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Making it right? Social norms, hand writing and cognitive skills

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Making it right? Social norms, hand writing and cognitive skills

Preliminary Version — Please do not cite

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Abstract

Forcing a left-handed child to use the right hand for writing was long common practice in the Western world. Although it is rare now in these societies, it is still highly prevalent in developing countries and across various cultures. In this paper we investigate how this intervention affected educational outcomes and cognitive skills in German adults in the mid and long run. Forced right-hand writing is a rare early childhood intervention that was performed on a large scale and throughout history. To identify causal effects we use the decline of the right-hand writing norm across cohorts in a difference-in-differences first stage, where right-handers serve as counterfactual group. While OLS estimates indicate that treated individuals obtained more years of education and better math grades (compared to all others), our 2SLS coefficients suggest zero or negative effects for educational outcomes, and strong negative effects on cognitive skills. These findings are in line with brain scans that show reduced gray matter in the putamen of switched German adults, which is responsible for motor skills and cognitive functioning.

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1 Introduction

Throughout history, left-handers faced superstition, stigmatization and discrimination in various areas of life [Harris, 1980]. To a significant extent, prejudices on left-handers inferiority originate in religion, but not exclusively. For example China has one of the lowest reported left-hander rates, where right-hand writing is a social convention and tradition, rooted in the strict stroke order of Chinese characters [Kushner, 2013]. In Christianity the left hand is considered to be the devils hand and in Islam it is forbidden to use the left hand for eating and human interaction. On more practical grounds, the world is designed for right-handers, in particular machinery and equipment. Forcing a left-handed child to use the right hand for writing and other daily activities thus seems to be for the child's long-term benefit. In this paper we show the contrary. This practice, called switching from now on, is a potentially life-changing intervention, that reduces cognitive capabilities as measured in German adults.

Switching was common practice in Europe and North-America until a few decades ago, but is still prevalent among developing countries in Asia, Africa, the Middle-East, and South America [Medland et al., 2004, Porac and Martin, 2007, Kushner, 2013]. Since the share of left-handers in the population is estimated to be around 10 to 15% [McManus, 2009], our findings are relevant for a considerable share of the population and in particular for educational policymakers in these countries. More general, our results document long-term consequences of treatments that affects children's brain structure at a young age where the brain plasticity is still relatively high.

Our sample is drawn from the German Socio-Economic Panel (SOEP). As part of a grip strength measurement module, respondents were asked "Are you a natural right- or left-hander?" and "With which hand do you actually write?".¹ We take a difference in the answers to these questions as an indication for switching of the writing hand. The grip strength measurement module was part of the survey in 5 waves biannually from 2006 to 2014. To the best of our knowledge, the SOEP is the only large-scale data source that allows to differentiate between switched and non-switched left-handers. Other general or health surveys such as the HRS, ELSA or SHARE collect only one variable on the individuals handedness, which may or may not be the hand used for writing.² The SOEP also contains rich socio-economic background and outcome variables for all individuals as well as cognitive and non-

¹See Ambrasat and Schupp, 2011(in German only) for further details on the grip strength measurement.

²The survey question usually asks for the participants dominant hand.

cognitive skill measures for subsamples.

Switching is a deliberate choice by parents or teachers and thus unlikely to be free of unobservable confounding factors. We consider a simple parental child-investment model and discuss which direction of selection can be expected along different dimensions of the model. These predictions are broadly confirmed by our data. The model also motivates our identification strategy by incorporating social norms into the investment decision. To identify causal effects, we employ a difference-in-differences approach in the first stage of a two-stage least-squares estimation using differing cohort trends between left- and right-handers. Outcome trends of right-handers, who were never switched, serve as a counterfactual for left-handers.

