR, (c) having spent the childhood (at least 10 years) in the former GDR. However, none of these variables were statistically significant, and the test score estimates were not affected.

Table 3 Parents' IQ test scores and family background

	Speed test			Word fluency test		
	(1)	(2)	(3)	(4)	(5)	(6)
Male	0.026	−0.022	0.052	0.111	0.022	0.123
	(0.115)	(0.081)	(0.115)	(0.110)	(0.078)	(0.110)
No school degree	−0.119	−0.157	−0.156	0.126	0.079	0.112
	(0.125)	(0.121)	(0.126)	(0.119)	(0.116)	(0.120)
High School, no college	−0.007	−0.056	−0.053	−0.049	−0.123	−0.074
	(0.111)	(0.105)	(0.111)	(0.105)	(0.100)	(0.106)
College/university degree	0.029	0.012	−0.002	0.057	−0.008	0.046
	(0.163)	(0.157)	(0.162)	(0.156)	(0.152)	(0.156)
Test score parents	0.441***	0.449***	0.442***	0.464***	0.480***	0.495***
	(0.043)	(0.041)	(0.043)	(0.045)	(0.043)	(0.046)
Single parent	−0.064		−0.010	−0.036		−0.033
	(0.129)		(0.131)	(0.125)		(0.127)
First born	0.063		0.045	−0.019		−0.017
	(0.088)		(0.087)	(0.083)		(0.083)
Number of brothers	−0.035		−0.031	−0.041		−0.024
	(0.039)		(0.039)	(0.035)		(0.035)
Number of sisters	−0.005		0.001	−0.018		−0.009
	(0.041)		(0.041)	(0.039)		(0.040)
Father secondary school degree	0.193		0.127	0.019		0.066
	(0.190)		(0.192)	(0.189)		(0.192)
Father intermediate degree	0.133		0.113	0.182		0.208
	(0.207)		(0.211)	(0.203)		(0.207)
Father upper school degree	0.269		0.202	−0.010		0.000
	(0.220)		(0.221)	(0.213)		(0.215)
Mother secondary degree	−0.004		0.009	0.068		0.079
	(0.213)		(0.215)	(0.214)		(0.214)
Mother intermediate degree	−0.052		−0.062	0.076		0.016
	(0.223)		(0.223)	(0.223)		(0.223)
Mother upper school degree	−0.157		−0.126	−0.292		−0.294
	(0.250)		(0.249)	(0.245)		(0.244)
Childhood in town	−0.181		−0.153	−0.078		−0.022
	(0.120)		(0.120)	(0.114)		(0.115)
Childhood in city	−0.208*		−0.248**	−0.122		−0.100
	(0.114)		(0.115)	(0.111)		(0.113)
Childhood in urban area	−0.102		−0.126	−0.001		0.098
	(0.117)		(0.122)	(0.112)		(0.117)
Unknown childhood area	−0.040		−0.113	0.152		0.192
	(0.172)		(0.174)	(0.165)		(0.168)
Height (in cm)	0.155		0.207	−0.017		0.006
	(0.131)		(0.132)	(0.124)		(0.126)
Height squared, divided by 100	−0.046		−0.061	0.004		−0.003
	(0.037)		(0.038)	(0.035)		(0.036)
Work experience (years)		0.006	0.001		−0.003	−0.005
		(0.007)	(0.007)		(0.007)	(0.007)
Unemployment exp (years)		−0.090**	−0.079*		−0.007	−0.012
		(0.039)	(0.041)		(0.036)	(0.037)
Married		0.016	0.049		0.025	−0.000
		(0.121)	(0.126)		(0.116)	(0.120)
Disabled		−0.654**	−0.661**		−0.726***	−0.700***
		(0.255)	(0.266)		(0.231)	(0.242)
Residence in North Germany		−0.014	−0.021		−0.140	−0.150
		(0.130)	(0.138)		(0.123)	(0.130)

Table 3 (continued)

