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The role of parental cognitive aging in the intergenerational mobility of cognitive abilities

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Abstract

This paper studies intergenerational transmission of cognitive abilities from parents to children. We create a measure of parental cognitive evolution across time, which combines cognitive tests scores obtained at the age of 16 with the ones at the age of 50. We are thus able to identify cognitive aging patterns and assess their impact in the intergenerational perspective. The British National Child Development Study (NCDS) allows us to investigate the effect of parental cognition on two distinct offspring's outcomes: cognitive abilities and educational attainment. Our analysis provides novel results concerning the role of parental cognitive transition during adult life. We find that children benefit not only from the stock of cognitive abilities their mothers and fathers hold as adolescents, but also from cognitive evolution their parents achieve as adults. This outcome is significant and robust under various model specifications. Finally, we investigate the determinants of parental cognitive transition. We find that cognitive aging is attenuated for individuals who undergo multiple job variations, follow on-the-job trainings and engage in leisure activities. This analysis delivers new evidence on the role of policy interventions aimed at fostering cognitive function during adult life, which aside from improving individual outcomes, has positive externalities for the subsequent generations.

Keywords: intergenerational mobility, cognitive ability

JEL classification: I20, J24, J62

1 Introduction

Transmission of cognitive abilities from parents to offspring is an important aspect of human capital formation. Cognitive abilities are studied in economics due to their positive association with earnings.[1] Numerous authors study intergenerational transmission of income and education (e.g. Dearden et al. 1997, Blanden et al. 2007, Black et al. 2005, Chevalier et al. 2010), little concern however is given to transmission of cognition.[2] Parents provide their children with both genetic endowment and parental investments (Heckman et al 2007). The magnitude and productivity of these investments depend on the cognitive functioning of parents, which on the other hand is subject to age-related depreciation. The human capital approach argues that the age-related decline of adult cognitive function does not necessarily coincide with the natural deterioration, since people may invest in cognitive repair activities to mitigate the effects of aging. This idea is confirmed by psychometric studies. Stern (2002, 2003) formulates the concept of cognitive reserves, defined as a set of skills or repertoires which allow people to build on their cognitive abilities stock, thus preventing/attenuating the cognitive decline associated with aging. These reserves are determined by innate abilities and life experiences, such as educational or occupational histories. What emerges from the studies is that cognitive function may be stimulated in adulthood and, as a consequence, the decline related to aging may be avoided or reduced. In the intergenerational perspective, children's outcomes depend on the level of cognition which their parents hold when they are parents, not only when they were teenagers. Hence, if the cognitive decline of parents is not mitigated, one may expect the children's outcomes

[1]See seminal works of Becker and Toms (1976), Cameron and Heckman (1993), Cuhna and Heckman (2007)

[2]The state of art on intergenerational mobility of human capital literature is well described by Black and Devereux (2010)

to suffer from it.

We use data from the National Child Development Study (NCDS). The data provides detailed information on a cohort of British individuals born in 1958 and surveyed cyclically along their lives. For the individuals who become parents, the data registers a wide range of information on their offspring. This setting allows us to study the intergenerational mechanisms of cognitive abilities transmission. In particular, the data contains information on parental cognitive abilities measured at the age of 7, 11, 16 and 50. At each age the assessments provide multiple test outcomes. We therefore use principal component analysis in order to compute unified age specific cognitive scores. The key aspect our analysis it to capture the pattern of parental cognitive evolution between the age of 16 and the age of 50. To do that we transform cognitive scores into distributional rankings which assigns each individual an integer corresponding the centile where her cognitive score falls into, first at the age of 16, then at the age of 50. We finally define the measure of parental cognitive evolution as a difference between the centile position at the age of 50 and the one at the age of 16. We thus obtain individual parental cognitive profiles, which may remain stable, improve or deteriorate over time. In the empirical analysis, we study the impact of this measure on two different offspring's outcomes: cognitive tests scores and years of schooling. We control for the socio-economic and educational outcomes of the parents' mothers and fathers, thus building an empirical model which refers to three subsequent generations. To our knowledge, we are the first to study the evolution of parental cognitive abilities in the perspective of intergenerational mobility. Our framework, thus, provides a broad analysis of intergenerational transmission mechanisms relative to cognitive abilities and offers an important contribution to the present body of literature.

We find a strong positive effect of parental cognitive evolution on both offspring's outcomes: cognitive skills, and years of schooling. Hence, conditional on the initial level of cognitive abilities, parents who maintain or build on their cognitive "reserves" during adult life enhance their children's outcomes. Put differently, it is important to identify plausible channels through which parental cognitive function may be improved, so as to create positive externalities for their children. For this purpose, the final part of the analysis examines the factors which contribute to the maintenance of the parental cognitive profile over time. We find that job related activities offered by employers as well as leisure activities that individuals engage in, strongly attenuate the effect of cognitive aging.

In what follows, Section 2 introduces the data, discusses the construction of the cognitive profiles and the dependent variables. Section 3 presents the empirical analysis framework relative to the intergenerational transmission and discusses the results. Section 4 examines the factors associated with the parental cognitive evolution over time. Finally, Section 5 draws the conclusions and offers some policy implications.

2 Data and variables

We use the NCDS which cyclically surveys all individuals born in UK between the 3rd and the 9th March 1958. We consider waves where cohort members are aged 7, 11, 16, 23, 33, 46 and 50. An interesting feature of the NCDS concerns multidimensional cognitive assessments which are administered to cohort members at the age of 7, 11, 16 and 50. Moreover, each wave contains a wide range of information concerning family background, as well as educational and socio-economic outcomes. Importantly, when cohort members are 33 a supplementary questionnaire is administered to a randomly sampled one third of their children. This survey includes nine age-specific tests measuring cognitive abilities of children aged 4 and older. It also offers a very detailed set of variables relative to early childhood conditions. Additionally, updated information on the offspring's educational attainment is collected when the cohort members are 46. Finally, we also consider information on cohort members' partners. Each wave of the NCDS provides details on parents' partners' education, socio-economic status and the duration of the ongoing relationship.