Our data show that the norm of right-hand writing diminishes rapidly across cohorts. Starting among cohorts born in 1950, switching rates decline monotonically from about 90% to 60% by 1960 and to nearly zero in 1990 in Germany.³ The downward trend is steepest among individuals born in the 1960's, whose parents were the first generation to be raised after the Second World War and who became increasingly reluctant to adopt the norms of their parents. Thus, the observed pattern originates in a change of the *Zeitgeist* on parenting, education and the importance of religion, and not in the long-term consequences of switching, which were not known at this point of time in Germany [Sattler, 1996].⁴ It is also unlikely that our findings are driven by special treatment of left-handed children. It was not until the late 1980's when educational policymakers recognized that teachers should adapt their writing lessons to the needs of left-handed child. Nevertheless, it might be the case that changing attitudes towards left-handedness materialized not only in lower switching rates, but also in less social stigma, which itself may drive our results. We investigate this issue in our data and find our results robust to these concerns.

We consider two sets of outcome variables. The first contains intermediate measures of human capital such as years of education and self-reported grades in math and German. The second consists of two measures of cognitive skills, the symbol-digit-test (SDT) and the animal naming task (ANT), which we consider as long-term outcomes.⁵ Simple OLS estimates show that switched individuals achieve about half a year more education and perform significantly better in math than right- or

³Note that the school entry age in Germany is 5 to 7, usually 6, and that children learn to write in first grade (corresponds to kindergarten in the US).

⁴The short term effects of switching, such as stuttering, concentration and attention problems, were known, however. Although three studies were published in the 1970's that discouraged switching, these were largely ignored by parents and policymakers alike and are unlikely to have had an impact on the practice [Sattler, 1996]. We are thus confident that the decline in switching rates is orthogonal to long-term effects on cognitive skills, which we focus on.

⁵See Lang et al. [2007] for the validity and reliability of these tests in the SOEP.

non-switched left-handers. The latter group performs worst on these measures. IV regression coefficients however are close to zero and even suggest negative effects when excluding migrants from the sample. For cognitive skills, IV estimates clearly show a large negative effect on the SDT in the order of about one-third of a standard deviations and 0.14 on the ANT. Our results prove also robust to a range of difference-in-differences specifications, inclusion of covariates, and exclusion of certain demographic groups.

This paper addresses two strands of literature. The first one is the formation of cognitive and non-cognitive skills during childhood. The accumulation of human and social capital during this sensitive period is considered to be one of the most important determinants of future economic success in various dimensions, such as education, income, health, and criminality [Heckman, 2007, 2008]. Experimental evidence from the Perry Pre-school program [Schweinhart et al., 2005] and the Abecedarian program [Campbell et al., 2002], have shown that early childhood interventions around school entry age can enhance cognitive and non-cognitive skills permanently, and that these are followed by huge benefits later in life [Cunha et al., 2006, Heckman et al., 2013]. However, there exist few studies that are able to exploit natural experiments to study long-term effects of interventions, see Currie and Almond, 2011 for an overview. We add to this literature by studying a practice that was both early and an intervention, as it was performed at school entry age and was intended to significantly change the child’s behavior. Furthermore, switching is a rare case of a non-institutional intervention which was administered at the micro level and in a considerable share of the population. At last, to the best of our knowledge no study so far concerned the impact of a treatment that, knowingly or unknowingly, can cause negative effects on those treated.

The second branch of literature to which we contribute concerns the economic consequences of handedness. Denny and O’Sullivan [2007] find a wage premium for left-handedness among males and a wage penalty for women. Similar observations have been made by Ruebeck et al. [2007]. On the other hand, Johnston et al. [2009] and Johnston et al. [2013] find that left-handed children in the Longitudinal Study of Australian Children (LSAC) and in the NLSY perform worse on cognitive development test scores than right-handed children. Goodman [2014] continues to debunk the myth of the gifted lefty. Using five comprehensive data-sets from the US and UK, he showed that left-handed children have significantly lower cognitive skills, years of schooling, and are more likely to suffer from learning disabilities and behavioral problems. Left-handed adults earn lower wages because they select into occupations that require lower levels of cognitive skills. We add to this literature by investigating to what extent switching the writing hand is responsible for the

deficits observed among adults, while allowing for and estimating a direct effect of left-handedness.