	Speed test			Word fluency test		
	(1)	(2)	(3)	(4)	(5)	(6)
Residence in South Germany		−0.075 (0.128)	−0.119 (0.134)		0.068 (0.123)	0.043 (0.129)
Residence in Middle Germany		0.137 (0.111)	0.135 (0.123)		−0.131 (0.106)	−0.155 (0.117)
Constant	−12.99 (11.49)	0.055 (0.113)	−17.51 (11.56)	1.762 (10.90)	0.102 (0.108)	−0.090 (11.05)
Observations	481	481	481	488	488	488
F test schooling degrees	0.346	0.609	0.538	0.628	0.867	0.673
Adjusted R^2	0.195	0.220	0.212	0.198	0.206	0.208

Dependent variable: age-standardized test scores of the child's speed test / word fluency test. "Test score parents" refers to the average of parents' test scores when test scores for both parents are available. The slightly smaller sample size compared to Table 2 is due to missing information on labor market experience for some of the respondents. Source: SOEP 2006
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Apart from parental cognitive skills, there are only three other predictors for individuals' speed test scores in these equations. First, there is a negative relationship between growing up in a city and SCT scores. Second, there is a link between coding speed and unemployment experience inasmuch as one additional year of unemployment is associated with a 0.08-point decrease in the age-standardized coding speed. Again, we are aware that this covariate might be endogenous, since lower cognitive skills might have led to unemployment in the first place. In contrast, childhood area and unemployment history are not related to the WFT (Table 3, column 6). The only control variable, which has a sizeable and statistically significant effect on both coding speed and word fluency, is the respondent's disability status, which lowers their age-standardized ability test scores by up to 0.73 points.[20] The coefficients on having been raised by a single parent and being the firstborn child have mostly the expected signs but are not statistically significant. Likewise, parental schooling does not have any significant effect on the child's cognitive ability test scores, which again is in line with the findings of Brown et al. (2009). They rule out the case that the intergenerational effect of parents' test scores occurs via their impact on parents' income or educational attainment.

We so far estimated the cognitive ability test score of individuals for whom we have the test score of either father or mother without distinguishing effects

[20] As an additional robustness check, we included the disability status of the parents and an interaction term with parents' test scores. Both main and interaction effects were negative for coding speed and positive for the word fluency test, but none of them was statistically significant. Parental test score coefficients however were not affected.

of fathers and mothers on their sons and daughters. Now, Tables 4 and 5 provide results for three subsamples of our data to disentangle the effects by gender of the parents and of the children. In addition to the displayed variables, we include controls for having been raised by a single parent, being a firstborn child, number of brothers, number of sisters, parental education, childhood area, and height so that the results compare to columns 1 (SCT) and 4 (WFT) in Table 3. We first present estimates for all children for whom there is information on both parents' cognitive abilities (Tables 4 and 5, column 1), followed by separate estimates for daughters and sons (Tables 4 and 5, columns 2 and 3).

Most coefficients on parents' test scores remain highly statistically significant when the sample is restricted so to include both parents' test scores in order to compare the influence of fathers and mothers (Tables 4 and 5, column 1). For both types of ability tests, we find higher coefficients for mothers' test scores than for fathers' IQ scores. For coding speed, the coefficient of the mother's ability amounts to 0.30, which compares to the father's ability coefficient of 0.17. The difference between parents is slightly smaller for the WFT: 0.33 for the mother vs. 0.24 for the father. Note that this result is consistent with the findings above (Table 2), as the individual ability effects of mothers and fathers roughly sum up to the effect for both parents together found before (0.45 for the SCT and 0.49 for the WFT). Moreover, the results in Tables 4 and 5 show that the distinction between both parents' test scores is relevant, as we obtain additional insights with respect to the relative importance of mothers and fathers for the transmission of cognitive skills.[21] The finding of a maternal effect is in line with previous research on educational mobility, which provides evidence for a larger effect of the mother's educational qualification on the child's educational performance (e.g., Ermisch and Francesconi 2001). The explanation may be that, on average, mothers spend more time with their children than fathers, which may strengthen the link between mother's and child's ability.

In order to investigate whether the role that mother and father play for their offspring depends on the gender of the child, we separate the sample by daughters and sons (Tables 4 and 5, columns 2 and 3). Table 4 shows that there are differences between females and males with respect to the effect

[21] The differences between mothers' and fathers' transmission effects on children's IQ scores were formally tested using Wald tests. The test statistics yielded hardly significant results. This may however be attributed to the small sample size and the related lack of precision. A statistically significant difference between mothers' and fathers' transmission effects at the 8% significance level was shown in the estimates of the SCT scores for the sub-sample of daughters. The remaining differences between coefficients should be interpreted with caution.