Thus, the NCDS contains three extremely important features which allow for a thorough analysis of the intergenerational transmission mechanisms: i) the time span, which provides information on cohort members from their birth until the age of 50, ii) the comparability of cognitive test scores, and iii) the specific structure which embraces three generations, the cohort members, their parents and their children. These are all innovative aspects with respect to other studies. The majority of the existing literature is based on military enrollment data, which provide information only on males.[3] Moreover, such data are likely to suffer from IQ underreporting aimed at avoiding the draft. Finally, all the studies examine the correlations between cognitive abilities measured in a single point in time during adolescence. The present analysis seems to be the first to analyze the course of parental cognitive function over time.

2.1 The transition profiles of cognitive abilities

Within the NCDS, parental cognitive skills are measured by aptitude assessments administered to cohort members at the age of 7, 11, 16 and the cognitive appraisal performed at the age of 50. At the age of 7 cognitive tests are based on arithmetics and reading; at the age of 11 on mathematics, reading and general abilities; at the age of 16 on mathematics and reading; at the age of 50 on word list recall, delayed word list recall, letter cancelation speed, letter cancelation accuracy and animal naming. Moreover, the cog-

[3]See Black et al. (2009), Bjorklund et al. (2010), Gronqvist et al. (2009)

nitive assessments relative to the age of 7, 11 and 16 are independent from the curricular tests which are administered to children within schools. We impute cognitive scores for a narrow portion of individuals whose data on one of multiple cognitive tests is missing. For further details on the imputation of missing data see Appendix 1 .

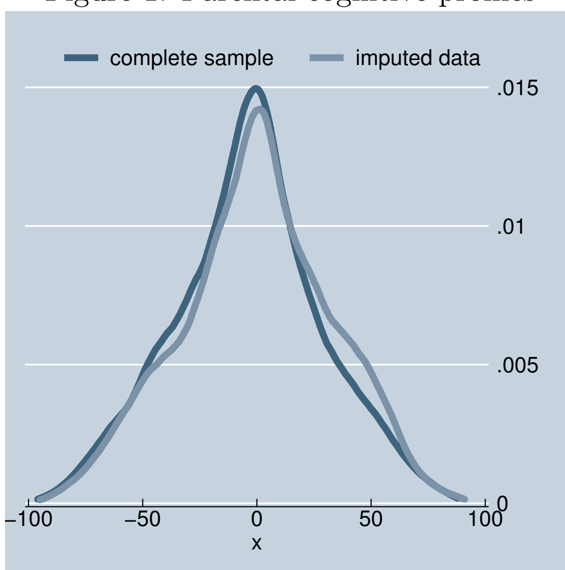
Overall, the number of cohort members in the first wave amounts to 18533. Among this group, we identify parents by selecting individuals who report to have natural children either at the age of 33 or 46. We thus end up with 6086 cohort members. The gender structure of the parents' sample changes over time, with a remarkable majority of females observed at the age of 33. This proportion levels off at the age of 46. Such a composition reflects the timing of specific waves: it is certainly more likely that, in a cohort of 33 year olds, there are more females than males who are already parents.

The tests evaluate individuals in multiple dimensions of cognition. In order to compute unified age-specific cognitive scores, we use the principal component analysis. Appendix 2 offers a more detailed description of the principal component procedure applied. We thus end up with unified cognition measures for the age of 7, 11, 16 and 50. The central aspect of our analysis is to measure how a parent evolves during his/her adult life in cognitive terms with respect to other cohort members and independently of the common age related decline. We thus measure in centiles the distributional shift accomplished by each parent in terms of cognitive abilities between the age of 16 and the age of 50. We first divide the distribution of cognitive abilities into centiles q_c (c = 1,...,100) and subsequently assign each individual an integer ranging from 1 to 100 corresponding to the c^{th} centile where her cognitive score falls into. We perform this transformation for the cognitive abilities measured at the age of 16 and the age of 50 separately. Finally, we deduct the centile position of an individual at the age of 16 (c_i^{16}) from the one at the age of 50 (c_i^{50}):

$$\Delta CA_i^{parent} = c_i^{50parent} - c_i^{16parent} \quad (1)$$

The measure ΔCA_i then is a cognitive shift performed by each individual during adult life, with possible values included in the interval [-99, 99]. The figure below shows the empirical distribution of this measure, both for the complete sample and for the sample with imputed data.

Figure 1: Parental cognitive profiles



In table 1 we provide generalized descriptive statistics on cognitive profiles of parents between the age of 16 and 50. In order to give an intuition on the cognitive aging patterns, we divide cohort members into high and low cognitive ability types, where the median is used as the cutoff point (hence $c = 1, 2$). We construct a two entry transition matrix, where the three possible cognitive aging profiles refer to parents who switch type from: high to low; low to high or do not change their type over the adult life.

Table 1: Transition profiles of cognitive abilities

	Low-ability age 50	High-ability age 50	Total
Low-ability age 16	2025 (33.27%)	1024 (16.83%)	3049 (50.10%)
High-ability age 16	1018 (16.73%)	2019 (33.17%)	3037 (49.90%)
Total	3043 (50.00%)	3043 (50.00%)	6086 (100%)

2.2 Dependent variables

The NCDS provides the offspring's cognitive outcomes within Peabody Individual Achievement Test (PIAT). This assessment is designed for children aged 5 or older and evaluates their cognitive skills in mathematics, reading recognition and comprehension. We impute the missing values following the procedure explained in Appendix 1 for children for whom the data does not report all the three test scores. As previously, in order to create unified age-specific cognitive scores, we use the principal component analysis. The principal component analysis is performed separately for each age/gender group since the aptitude tests differ according to the age of a child and there are likely to be systematic differences in test scores between boys and girls at early stages of life.[4] For further details concerning principal component

[4]The PIAT Math test measures the child's attainment in Mathematics as taught in the mainstream education. It consists of multiple-choice questions which range from the basic skills in recognizing digits to the advanced concepts of geometry and trigonometry. The PIAT Reading evaluates the child's skills in word recognition and pronunciation as well

analysis see Appendix 2.