This paper proceeds as follows. In the next section, we briefly review some literature on left-handedness and how switching may effect the child. Section 3 introduces the data and describes the prevalence of left-handedness and switching in our sample. Section 4 theoretically and empirically discusses selection into switching and explains our identification strategy. Results are presented in section 5 and robustness checks in section 6. Finally, we conclude in section 7.

2 Handedness and Switching

A large literature on the origins and consequences of left-handedness, or laterality, exists in neuro-psychology, neuro-sciences and related fields. The origins of left-handedness are still quite unclear and different theories are prevalent.⁶ Psychologists are mostly concerned with the relation of left-handedness to mental health and cognitive functioning, see for example Coren [2012]. Many of these studies seem to confirm prejudices about lower cognitive capabilities and mental health among left-handers, but results are often mixed as the mode of measuring handedness and the sampled population vary greatly.⁷ Goodman [2014] made similar and additional observations among children and adults in different cohorts of the NLSY, the National Child Development Study and the British Cohort Study. These findings corroborate to the idea of a pathological left-hander [Satz, 1972]. According to this theory, even mild damage to the left brain hemisphere during the pre- or perinatal period can cause a shift of laterality to the right hemisphere. Hence, lower cognitive skills, mental problems and left-handedness might have the same cause.

In contrast to handedness, the direct consequences of switching are much less well researched, whether in psychology nor in any other science.⁸ This comes as a surprise, because as Perelle and Ehrman [2005] and Vuoksimaa et al. [2009] note, switching may also be a cause for the mixed results in the laterality literature, as most studies do not concern this issue in their measurement of handedness across different cohorts. Our knowledge on how switching of the writing hand may affect an individual is drawn from Sattler [1996]. Channels can broadly be divided into two categories. The first one are of a psychological nature. Applied methods of switching range from friendly persuasion and positive incentives to threats, parental neglect,

⁶See Johnston et al. [2013] for a short summary and McManus [2009] for an overview on the prevalence of left-handedness across time and geography.

⁷Medland et al. [2004] and Perelle and Ehrman [2005] for a discussion on this topic.

⁸Previous work in psychology was done e.g. by Porac et al. [1986], Porac and Searleman [2002].

beatings, and breaking of the left-arm [Perelle and Ehrman, 1994, Sattler, 1996]. In school, those forced to switch writing hands have to invest an over-proportional share of their energy and concentration capacity in learning to write with the wrong hand. Hence they are quickly exhausted, are less able to follow the lessons, and are more likely to become stigmatized as a problematic child by teachers and peers. The second category of channels can be labeled as physiological. Brain scans of switched German left-handers have shown that switching does not truly alter a person's handedness, as measured by the location of higher order motor control areas. Instead, one can see shifts of executive motor regions from the right to the left brain hemisphere [Siebner et al., 2002, Klöppel et al., 2007]. Moreover, Klöppel et al. [2010] find that the volume of gray matter in the putamen, a part of the forebrain that controls movements and learning [Packard and Knowlton, 2002], is reduced among switched German adults, compared to non-switched right- and left-handers. This could be a consequence of pruning unused brain matter during childhood. It may be this form of scarring of the brain, that can give rise to long-term consequences on cognitive skills. However, confronted with these multiple and little understood psychological and physiological mechanisms that may connect switching to educational outcomes or cognitive capabilities, we will stay agnostic about them for the rest of this paper.

3 Data

3.1 Key Variables

The German Socio-Economic Panel (SOEP) biannually conducted grip strength measurements on parts of its sample from 2006 to 2014. Included in this module are two questions on natural handedness and actual writing hand. The gross sample comprises 13,240 individuals that participated at least once in the grip strength measurements. The share of missing answers to the innate handedness question is 1.59% and 2.56% for the writing hand. Note that these questions were asked regardless of a successful grip strength measurement which followed afterwards. Information on innate and writing hand is available for more than half of individuals that refused the grip strength measurement or for which no valid values could be obtained.