Table 4 Transmission of cognitive abilities according to parent and gender (speed test)

	All (1)	Daughters (2)	Sons (3)
No school degree	−0.054	−0.324	−0.008
	(0.172)	(0.263)	(0.249)
High school, no college	0.021	−0.214	0.110
	(0.146)	(0.204)	(0.226)
College/university degree	−0.136	−0.113	−0.271
	(0.212)	(0.313)	(0.313)
Male	0.197		
	(0.154)		
SCT score, Mom	0.296***	0.400***	0.242**
	(0.067)	(0.102)	(0.093)
SCT score, Dad	0.170***	0.093	0.205**
	(0.061)	(0.094)	(0.085)
Constant	−8.386	62.90	−77.83**
	(15.37)	(39.39)	(37.24)
Observations	275	125	150
F test schooling degrees	0.202	0.683	0.399
Adjusted R^2	0.179	0.143	0.211

Standard errors in parentheses. Dependent variable: age-standardized test scores of the child's speed test. Additional controls include single parent, first born child, number of brothers, number of sisters, parental education, childhood area, and height (see Table 3, column 1). Source: SOEP 2006

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table 5 Transmission of cognitive abilities according to parent and gender (word fluency test)

	All (1)	Daughters (2)	Sons (3)
No school degree	−0.021	−0.105	−0.004
	(0.152)	(0.235)	(0.217)
High school, no college	−0.224	−0.249	−0.203
	(0.137)	(0.183)	(0.213)
College/university degree	0.071	0.329	−0.292
	(0.193)	(0.262)	(0.295)
Male	0.207		
	(0.142)		
WFT score, Mom	0.329***	0.249**	0.331***
	(0.072)	(0.115)	(0.098)
WFT score, Dad	0.236***	0.217**	0.303***
	(0.064)	(0.097)	(0.089)
Constant	−15.36	11.97	−13.49
	(14.40)	(34.95)	(36.20)
Observations	275	125	150
F test schooling degrees	1.128	1.591	0.562
Adjusted R^2	0.223	0.191	0.268

Standard errors in parentheses. Dependent variable: age-standardized test scores of the child's word fluency test. Additional controls include single parent, first born child, number of brothers, number of sisters, parental education, childhood area, and height (see Table 3, Column 4). Source: SOEP 2006

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

of parents' fluid intelligence.[22] It is striking that fathers' SCT scores are not related to the coding speed of their daughters, whereas they play a substantial role for their sons' speed of cognition. In the estimate for daughters, the coefficient on the fathers SCT scores is only half of the size of the coefficient in the estimate for sons and not statistically significant. Likewise, there are differences between males and females with respect to the effect of mothers' SCT scores. For daughters in particular, the influence of the mother is clearly stronger with a highly statistically significant coefficient of 0.40. This means that, in addition to the maternal effect revealed above, the results point to an own-gender effect in the transmission of coding speed.

Table 5 displays the transmission of mother's and father's crystallized intelligence according to the gender of the child (Table 5, columns 2 and 3). Here, fathers' test scores are related to the ability of both sons and daughters. While the coefficients are again lower than the coefficients on mothers' test scores, this parental difference is not significant for both males and females. The mothers' word fluency seems to be a more important determinant for the ability of sons (coefficient of 0.33) than for daughters (0.25), although this gender difference is not statistically significant.

Compared to the psychological studies presented by Bouchard and McGue (1981), the IQ transmission effects found in our data are below their reported correlations for mother–child and father–child pairs (between 0.38 for father–son correlations and 0.43 for mother–daughter correlations). However, these discrepancies can be attributed to the fact that we additionally control for the cognitive skills of the other parent in our estimates. Our raw correlations of IQ between parents and their children are in the range between 0.34 (father–daughter correlation) and 0.48 (mother–daughter) and therefore in line with the ones reported by Bouchard and McGue (1981).