The seventh wave of NCDS provides us with the information on educational attainment of the offspring. The wave is administered to cohort members when they are 46 years old, hence it is likely that at that time a number of the children is still in the education process. In fact, for a part of the offspring, the data reports the age when a child left full time education, whereas for children who are still in full time education, the data reports the number of years of schooling completed so far. We therefore combine the two information and compute the number of years that a child has spent in full time education, in order to include in the analysis the maximum number of observations/children and consider all the existing set of information.[5]

Tables 7 and 8 provide overall descriptive statistics for offspring and parents, respectively.

3 Empirical analysis

3.1 Model

We employ two distinct empirical specifications to estimate the intergenerational transmission of cognitive abilities and the role of parental cognitive transition on two offspring's outcomes, cognitive abilities (CA_i^{Child}) and years of schooling (Edu_i^{Child}). We therefore estimate separately the two following equations by means of ordinary least squares (OLS):

as the ability in deriving meaning from sentences that are read silently.

[5]In the empirical analysis we consider both types of information, the one on the sole children who have already completed the full time education, and the other on the number of years of schooling accomplished so far. This delivers a robustness check of the results on educational attainment of the offspring. The estimates performed on the combined measure are not reported in this paper.

$$
\begin{aligned}
CA_i^{Child} =& \alpha_0 + \alpha_1 \Delta CA_i^{Parent} + \\
& \alpha_2 CA_i^{7Parent} + \alpha_3 CA_i^{16Parent} + \\
& \boldsymbol{\alpha_4 X_i^{Child}} + \boldsymbol{\alpha_5 X_i^{Parent}} + \boldsymbol{\alpha_6 X_i^{Family}} + e_i
\end{aligned}
\tag{2}
$$

$$
\begin{aligned}
Edu_i^{Child} =& \beta_0 + \beta_1 \Delta CA_i^{Parent} + \\
& \beta_2 CA_i^{7Parent} + \beta_3 CA_i^{16Parent} + \beta_4 CA_i^{Child} + \\
& \boldsymbol{\beta_5 X_i^{Child}} + \boldsymbol{\beta_6 X_i^{Parent}} + \boldsymbol{\beta_7 X_i^{Family}} + u_i
\end{aligned}
\tag{3}
$$

where as defined before, $\Delta CA_i^{Parent} = c_i^{50} - c_i^{16}$ denotes the distributional transition of parental cognitive abilities. $CA_i^{16Parent}$ and $CA_i^{7Parent}$ are the levels of parental cognitive abilities as measured at the age of 7 and 16, X_i^{Child} is a vector of children individual characteristics including age, sex, birthweight and a dummy variable equal to 1 if the child was breastfed, X_i^{Parent} includes parents' socioeconomic status and education, X_i^{Family} is a vector of family traits including the number of the child's siblings, the parent's partner education and socioeconomic status as well as the region of residence of the child's family. Finally, e_i and u_i denote the error terms. In our analysis, for both dependent variables, child cognitive abilities and years of schooling, we start by estimating parsimonious models with explanatory variables set containing parental cognitive abilities ($CA_i^{16Parent}$), the cognitive transition variable (ΔCA_i^{Parent}) and the vector of child characteristics (X_i^{Child}). In order to test the robustness of the estimates, we increment the number of controls in both specifications, adding education attainment of both parents, as well as their socio-economic status, and finally the family traits (X_i^{Family}).

In order to correct for the fact that single cohort members may be parents of more than one child in the sample, we cluster the standard errors at the cohort member level.[6] The reference categories for education and socio-economic status is always the least educated and the lowest SES category.

3.2 Results

Table 9 and 10 present the coefficients and estimation results. Our findings point to a substantial degree of transmission of cognitive abilities across generations. When we examine the nexus between parental and offspring cognitive abilities, we learn that a one standard deviation increase in parental cognition as measured at the age of 16 is associated with a 0.36 standard deviation rise in the children's cognition. This coefficient decreases slightly (to 0.27) although remains positive and significant, once we control for the education attainment of parents, their socio-economic status and early childhood conditions of the offspring. Both the education attainment of parents and their socio-economic status seem to play no role for the cognitive abilities of the children, once we control for the parental level of cognition, family characteristics and early childhood conditions. Moreover, coefficients on variables related to family traits and early childhood features of the offspring provide interesting insights. Having been breastfed is associated with a 0.16 standard deviation increase in cognitive scores, while each additional ounce of birthweight with another 0.003. Furthermore, the stability of the relationship of the parents is associated with higher cognitive outcomes of children, with each additional year accounting for a 0.03 standard deviation of cognitive score increase. On the contrary, the number of siblings of the children seems to curb their cognitive scores. In fact, each additional child in the family is associated with a 0.08 standard deviation decrease in children's cognitive abilities.

An important result concerns the measure of parental cognitive transition.

[6] All standard errors are bootstrapped with 1000 replications.