We find that the answer to the innate and writing hand questions varies substantially within individuals across survey waves. On average, 27.95% (35.03%) of individuals that identify themselves as innate left-handers (write with left hand) in one year, report being right-handed (write with right hand) in the next year. The transition rate from right to left is only 1.84% (0.98%). About 43% of individuals participate once, 23% two times, 11% three times, 9% four times, and 14% five times

in the grip strength module. Observations from individuals that participated only once in the grip strength module are most unreliable as we cannot observe if they would change their answer if asked again. Given this limitation, we can construct three indicators for left-handedness and respectively switching, denoted as L_1 , L_2 , L_3 and S_1 , S_2 , S_3 . Let \tilde{L} (\tilde{S}) be a dummy equal to one if an individual reports being left-handed (switched) in a given wave t and T denote the number of waves the individual participated in the grip strength module.⁹ Then, our six measures are defined as

$$\begin{aligned} L_1 &= \mathbf{1}\{P_i(\tilde{L}) \geq 0.5\}, S_1 = \mathbf{1}\{P_i(\tilde{S}) \geq 0.5\}, \\ L_2 &= \mathbf{1}\{P_i(\tilde{L}) > 0\}, S_2 = \mathbf{1}\{P_i(\tilde{S}) > 0\}, \\ L_3 &= \mathbf{1}\{P_i(\tilde{L}) = 1\}, S_3 = \mathbf{1}\{P_i(\tilde{S}) = 1\} \end{aligned}$$

where $P_i(A)$ denotes individual i 's probability for reporting A and is estimated by $1/T \sum_t A$ for $A \in \tilde{L}, \tilde{S}$.

L_1 , our preferred measure, assigns individuals to the left-hander group if they report being so at least half the time. Likewise, S_1 labels them as switched if they report a difference between innate and writing hand at least in half the waves observed. L_2 and S_2 assign individuals to the left-handed or switched group if they report so at least once. L_3 and S_3 assign individuals to the left-handed, respectively switched group, only if they report so in every wave, i.e. consistently. The reasoning for the second measure is that no true right-hander has an incentive to ever report being a left-hander. However, false positives are most likely to be included in this measure, which leads differences between the two groups to be biased towards zero. The third measure is likely to assign positively selected individuals to the left-handed group. Given stigmatization against left-handers, some individuals will report being right-handed in some wave out of social desirability and would thereby not be included in the left-hander group. The first measure is thus a compromise between the second and the third, as it is robust to random reporting error to some degree, while also including individuals that are likely to be left-handed, but do not report so in every wave.

Table 1 shows the share of left-handed and switched individuals (conditional on being left-handed) in the full sample and for all measures. We see that the estimated share of left-handers in the sample strongly depends on the measure, varying between

⁹In 2006 and 2014, individuals had "left- and right-hander" as a third answer option for both questions. We assign these 28 (13 for writing) individuals to the left-hander group (writing hand left group). Qualitatively, your findings do no change if we include them to the right-hander group.

roughly 6 and 9%.¹⁰ The left-hander rate is more than 50% higher under measure L_2 than under L_3 . Furthermore, we find that the share of switched individuals is lowest among those that always report being left-handed. This indicates a plausible positive relation of true switching status to social desirable responding behavior and stigmatization.