In additional regressions, we average the two types of ability test scores, since this approach has been used in the literature on intergenerational mobility to account for measurement error (e.g., Zimmerman 1992). Employing average test scores should reduce the error-in-variable bias by diminishing the random component of measured test scores. Furthermore, average test scores might be seen as extract of a general ability type, which captures both coding speed and verbal fluency. Without showing it in detail, averaging test scores for parents and children yields a transmission effect of 0.486 when including educational controls and a gender dummy, which compares to a coefficient

[22] In order to test differences in the transmission effects between sons and daughters, we run additional regressions fully interacted with a gender dummy. Again, the small sample size decreases the chance that any interaction term with parental test scores is statistically significant. The interaction term for mothers' test scores is not statistically different from zero in any specification. The only relevant gender difference in the fully interacted model was shown by the interaction term between gender and fathers' SCT scores, which is positive and statistically significant at the 14% level, whereas the main effect vanishes completely.

of 0.450 for the SCT and of 0.489 for the WFT (Table 2).[23] That is, the intergenerational correlation of general cognitive skills is somewhat higher than that of coding speed but almost identical to the transmission of verbal fluency. Consequently, and reinforcing our findings from the extreme bounds analysis noted above, we may conclude that measurement error could play a role with respect to the measurement of cognitive speed, but does not greatly affect our results.

To compare our results directly to the findings for the IQ transmission from fathers to sons in Norway (Black et al. 2009) and Sweden (Björklund et al. 2009), we additionally estimate only fathers' IQ transmission for the sample of sons ($n = 177$), disregarding any effects of mothers' cognitive skills. Our estimates using only educational controls show a coefficient of 0.37 (standard error, 0.064; adjusted R^2, 0.153) for coding speed, which resembles the findings for Norway and Sweden. Furthermore, our coefficient is almost exactly identical to the weighted average of father–son IQ correlations reported by Bouchard and McGue (1981). For verbal fluency, our coefficient of 0.45 (standard error, 0.069; adjusted R^2, 0.176) is clearly higher than the ones found by Black et al. (2009) and Björklund et al. (2009). The explained variation in our regressions is slightly larger than in previous studies for Scandinavia but smaller than in our estimates when including maternal cognitive skills (Tables 4 and 5, columns 3).

This additional exercise reveals two findings: First, depending on the type of cognitive abilities, the IQ transmission from fathers to sons in Germany is of similar or larger size than that in Norway. Second, the comparison of our estimates with and without the mother's IQ shows that the overall intergenerational IQ transmission and the explained variation are larger when the mother's IQ is taken into account. It therefore is important to consider both fathers' and mothers' cognitive abilities to get a full picture of IQ transmission.

Our results moreover imply that it is important to distinguish between different types of cognitive abilities: the findings point to substantial gender differences with respect to transmission of fathers' coding speed where skills are transmitted from fathers to their sons but not to their daughters. Verbal fluency on the other hand is passed on from fathers and mothers independent of the child's gender. Unlike Bouchard and McGue (1981), who did not find evidence for either sex role or maternal effects, we conclude that there are own-gender effects with respect to coding speed.

Although our estimates of intergenerational IQ transmission do not allow to clearly identify genetic effects from environmental influences, some of the results above may be cautiously interpreted in the light of the nature vs. nurture debate. First, we find a stronger intergenerational transmission of verbal fluency, i.e., cognitive abilities that are based on knowledge and skills acquired in the past, than for coding speed, which comprises general and

[23] This result does not change qualitatively when factorized data is used instead of averaging.

largely innate abilities. The stronger transmission of the cognitive ability type, which is prone to be more malleable, may point to the importance of home environment, such as parenting style. Second, our estimates show own-gender effects for coding speed. The interpretation could be that, on average, mothers spend more time with their daughters, while fathers spend more time with their sons, which may strengthen the link between parents' and own-gender children's performance of solving tasks that are related to new material. The finding of significant own-gender effects with respect to the transmission of coding speed points to the importance of upbringing and is not compatible with a pure genetic model. Altogether, these findings provide evidence that parental investments are relevant for the transmission of cognitive skills but do not refute the existence of genetic effects.