The analysis suggests that when parents' cognitive ability scores shift from bottom to top tail of the distribution during adult life, children's cognitive abilities rise by a 0.25 standard deviation, net of the educational attainment, initial cognitive abilities and socio-economic status. The robustness of this outcome is confirmed by the fact that this relationship is stable and significant in all model specifications containing additional controls. Moreover, we estimate the model on two distinct samples, one where we ignore the imputations using the observations with complete data only (the complete case analysis), and the other where we impute the data on parental cognitive scores. In the second case we additionally correct for incorporating the imputed values by augmenting the regression model with a set of binary indicators for each covariate with missing values.[7] When we confront the estimates performed on the two samples we find that the coefficients and standard errors remain unchanged, which reinforces the robustness of the results. Moreover, coefficients on the dummy variables indicating imputed covariates are always statistically not significant. Our findings show that attenuating cognitive aging in parents is beneficial for the cognitive development of the next generation. So far, the literature has always focused on the stock of abilities accumulated by parents at early stages of their lives to investigate its effect in the intergenerational perspective. What our results add to this evidence is the importance of parental cognitive aging and the beneficiary effect of potential cognitive development for the parents themselves and their children.

Subsequently, we perform a similar analysis using as dependent variable the offspring's education attainment. The results are presented in Table 10. Starting from the parsimonious model presented in column 1, we see that one standard deviation of parental cognitive scores is associated with 0.35 year

[7] For the missing-indicator method see Little (1992), Horton and Kleinman (2007) and Little and Rubin (2002)

increase in years of education completed by children. Once we control for education and socio-economic status of parents, the coefficient on the stock of cognitive abilities measured at the age of 16 becomes no-longer significant.

Concerning the impact of parental cognitive shift, we find that parental transition from the bottom to the top tail of distribution of cognitive abilities increases by around a half year the amount of years spent by offspring in full time education, net of all other controls. This coefficient varies slightly between the complete case model an the imputed data results, but remains significant across all the model specifications. Moreover, the results show that while the stock of cognitive abilities as measured at the age of 16 ceases to be significant once we control for parental education attainment and socio-economic status, the cognitive evolution between the age of 16 and 50 remains significant. It is plausible, that the initial stock of parental cognitive abilities translates into educational and socio-economic outcomes, that is why once we control for the latter, the former are no longer significant. The results on cognitive transition on the other hand hold true, independently of the specification of the model. This outcome may support manifold interpretations. Cognitive aging can undoubtedly influence parenting style or upbringing efforts, which in turn are likely to encourage education attainment of children.

4 Determinants of the cognitive transition

Having assessed the importance of parental cognitive aging profiles for children's outcomes, in this section we investigate the determinants of parental cognitive evolution. For this purpose we carry out a simple OLS estimation based on the following specification:

$$\begin{aligned} \Delta CA_i^{Parent} =& \gamma_0 + \gamma_1 CA_i^{7Parent} + \gamma_2 CA_i^{11Parent} + \gamma_3 CA_i^{16Parent} + \\ & \boldsymbol{\gamma_4 Z_i^{EarlyChildhood}} + \boldsymbol{\gamma_5 Z_i^{Grandparents}} + \boldsymbol{\gamma_6 Z_i^{ParentSES}} \\ & \boldsymbol{\gamma_7 Z_i^{Partner}} + \boldsymbol{\gamma_8 Z_i^{Job}} + e_i \end{aligned} \quad (4)$$

Table 11 presents the results of the estimation performed on the entire sample of parents, as well as on mothers and fathers separately.

A key aspect of our analysis lies in variables concerning training courses, leisure activities and general wellbeing indicators of both males and females. We show that cognitive function of adult parents benefits from job related activities such as vocational trainings and on-the-job trainings offered by employers. A similar effect is found for leisure activities.[8] The evidence related to the influence of job and leisure trainings on cognitive aging has been frequently advocated in neuroscience literature (Scarmeas et al (2003); Ball et al (2002)). Nevertheless, the economic literature does not provide clear-cut evidence concerning the impact of training activities on cognition. Our findings contribute to this debate. In line with the human capital approach, we confirm the hypothesis that individuals can invest in repair activities and mitigate the effect of cognitive aging. In particular, our results suggest that investments in vocational trainings (for women) and on-the-job trainings (for men) have a strong and positive impact on the cognitive function of adults. The effect of vocational training accounts for a 3 centile upward shift for females, whereas the impact of on-the-job trainings causes a similar shift for males. As far as leisure activities are concerned, they also seem to attenuate age-related cognitive decline. Moreover, males who are subject to frequent job variations, undergo a weaker cognitive decline over the lifetime.

In this part of analysis we also control for factors related to early childhood conditions of cohort members. Higher birthweight and having been breastfed have both an important contribution to the cognitive evolution in adult life. In particular the coefficient on breast feeding is high and statistically significant for females. An important aspect for the cognitive aging evolution is rooted in the educational attainment: having the highest ed-

[8] Leisure activities refer to courses for personal interest or leisure which the cohort member has done since he left full-time education.

ucation level translates approximately in an 8 centile upward shift of the cognitive skills between the age of 16 and 50, with this effect being equally strong for females and males. On the other hand, socio-economic status has an important impact on the attenuation of cognitive aging for females, with the high skilled women gaining around 6 centiles above the unskilled ones.

In order to investigate the aspect of assortative mating, we control for the education attainment and employment status of parents' partners. While the employment status of partners seems to have no important role for cognitive function of males and females, we find that having a low educated partner is associated with a downward shift of cognitive abilities especially for males.

Moreover, we use a composite indicator of individual wellbeing, malaise score, which combines subjective health problems as well as aspects of life satisfaction[9]. The index ranges form 0 to 9, with 9 indicating the worst shape. We find an important role of malaise indicator, which is associated with a deterioration of cognitive function, in particular for males.