- Table 1 about here -

Our analysis is based on L_1 and S_1 and we set $L = L_1$ and $S = S_1$ for the remainder of the paper. Under this measure of left-handedness, thirty individuals report being innately right-handed, but write with their left hand. We assume random measurement error for these observations and drop them from the analysis, which leaves 12,863 observations.¹¹

3.2 Outcome and control variables

We consider two sets of outcome variables. The first set are years of education and self-reported grades in math and German from the last school certificate. We'd like to label these outcomes as intermediate, as they materialize shortly before the end of schooling (grades) or further training (years of education). Assuming that children were on average six years old when they started to learn writing, the time from treatment to outcome is roughly 11 to 18 years for years of education and 8 to 13 years for grades.¹² The second set are two measures of cognitive skills, the symbol-digit-test (SDT) and the animal naming task (ANT).¹³ Both were elicited in 2006 and 2012 among a random sample of SOEP participants and have been used in other studies before us [Dohmen et al., 2010, Heineck and Anger, 2010]. We consider these outcomes as long-term, because they were measured when individuals are in adult age, on average 50 in 2006 and 53 in 2012. We pool observations from both years.

During the SDT, individuals had to match as many numbers to symbols as possible within 90 seconds and enter their answers in the interviewer's computer. This test intends to measure an individual's fluid intelligence, i.e. the ability to process

¹⁰The dependence of the estimated share of left-handers on the measure has also been observed by Perelle and Ehrman [2005] in the psychological literature.

¹¹Two-thirds of these individuals participated only once in the grip-strength module. The corresponding number is 32 for L_2 and 27 for L_3 . It is possible that these individuals use the left-hand because they imitated their parents [Sattler, 1996].

¹²For the lower bound we think of an individual having completed only basic school (9 years, earlier cohorts 8 years) with a subsequent apprenticeship of 2 years. The upper bound corresponds to an individual completing high school (13 years) and higher education (5 years).

¹³See Lang et al. [2007] for the validity and reliability of these tests in the SOEP.

and make use of new information, which is not already stored in memory [Cattell, 1987]. The ANT is a knowledge-based word fluency test which required respondents to name as many distinct animals as possible in 90 seconds. We use the number of uniquely named animals, i.e. without repetitions. Both tests are utilized sub-modules in intelligence testing, such as the WAIS [Wechsler, 2008], which currently comprises ten modules. The ANT is a mixture of fluid (word fluency) and crystallized (vocabulary) intelligence. Both, SDT and ANT were measured after 30, 60 and 90 seconds and we use the measure after 90 seconds. Note that since the cognitive ability and grip strength measurement are only available for sub-samples of the SOEP, we can only use overlapping samples. In the next section, we check whether selection into treatment is different between the three outcome-based samples.

Our control variables comprise basic demographic characteristics such as gender, an indicator for being born in the German Democratic Republic (GDR) and migration status. Migration status splits up into having no migration background, indirect, or direct migration background, the latter being all non-German citizens. Socioeconomic background is proxied by mothers and fathers education (three categories) and by the size of the town the individual primarily grew up until the age of 15 (four categories). These variables are chosen to mitigate treatment selection bias and will be discussed in the next section. Note that for our analysis we use only complete cases. Missing maternal and parental education are responsible for most observations being dropped, with a share of missings of about 10%. Furthermore, the analysis sample for all outcomes is restricted to individuals born before 1930 and after 1997, in order to avoid small cell sizes and differential survival probability between treatment groups. This gives us a total sample size of 12,809 observations.

Descriptive statistics for outcome and control variables for the full sample are presented in table 2. Appendix tables 11, 12 and 13 show descriptive statistics for the outcome-based samples ultimately used in the analysis.

- Table 2 about here -

4 Identification

4.1 A Model of Social Norms

We consider a simple model based on Becker and Tomes [1994] which involves social norms and relates future child outcomes with the parents decision to perform some treatment when the child is still young. This model helps to motivate our identification strategy and is informative on which children will be treated. For simplicity we

abstract from constraints.