5 Conclusion

It is widely accepted that societal inequality is partially related to the intergenerational transmission of socioeconomic status. So far, economic research mainly concentrated on income mobility or the transmission of educational attainment as potential links. We complement this research by studying the less researched transmission of parents' cognition to their adult children's abilities using, for the first time, nationally representative data for Germany. Specifically, we use parents' and children's scores from two ultrashort intelligence tests on coding speed (SCT) and on verbal fluency (WFT) from the German SOEP. In contrast to the few previous studies based on representative data, we are able to link both males *and* females to their fathers *and* mothers, which allows us to analyze potential gender differences. Furthermore, we account for family background, childhood environment, labor-market-related variables, and other relevant factors for the determination of two different types of cognitive skills. For both the SCT and the WFT, we find evidence for the intergenerational transmission of cognitive abilities: Individuals' cognitive abilities are substantially associated with the skills of their parents. Furthermore, individuals' educational attainment becomes statistically meaningless as soon as parents' abilities are accounted for. The transmission coefficients we find—about 0.45 for coding speed and 0.5 for word fluency— are higher than those found in comparable studies for other countries, and they are very robust to the inclusion of family background, childhood variables, and other factors, which potentially affect an individual's ability. Furthermore, we study the channels of intergenerational IQ transmission by examining the respective influence of each parent. Our first results show that mothers play a more important role than fathers in the transmission of cognitive abilities. In addition, we find evidence for own-gender effects for fluid intelligence: Coding speed is transmitted from fathers to sons only and more strongly from mothers to daughters.

In terms of implications, the evidence for a transmission of cognitive skills from parents to children adds to a better understanding of low intergenerational mobility in various socioeconomic outcomes. The persistence in income inequality and education has been intensively investigated by a large number of studies but few studies considered the transmission of cognitive skills from parents to children as one of the underlying mechanisms. Taking into account the importance of the intergenerational transmission of cognitive abilities may significantly alter the policy implications of those studies. If intergenerational correlation of education is mainly driven by IQ transmission from parents to children, then investments in children's higher education would be less profitable than previously thought. Furthermore, policy recommendations to raise parental IQ for the benefit of future generations will be misplaced if the correlation between parents' and children's IQ is driven by confounding factors, which are related to IQ at adult age. However, our finding of an intergenerational transmission of cognitive skills is robust to the inclusion of a number of factors that are possibly correlated with cognitive abilities.

This study adds to the discussion on intergenerational IQ transmission in various aspects. Our estimates show that, for a full understanding of intergenerational IQ transmission, it is indispensable to take into account both fathers' *and* mothers' cognitive abilities and to analyze the IQ transmission from parents to both sons *and* daughters. Furthermore, our results point to the importance of distinguishing between different types of cognition, as these vary in their degree of dependence on innate abilities and hence are not equally malleable.[24] In addition, it is remarkable that despite controlling for more individual and family background variables, the IQ transmission found in our analysis is stronger than the one found by Black et al. (2009) for Norway, by Björklund et al. (2009) for Sweden, and by Agee and Crocker (2002) for the USA. This finding corresponds to the relatively high educational transmission, i.e., low educational mobility, in Germany compared to other developed countries (Pfeiffer 2008), and corroborates the need to direct future research toward a closer examination of the link between IQ transmission and educational and income mobility.

The question we cannot fully answer is whether the transmission of abilities is a direct effect in the sense that children inherit the cognitive skills of their parents or whether the transmission works indirectly through third variables, such as nutrition, and other health-related or social factors. In case intelligence is fully biologically inherited, not much could be done to fight inequality persistence. If however children's cognitive skills are influenced by other factors, policy actions could be taken to enhance socioeconomic mobility. As the SOEP data do not allow us to further disentangle these aspects, we refer to recent research by Cunha and Heckman (2007), who point out the importance of both nature and nurture, which interact in complex ways. Likewise, our results should be interpreted in light of a compound effect,

[24]Moreover, there is evidence that not all types of cognitive abilities are equally economically important. The findings of Anger and Heineck (2010) suggest that coding speed is positively related to earnings, whereas verbal fluency is not.

which comprises factors such as the inherited genetic endowment, education, nutrition, other health factors, and parenting style. If children's cognitive skills can be influenced by such factors, resources could be allocated to the fostering of a favorable home environment in childhood and to the support of positive parental attitudes with respect to investment in their children. Our finding of a stronger intergenerational transmission of verbal fluency, i.e., those cognitive abilities that improve with skills acquired in the past, points to the importance of parental investments. To the extent that cognitive skills are malleable, policy could take actions to alleviate inequality persistence and to enhance socioeconomic mobility by creating favorable environments, which will help everyone to achieve their potential.