5 Conclusions

Our analysis confirms the hypothesis that a substantial degree of cognitive abilities is transmitted across generations. The novelty of our approach however is based on a measure of parental cognitive evolution during adult life which reflects parental cognitive transition between the age of 16 and 50. We find that children's outcomes - as measured by cognitive abilities and education attainment - benefit from a slower deterioration of parents' cognitive abilities over time, net of the initial level of parental cognitive scores. This finding is robust under numerous specifications of the model. Our evidence

[9]This score accounts for feeling: i) tired; ii) miserable or depressed; iii) easily worried about things; iv) easily violent; v) scared for no good reason; vi) easily upset or irritated; vii) keyed-up or jittery; viii) nervous; ix) anxious.

provides an important contribution to the existing literature which studies the role of cognitive abilities' stock measured in a single point in time. We find that a child benefits not only form the level of cognitive abilities her parents had when they were kids, but also from the cognitive function the parents achieved as adults.

In a further step, we invoke the human capital approach which argues that individuals may invest in repair activities to attenuate the process of cognitive aging. We thus identify activities which stimulate cognition function during adult life, and as a result curb the process of cognitive decline. We provide novel results on the relationship between parental cognition patterns and activities related to on-the-job trainings and leisure. Although job-related trainings are originally designed to foster the productivity and employability of their participants, we shed light on the positive externalities of such programs on adults' cognition, which in turn boosts the offspring's outcomes. From the policy perspective, it is important to further investigate and qualify this relationship. It would allow to design policies serving a dual purpose: attenuate parental cognitive aging and, indirectly, foster the human capital accumulation of the offspring.

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Appendix 1

We impute missing data on parental cognitive test scores measured at age of 7, 11, 16 and 50 as well as on cognitive outcomes of the offspring. We impute test scores at each age separately if one of multiple assessment scores is missing. To perform the imputation, we identify a set of fundamental explanatory variables which are likely to affect cognition: i) other test scores administered at the same age, ii) years of education completed by both parents, iii) father's socio-economic status, and iv) region of residence reported at the age when the assessment took place.

Hence to perform the imputation, for each individual i with missing data in wave t on cognitive abilities score j we use other cognitive scores k belonging to the cognitive assessment performed at the same wave t together with a set of "key" explanatory variables with complete data. The procedure boils down to a standard imputation where the following equation is estimated and an "out-of complete sample" prediction is made.

$$C_{ijt} = f(C_{ikt}, Gender, Schooling^{parents}, SES^{parents}, Region) \tag{5}$$

We additionally construct a set of missing-indicators dummy variables which subsequently augment our regression models controlling for each covariate with missing values.

Appendix 2

The NCDS provides multiple assessments of parental abilities. Cohort members undergo cognitive appraisals at the age of 7, 11, 16 and 50. Moreover, at each age the assessments include various tests. The focal point of our analysis is the course of parental cognition between the age of 16 and 50. We therefore use principal component analysis for a dual purpose: we first want to detect patterns in test scores between the age of 16 and 50 in order to examine differences and similarities between them, and second, we want to obtain at each age one compressed measure of cognition without much loss of information. For all principal component analysis we use Stata `factor` command.

In the first step, principal component analysis allows us to identify the tests which capture the same cognitive dimension at age of 16 and 50, hence comparable across time. Table 2 shows the results of the principal component analysis performed on pooled test scores for the age of 16 and 50. This preliminary outcome indicates two factors retained, which respectively account for 36% and 23% of the variance. From Table 3 a clear pattern of loadings emerges: factor 1 (the principal component) captures the cognitive dimension which is common to adolescence and adulthood. It indicates that age 16 tests scores (Mathematics and Reading) capture the same dimension of the first three age 50 test scores (World list recall, Animal naming and Delayed word list recall). The other factor accounts for the variability underlying solely the two remaining scores obtained at the age of 50 (Letter cancellation speed and Letter cancellation accuracy). We will therefore consider only the first three test scores when constructing age specific synthesized cognitive measures.

In the next step, we use principal component analysis in order to generate unified age specific cognition measures. We extract principal components relative to cognitive scores measured the age of 7, 11, 16 and 50. As shown in

Table 4, at each age principal components account for the most of the relationship between the cognitive scores. Since the eigenvalues of the remaining factors can be considered ignorable, without significant loss of information, we concentrate only on principal components. For each age, the synthesized cognitive abilities measure is obtained using the scoring regression method as suggested by Thomson (1951).

Table 2: Principal component analysis of cognitive scores at age 16 and 50

Factor	Eigenvalue	Difference	Proportion	Cumulative
1	2.525	0.901	0.3609	0.3609
2	1.624	0.652	0.2321	0.5930
3	0.971	0.196	0.1388	0.7318
4	0.775	0.353	0.1108	0.8425
5	0.421	0.061	0.0603	0.9028
6	0.359	0.0394	0.0514	0.9542
7	0.320	.	0.0458	1.000

Table 3: Factor loadings at age 16 and 50

Variable	Factor 1	Factor 2	Uniqueness
Mathematics age 16	0.752	-0.008	0.4336
Reading age 16	0.7658	0.0006	0.4135
Word list recall age 50	0.7162	0.0151	0.4868
Animal naming age 50	0.5672	0.0862	0.6709
Delayed word list recall age 50	0.6982	-0.072	0.5124
Letter cancellation speed age 50	0.1595	0.8988	0.1667
Letter cancellation accuracy age 50	-0.1468	0.9016	0.1655

Table 4: Principal component analysis outcomes for age 7, 11, 16 and 50

	age 7 (2 scores)		age 11 (3 scores)		age 16 (2 scores)		age 50 (3 scores)	
	Eigenval.	Var	Eigenval.	Var	Eigenval.	Var	Eigenval.	Var
Factor 1	1.56	0.78	2.55	0.85	1.67	0.84	1.80	0.60
Factor 2	0.44	0.22	0.27	0.09	0.33	0.16	0.78	0.25
Factor 3			0.18	0.06			0.42	0.15

When the parents are 33 years old, a randomly sampled one third of their children is administered with a multidimensional cognitive assessment. The children are evaluated within three tests, based on reading comprehension, reading recognition and mathematics. Also in this case, we use the principal component analysis in order to create a synthesized measure of cognitive abilities. We compute the analysis separately for sons and daughters of each age. Table 5 shows a sample output of principal component analysis, here performed on test scores of sons aged 10. The results are fairly the same for children of different age and sex. Again, the Keiser criterium retains only one factor (the principal component). Table 6 presents the factor loadings/correlation between each cognitive test score and factor 1 (the principal component). Again, the synthesized cognitive abilities measure of children's outcomes is obtained using the scoring regression method suggested by Thomson (1951).