We consider only parents of innately left-handed children. Let x be equal to one if the child writes with the right hand and since we consider only left-handed children, this implies that the child's handedness has been switched. As in Becker and Tomes [1994], parents utility at time t depends on their own consumption of a good z_t minus immediate treatment costs k plus their child's utility u_c . Then

$$u_t = u(z_t - kx) + \delta u_c(y_{t+1,x}), \quad (4.1)$$

where δ is the parents degree of altruism and $y_{t+1,x}$ is some (discounted) future outcome of the child such as its human capital.¹⁴ Consider only two points in time t and $t + 1$ and assume all utility functions are concave. We now incorporate parents social norms when making investment decisions, as proposed by Cunha and Heckman [2008], but for simplicity we do not make use of the full capacity of the model formulated in Cunha and Heckman [2007]. Parents may not know whether $y_{t+1,1}$ or $y_{t+1,0}$ is larger, but form expectations about it based on a given social norm \bar{x}_t at t :

$$\tilde{y}_{t+1,x} = a_t - d |\bar{x}_t - x|, \quad (4.2)$$

where d is a penalty term corresponding to the degree of conformity to the norm and a_t is a set of other important factors, such as parental education and resources, institutional policies and innate ability.¹⁵ Our formulation reflects the idea that parents think non-conformity to existing norms leads to a possibly life-long penalty for the child due to discrimination by teachers, other students and at the labor market. This is similar to Lindbeck and Nyberg [2006], who study the imposition of work norms by parents on their children. The decision whether to switch the child's handedness is based on (4.1) where $y_{t+1,x}$ is replaced with (4.2). In times when $\bar{x}_t = 1$ parents will switch their child if

$$u(z_t - k) + \delta u_c(a_t) \geq u(z_t) + \delta u_c(a_t - d) \quad (4.3)$$

$$\Leftrightarrow \delta (u_c(a_t) - u_c(a_t - d)) \geq u(z_t) - u(z_t - k). \quad (4.4)$$

Switching will thus be performed when the present forgone utility of doing it is smaller than the child's future gain. Obviously, no switching will take place if parents are selfish ($\delta = 0$), sardistic ($\delta < 0$), non-conformists ($d \leq 0$) or simply do not know that $\bar{x}_t = 1$. If $\bar{x}_t = 0$, these relations are obviously reversed. While this is the parents

¹⁴For simplicity we let human capital directly influence utility, without considering the standard way over wages and then consumption goods.

¹⁵This formulation of conformity is borrowed from the model of social distance by Akerlof [1997].

decision model, the actual future outcome $y_{t+1,x}$ truly develops according to some function $f(\cdot)$ which does involve endowments a_t and switching x , but not the norm \bar{x}_t :

$$y_{t+1,x} = f(a_t, x). \quad (4.5)$$

What can we learn from this model for our empirical analysis? First, it provides us with an identification strategy. From (4.2) and (4.4) we see that the social norm \bar{x}_t influences the decision to switch the child and it varies across t . We can use this variation in social norms, because individuals in our data-set belong to different cohorts. At the same time, the norm has no direct effect on the realization of $y_{t+1,x}$, other than through x as indicated in (4.5). This makes cohort based social norm variation a valuable candidate for an instrumental variable.¹⁶ Clearly, norms gradually change over time and do not suddenly disappear. The empirical challenge then is to separate the change in norms from other cohort effects in a_t . We further illustrate our identification strategy and set up an econometric model in the next section.

Second, the model is informative on which parents are likely to switch, or let switch, their child. Consider how parental resources from the set a_t relate to other factors that influence the switching decision. As seen from (4.4), the threshold to switch the child is lower when parents already have a high level of consumption, because then the difference $u(z_t) - u(z_t - k)$ is relatively lower for low levels of consumption. If the correlation between consumption and parental resources is positive, then wealthier parents are more likely to apply the treatment. Put differently, parents with low consumption levels have other worries than their child's human capital accumulation. Altruism δ in general induces parents to invest in to their child's future well-being. Hence, switching is just one in a range of measures that parents undertake to foster their child's capabilities. On the other hand, the difference $u_c(a_t) - u_c(a_t - d)$ decreases in a_t and the switching costs k may be negatively related to a_t , because of higher opportunity costs (raising the child vs working). In addition, stronger conformism to norms (expressed in a higher d) is likely to lead to a negative selection of switched individuals.