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Appendix

Representativeness of the sample

The severe reduction in sample size (from a total number of 22,665 SOEP respondents in 2006 to 504 test participants with information on their parents' test performance) raises the issue of representativeness of the data, as there might be selection problems with respect to (a) test participation and (b) availability of parent–child pairs. The first question is whether individuals who participated in the cognitive ability tests differ systematically from test deniers or from those respondents who were not asked to participate in the IQ tests, since they were not CAPI interviewed. Table 6 shows summary statistics of the variables used in the analysis for all SOEP respondents in 2006 by interview mode and test participation. Persons who refused to participate in the IQ test were, on average, somewhat older, had slightly lower education, were more often raised in rural areas, and had their residence more often in South Germany. These differences are statistically significant, but except for the regional discrepancies, the comparison of the sample means yields no overwhelming differences between groups. The same is true when test participants are compared to SOEP respondents who were interviewed with other than the CAPI interview mode and hence not asked to participate in the IQ tests. Compared to respondents with other interview modes, East Germans are underrepresented in the sample of test participants. We therefore have to keep in mind that our sample of IQ test participants might not be fully representative for all regions in Germany. However, we conclude that there are no severe selection problems due to test participation with respect to the central variables in our study.

The second question is whether individuals whose parents also participated in the IQ test can be compared to the rest of the population. Table 7 in the

Table 6 Summary statistics for all SOEP respondents according to interview mode and test participation

	CAPI interviews				Other interview modes[a]		*t* test statistics: participants vs. refusers
	Test participants		Test refusers				
	Mean	(SD)	Mean	SD	Mean	SD	
Age	51.19	(17.27)	54.77	(17.16)	48.18	(17.02)	−7.07
No school degree	0.04	(0.20)	0.04	(0.20)	0.05	(0.21)	0.04
Other secondary degree	0.68	(0.47)	0.71	(0.45)	0.62	(0.49)	−2.76
High School, no college	0.10	(0.30)	0.07	(0.25)	0.11	(0.32)	3.34
College/University degree	0.18	(0.39)	0.18	(0.38)	0.22	(0.41)	0.82
Height (in cm)	171.28	(9.27)	171.12	(9.20)	171.6	(9.33)	0.59
Single parent	0.09	(0.29)	0.10	(0.30)	0.07	(0.26)	−0.62
Number of brothers	0.85	(1.07)	0.76	(1.01)	0.78	(1.01)	2.86
Number of sisters	0.88	(1.07)	0.80	(1.02)	0.80	(1.03)	2.68
Childhood area: rural	0.33	(0.47)	0.38	(0.49)	0.36	(0.48)	−3.75
Childhood area: town	0.19	(0.39)	0.18	(0.38)	0.21	(0.41)	1.10
Childhood area: city	0.16	(0.36)	0.13	(0.34)	0.18	(0.38)	2.65
Childhood area: urban	0.22	(0.41)	0.18	(0.39)	0.20	(0.40)	2.98
Childhood area: missing	0.10	(0.30)	0.13	(0.33)	0.04	(0.20)	−2.65
Work experience (years)	20.42	(13.97)	21.87	(13.83)	18.70	(13.41)	−3.36
Unemployment exp (years)	0.73	(1.91)	0.64	(1.96)	0.80	(1.96)	1.57
Married	0.61	(0.49)	0.63	(0.48)	0.60	(0.49)	−1.76
Disabled	0.14	(0.34)	0.15	(0.36)	0.12	(0.33)	−1.40
North Germany	0.20	(0.40)	0.13	(0.33)	0.13	(0.33)	6.32
South Germany	0.20	(0.40)	0.33	(0.47)	0.27	(0.44)	−10.14
Middle Germany	0.39	(0.49)	0.38	(0.49)	0.29	(0.46)	1.02
East Germany	0.18	(0.38)	0.15	(0.35)	0.27	(0.45)	2.75
Observations	5,321		1,504		13,713		