Table 5: Principal component analysis of offspring's cognitive scores

Factor	Eigenvalue	Difference	Proportion	Cumulative
1	2.511	2.028	0.8373	0.8373
2	0.483	0.478	0.1611	0.9984
3	0.004	.	0.0016	1.000

Table 6: Factor loadings of offspring's cognitive scores

Variable	Factor 1	Uniqueness
Mathematics	0.7999	0.3602
Reading Comprehension	0.9678	0.0633
Reading Recognition	0.9672	0.0646

Table 7: Summary statistics children sample

Variable	Mean	Std. Dev.	Min.	Max.	N
child sex	0.491	0.5	0	1	2574
child age	8.673	2.828	5	16	2574
child breastfed	0.625	0.484	0	1	2519
child birthweight	115.607	20.783	0	211	2467
siblings	2.12	0.986	1	6	2574
parent lone	1.103	0.303	1	2	2574
lenght	11.187	3.267	0	18	2259
parent cognition 16	-0.123	1.014	-3.217	2.533	2574
parent schooling I	0.161	0.368	0	1	2574
parent schooling II	0.367	0.482	0	1	2574
parent schooling III	0.112	0.315	0	1	2574
parent schooling IV	0.115	0.319	0	1	2574
parent schooling V	0.051	0.221	0	1	2574
partner education 0	0.249	0.433	0	1	2574
partner education I	0.421	0.494	0	1	2574
partner education II	0.139	0.346	0	1	2574
partner education III	0.074	0.262	0	1	2574
parent's partner SES - professional	0.03	0.169	0	1	2574
parent's partner SES - managerial	0.19	0.393	0	1	2574
parent's partner SES - skilled non manual	0.112	0.315	0	1	2574
parent's partner SES - skilled manual	0.203	0.402	0	1	2574
parent's partner SES - partly skilled	0.128	0.334	0	1	2574
parent's partner SES - unskilled	0.04	0.195	0	1	2574
parent SES - professional	0.028	0.166	0	1	2574
parent SES - managerial	0.193	0.395	0	1	2574
parent SES - skilled non manual	0.256	0.437	0	1	2574
parent SES - skilled manual	0.168	0.374	0	1	2574
parent SES - partly skilled	0.197	0.397	0	1	2574
parent SES - unskilled	0.068	0.251	0	1	2574

Table 8: Summary statistics parents' sample

Variable	Mean	Std. Dev.	Min.	Max.	N
parent cognitive transition imputed	-3.323	33.64	-95	90	6359
parent cognitive transition complete sample	-3.056	32.529	-95	88	6270
parent cognitive abilities age 7	-0.004	0.976	-3.338	1.856	6359
parent cognitive abilities age 11	0.124	1.028	-2.788	2.78	6359
parent cognition 16	0.131	1.067	-3.891	2.635	6359
males	0.479	0.5	0	1	6359
parent birthweight	117.677	18.293	36	204	6359
parent breastfed	0.668	0.471	0	1	6359
parent handicap age 16	0.043	0.204	0	1	6359
grandfather SES age 16- intermediate	0.168	0.374	0	1	6359
grandfather SES age 16- skilled non-manual	0.073	0.26	0	1	6359
grandfather SES age 16- skilled manual	0.335	0.472	0	1	6359
grandfather SES age 16- semiskilled	0.103	0.304	0	1	6359
grandfather SES age 16- unskilled	0.034	0.182	0	1	6359
parent schooling I	0.107	0.309	0	1	6359
parent schooling II	0.304	0.46	0	1	6359
parent schooling III	0.125	0.331	0	1	6359
parent schooling IV	0.132	0.339	0	1	6359
parent schooling V	0.114	0.318	0	1	6359
parent SES - professional	0.04	0.195	0	1	6359
parent SES - managerial	0.259	0.438	0	1	6359
parent SES - skilled non manual	0.209	0.407	0	1	6359
parent SES - skilled manual	0.167	0.373	0	1	6359
parent SES - partly skilled	0.122	0.327	0	1	6359
parent unemployed	0.02	0.139	0	1	6359
parent employed full-time	0.55	0.498	0	1	6359
parent part-time employed	0.168	0.374	0	1	6359
parent self-time employed	0.135	0.342	0	1	6359
parent does not work	0.059	0.235	0	1	6359
parent retired	0.007	0.081	0	1	6359
parent disabled	0.05	0.218	0	1	6359
parent lives alone	0.065	0.246	0	1	6359
vocational trainings	0.198	0.399	0	1	6359
on-the-job trainings	0.379	0.485	0	1	6359
leisure trainings	0.209	0.407	0	1	6359
multi jobs	0.066	0.248	0	1	6359
malaise index	1.457	1.92	0	9	6359
partner employed	0.709	0.454	0	1	6359
partner education 0	0.16	0.367	0	1	6359
partner education I	0.325	0.468	0	1	6359
partner education II	0.166	0.372	0	1	6359
partner education III	0.124	0.329	0	1	6359