Total observations: 20,538 (excluding non-Germans and respondents who are still in school). Source: SOEP 2006

[a]Other interview modes include oral interviews without computer assistance and written questionnaires

Appendix shows summary statistics of all variables used in the analysis for our sample compared to all other parent–child pairs with interviews in 2006. These include parent–child pairs who are not part of the sample because either the child or the parent had an interview mode other than CAPI or refused to participate in the IQ test. Individuals who were included in our sample of parent–child pairs with IQ test scores were on average two years younger and, related to that, slightly less educated, less experienced in the labor market, and fewer of them were married than individuals who belong to the excluded

Table 7 Summary statistics for parent–child pairs according to their test participation

	Parent–child pairs with IQ test[a]				All other parent–child pairs				*t* test statistic
	Mean	(SD)	Min	Max	Mean	(SD)	Min	Max	
Characteristics of the child									
Age	26.09	7.70	17	64	28.37	8.61	17	72	5.58
No school degree	0.14	0.35	0	1	0.10	0.30	0	1	−2.48
Other secondary degree	0.57	0.50	0	1	0.53	0.50	0	1	−1.57
High School, no college	0.21	0.41	0	1	0.24	0.43	0	1	1.17
College/university	0.08	0.26	0	1	0.13	0.33	0	1	3.26
Height (in cm)	174.79	9.21	150	200	174.05	9.33	115	208	−1.64
Single parent	0.11	0.31	0	1	0.08	0.27	0	1	−2.11
First born	0.45	0.50	0	1	0.43	0.49	0	1	−1.21
Number of brothers	0.98	1.17	0	7	0.77	0.90	0	7	−4.57
Number of sisters	0.88	1.02	0	7	0.77	0.93	0	7	−2.40
Childhood area: rural	0.32	0.47	0	1	0.33	0.47	0	1	0.41
Childhood area: town	0.18	0.39	0	1	0.21	0.40	0	1	1.30
Childhood area: city	0.19	0.39	0	1	0.17	0.38	0	1	−0.64
Childhood area: urban	0.21	0.41	0	1	0.18	0.38	0	1	−1.52
Childhood area: missing	0.11	0.31	0	1	0.11	0.32	0	1	0.36
Work experience (years)	4.13	6.43	0	31	5.42	7.01	0	45	3.83
Unemployment exp (years)	0.43	1.07	0	9.1	0.53	1.32	0	21	1.65
Married	0.14	0.35	0	1	0.21	0.41	0	1	3.59
Disabled	0.03	0.16	0	1	0.04	0.19	0	1	1.12
North Germany	0.20	0.40	0	1	0.14	0.34	0	1	−3.61
South Germany	0.20	0.40	0	1	0.28	0.45	0	1	3.87
Middle Germany	0.41	0.49	0	1	0.29	0.45	0	1	−5.83
East Germany	0.18	0.38	0	1	0.26	0.44	0	1	4.00
Characteristics of the parents									
Mother no school degree	0.08	0.27	0	1	0.04	0.19	0	1	−4.10
Mother second. degree	0.50	0.50	0	1	0.46	0.50	0	1	−1.64
Mother intermed. degree	0.32	0.47	0	1	0.37	0.48	0	1	2.05
Mother upper degree	0.10	0.30	0	1	0.13	0.34	0	1	1.98
Father no school degree	0.10	0.29	0	1	0.05	0.22	0	1	−4.00
Father second. degree	0.54	0.50	0	1	0.48	0.50	0	1	−2.31
Father intermed. degree	0.23	0.42	0	1	0.27	0.45	0	1	2.24
Father upper degree	0.14	0.35	0	1	0.19	0.39	0	1	2.82
Observations		504				3020			

Source: SOEP 2006

[a]The child and at least one parent had to participate in the IQ test

parent–child pairs. In our sample, a higher percentage of parents had no school degree, and again, persons from South and East Germany were underrepresented. Since most discrepancies are rather small and furthermore can be explained by the age difference between the two samples, we conclude that the selection of parent–child pairs with information on IQ test performance does not erode the representativeness of the data. To undermine this, we check whether the results are driven by relatively young sons and daughters in our sample. By restricting our sample to children aged 25 or older (222 observations; average age: 32.6 years), we obtain virtually the same results as for the full sample.

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