Table 9: Estimates for child cognitive abilities

	(a) imputed	(a) complete	(b) imputed	(b) complete	(c) imputed	(c) complete
child sex	-0.017	-0.034	-0.008	-0.021	0.002	-0.004
	0.038	0.044	0.038	0.044	0.042	0.048
child age	0.026***	0.032***	0.041***	0.048***	0.035***	0.037***
	0.007	0.008	0.007	0.008	0.008	0.010
parent cognitive ab.16	0.365***	0.386***	0.276***	0.293***	0.254***	0.272***
	0.026	0.029	0.028	0.032	0.032	0.036
parent cognitive shift	0.003***		0.003***		0.003***	
	0.001		0.001		0.001	
parent cognitive shift		0.004***		0.003***		0.003**
		0.001		0.001		0.001
parent schooling I			0.119	0.213*	0.055	0.194*
			0.072	0.086	0.076	0.091
parent schooling II			0.257***	0.326***	0.111	0.211*
			0.063	0.073	0.071	0.083
parent schooling III			0.285***	0.338***	0.176*	0.212*
			0.082	0.095	0.089	0.103
parent schooling IV			0.356***	0.355***	0.199*	0.210
			0.082	0.095	0.093	0.111
parent schooling V			0.272*	0.252	0.160	0.149
			0.118	0.131	0.131	0.147
partner education I			0.139	0.113	-0.082	-0.061
			0.072	0.087	0.188	0.234
partner education II			0.303***	0.333***	0.035	0.130
			0.085	0.100	0.195	0.242
partner education III			0.365***	0.375**	0.068	0.128
			0.105	0.120	0.209	0.254
child breastfed					0.158***	0.146**
					0.046	0.055
child birthweight					0.003**	0.003*
					0.001	0.001
siblings					-0.081***	-0.089***
					0.023	0.026
parent lone					0.119	0.307
					0.303	0.347
lenght					0.024**	0.030**
					0.008	0.010
parent professional					0.036	-0.136
					0.181	0.203
parent managerial					0.143	0.025
					0.122	0.142
parent skilled non manual					0.207	0.053
					0.115	0.135
parent skilled manual					0.038	-0.115
					0.117	0.138
parent partly skilled					0.090	-0.076
					0.116	0.135
parent unskilled					0.031	-0.177
					0.144	0.168
partner professional					0.017	-0.009
					0.124	0.133
partner managerial					0.117	0.059
					0.075	0.089
partner skilled non manual					-0.034	-0.052
					0.083	0.096
partner skilled manual					-0.053	-0.113
					0.073	0.085
partner partly skilled					-0.038	-0.055
					0.085	0.094
partner unskilled					-0.093	-0.119
					0.095	0.117
N	2574	1883	2574	1883	2183	1619
R2	0.11	0.11	0.13	0.14	0.16	0.17

We control for the regions of residence

We control for the imputation by inserting a dummy variable

Bootstrapped clustered standard errors, p<0.01**, p<0.05*, p<0.1***

Table 10: Estimates for child years of schooling

	(a) imputed	(a) complete	(b) imputed	(b) complete	(c) imputed	(c) complete
child cognitive ab.	0.507***	0.533***	0.477***	0.493***	0.412***	0.466***
	0.087	0.094	0.091	0.102	0.092	0.104
child sex	-0.223	-0.281	-0.205	-0.281	-0.186	-0.274
	0.149	0.157	0.158	0.166	0.168	0.175
child age	0.223***	0.214***	0.241***	0.240***	0.240***	0.220***
	0.036	0.039	0.039	0.042	0.041	0.044
parent cognitive ab.16	0.351**	0.405**	0.149	0.185	0.039	0.079
	0.118	0.132	0.140	0.157	0.141	0.161
parent cognitive shift	0.004**		0.004**		0.004**	
	0.001		0.001		0.001	
parent cognitive shift		0.006**		0.005**		0.005**
		0.002		0.002		0.002
parent schooling I			0.306	0.195	0.347	0.131
			0.296	0.319	0.334	0.356
parent schooling II			0.729**	0.547	0.756*	0.578
			0.276	0.290	0.302	0.330
parent schooling III			1.033**	0.990**	1.029*	0.960*
			0.352	0.370	0.398	0.412
parent schooling IV			1.094**	1.046**	1.208**	1.163**
			0.369	0.393	0.401	0.444
parent schooling V			1.208	0.909	0.989	0.524
			0.696	0.741	0.593	0.602
partner education I					-0.406	0.211
					0.625	0.369
partner education II					-0.119	0.351
					0.665	0.448
partner education III					0.085	0.942
					0.699	0.499
child breastfed					0.483**	0.472*
					0.172	0.186
child birthweight					0.000	0.000
					0.004	0.005
siblings					-0.092	-0.057
					0.097	0.111
parent lone					-0.022	-0.608
					0.725	0.476
lenght					0.011	0.000
					0.029	0.029
partner professional					0.460	0.382
					0.567	0.589
partner managerial					0.187	0.405
					0.285	0.297
partner skilled non manual					-0.007	0.109
					0.331	0.342
partner skilled manual					-0.120	0.083
					0.292	0.296
partner partly skilled					0.168	0.284
					0.300	0.299
partner unskilled					-0.313	-0.268
					0.429	0.463
parent professional					1.098	0.780
					0.702	0.710
parent managerial					0.529	0.570
					0.443	0.495
parent skilled non manual					0.941*	0.838
					0.417	0.485
parent skilled manual					0.400	0.593
					0.431	0.494
parent partly skilled					1.095*	1.170*
					0.485	0.537
N	633	554	571	499	558	490
R2	0.18	0.20	0.22	0.23	0.26	0.26

We control for the regions of residence

We control for the imputation by inserting a dummy variable

Bootstrapped clustered standard errors, p<0.01**, p<0.05*, p<0.1***

Table 11: Estimates for parental cognitive transition

	(a) imputed	(a) complete	(b) males imputed	(b) males complete	(c) females imputed	(c) females complete
parent cognitive ab.7	0.637	0.758	0.796	0.864	0.567	0.733
	0.490	0.452	0.748	0.689	0.648	0.599
parent cognitive ab.11	5.970***	5.333***	5.702***	4.729***	6.187***	5.898***
	0.609	0.565	0.899	0.834	0.829	0.764
parent cognitive ab.16	-21.584***	-22.952***	-21.552***	-22.483***	-21.715***	-23.463***
	0.580	0.546	0.854	0.805	0.795	0.743
male	3.851***	-0.522				
	0.920	0.852				
parent birthweight	0.044*	0.039*	0.058	0.046	0.035	0.034
	0.020	0.019	0.030	0.028	0.027	0.025
parent breastfed	2.433**	2.209**	0.854	0.697	4.069***	3.755***
	0.781	0.722	1.129	1.040	1.085	1.007
parent handicap age 16	-3.025	-2.842	-2.638	-1.984	-3.642	-3.892
	1.729	1.658	2.401	2.266	2.492	2.432
vocational trainings	2.095*	1.641*	1.218	0.908	2.714*	2.067*
	0.929	0.805	1.392	1.256	1.246	1.010
on-the-job trainings	2.659**	2.620***	3.405**	3.331**	1.604	1.665
	0.869	0.788	1.273	1.153	1.193	1.083
leisure trainings	2.368*	1.802*	1.708	1.314	2.674*	1.960*
	0.920	0.846	1.388	1.279	1.238	0.933
multi jobs	2.855*	3.120*	7.302**	6.801**	-0.245	0.580
	1.417	1.347	2.294	2.081	1.974	1.769
malaise index	-0.808***	-0.808***	-1.315***	-1.297***	-0.523*	-0.508*
	0.200	0.189	0.330	0.313	0.251	0.237
grandfather intermediate	-1.927	-2.280	-4.333	-4.361*	0.453	-0.351
	1.611	1.471	2.367	2.163	2.209	2.012
grandfather skilled non manual	1.031	-0.175	-1.233	-2.489	3.386	1.852
	1.915	1.749	2.814	2.564	2.620	2.403
grandfather skilled manual	-0.055	-0.106	-1.246	-1.550	1.188	1.115
	1.498	1.373	2.228	2.040	2.027	1.853
grandfather semiskilled	-0.325	-0.133	-0.184	-0.409	0.066	0.296
	1.792	1.654	2.680	2.464	2.391	2.214
parent schooling I	2.995*	3.522**	3.720	2.416	2.774	4.361*
	1.435	1.355	2.354	2.155	1.813	1.705
parent schooling II	1.078	1.185	1.309	-0.008	0.909	1.832
	1.227	1.159	1.911	1.755	1.614	1.508
parent schooling III	2.486	2.121	3.646	1.715	0.691	1.546
	1.562	1.448	2.136	1.958	2.422	2.236
parent schooling IV	-0.113	0.247	-0.288	-1.778	-0.809	1.052
	1.617	1.506	2.376	2.175	2.218	2.057
parent schooling V	7.484***	8.103***	7.791**	7.455**	6.340*	7.661**
	1.902	1.759	2.655	2.444	2.758	2.534
parent professional	2.927	3.098	1.368	1.746	8.349*	7.687*
	2.311	2.112	3.004	2.735	3.876	3.456
parent managerial	4.049**	3.693**	2.701	2.544	6.277***	5.408**
	1.347	1.264	2.025	1.856	1.856	1.732
parent skilled non manual	2.031	2.009	5.133*	4.408	1.654	1.446
	1.326	1.256	2.468	2.263	1.605	1.512
parent skilled manual	-0.091	0.750	-0.636	0.777	0.974	0.376
	1.391	1.318	1.948	1.787	2.328	2.189
parent partly skilled	2.974*	3.471**	0.554	1.776	4.785**	4.522**
	1.393	1.338	2.347	2.176	1.736	1.652
parent unemployed	-2.147	-2.715	-5.882	-6.493	-1.525	-2.389
	2.850	2.692	4.993	4.808	4.480	4.249
parent employed full-time	-2.634	-3.489	-5.832	-6.687	-2.409	-3.200
	2.741	2.584	5.531	5.451	3.307	3.012
parent part-time employed	-1.060	-2.158	-1.450	-3.212	-1.144	-2.123
	2.804	2.635	7.027	6.759	3.331	3.040
parent self-time employed	1.399	0.863	-2.209	-3.052	2.466	2.084
	1.796	1.691	4.103	4.008	2.450	2.281
parent retired	5.996	3.729	10.193	7.460	-2.269	-3.659
	5.094	4.721	7.889	7.476	6.518	6.009
parent disabled	-4.518*	-4.316	-9.569*	-9.296	-2.057	-2.113
	2.201	2.214	4.729	4.784	2.664	2.672
parent lives alone	1.576	1.331	3.912	4.452*	-1.568	-2.579
	1.656	1.565	2.220	2.080	2.504	2.364
partner employed	1.552	1.379	2.046	2.263	0.960	0.385
	0.897	0.827	1.329	1.215	1.218	1.126
partner education I	-2.629**	-3.181**	-3.716*	-3.179*	-1.978	-2.542*
	0.945	1.075	1.465	1.346	1.256	1.170
partner education II	-1.762	-2.295	-3.487*	-3.140*	0.001	-0.181
	1.190	1.250	1.724	1.581	1.711	1.572
partner education III	0.517	0.087	-0.919	-0.548	1.492	1.212
	1.416	1.414	2.178	1.995	1.891	1.707
N	6359	6270	3048	3000	3311	3270
R2	0.26	0.34	0.27	0.34	0.27	0.35

We control for the regions of residence, we control for the imputation by inserting a dummy variable, bootstrapped clustered standard errors, $p<0.01$**, $p<0.05$*, $p<0.1$***