Finally, the switching decision may not be perfectly implementable. Instead its success probability depends on the child's already developed cognitive skills and motivation at time t also in the set a_t . Empirically, this would link switching and

¹⁶Note that, the utility function of the child may be extended to be $u_c(y_{t+1,x}, x)$ such that the writing hand itself provides direct intrinsic utility [Akerlof, 1997] and not only via $y_{t+1,x}$, reflecting stigma towards left-handers. However, this does not influence our outcome of interest $y_{t+1,x}$ directly and thus keep the exclusion restriction unviolated.

cognitive skills in adult age through reverse causality. Using a survey of more than 11,000 individuals, Perelle and Ehrman [1994] report that switching attempts were successful in 72% of the cases. A priori, we would expect that children of high cognitive skills are more successfully in achieving a task as hard as learning to write with the non-dominant hand. This notion is further confirmed by Sattler [1996] who notes that it are usually the brighter and motivated children on which switching attempts are successful.

Summarizing, our parental investment decision model gives us some reasons to expect a positive selection of switched left-handers and some to expect a negative. It seems plausible to assume that in times when the norm was to switch a left-handed child, non-switched children are negatively selected, because parents or teachers didn't care much about the child's standing in society. When this norm became out-dated however, we expect parents that nevertheless switch their child to be conservative and less focused on their child's well-being. Given that more than 80% of switched left-handers in our sample were born in years when switching was very common (before 1965), we expect the treated group to be positively selected, at least on average. However this conclusion only holds within the group of left-handers and not necessarily for the population in general. We return to this question empirically in section 4.3.

4.2 Difference-in-Differences Strategy

We illustrate cohort trends of reported left-handedness and switching in Germany between 1920 and 2000 using local linear regression of degree one in figure 1.¹⁷

The share of left-handed is drawn on the left axis and the share of switched individuals among left-handers on the right. It is easily seen that 80 to 100% of left-handers born before the end of the Second World War were forced to switch their writing hand to the right. Similar to the historical development of the practice in many European countries [Harris, 1990], switching was very common in Germany among older cohorts and rapidly decreased from 1960 on. Our sample is thus a snapshot in the time of near-full to near-non switching practice in Germany. The share of left-handers shows a clear linear upward trend from 6 to 7 up to nearly 9 percent, which was to be expected if stigma against left-handers decreases over time.¹⁸ As described in the introduction, this sudden downward trend in switching rates was initiated by the abandonment of conservative social norms by the first

¹⁷To this end, we use an Epanechnikov kernel with rule of thumb bandwidth.

¹⁸Cohort trends and age are obviously collinear here. However there is no evidence why elderly people should be more successful in re-learning to write than younger individuals.

generation of post-war parents, the so called generation of '68.

- Figure 1 about here -

This shift in norms allows us to identify the causal effect of switching. Since right-handers were never switched, their cohort trend serves as a counterfactual for left-handers. The identifying assumption in this approach is that time trends for left- and right-handers would have developed parallel in the absence of switching. We can then employ two-stage least-squares (2SLS) estimation, with a difference-in-differences specification in the first stage. We formalize this idea in the following two equations model

$$Y_i = \alpha S_i + \beta_1 X_i + \gamma_1 L_i + \theta_1 \phi(t_i) + \epsilon_i \quad (4.6)$$

$$S_i = \delta \phi(t_i) \times L_i + \beta_0 X_i + \gamma_0 L_i + \theta_0 \phi(t_i) + \tau_i, \quad (4.7)$$

where α is the treatment effect of interest, X_i are control variables and $\phi(t_i)$ is a function of the cohort trend. S_i and L_i denote an individuals reported switching and left-handedness status and ϵ_i and τ_i are two possibly correlated error terms.

We now discuss several aspects of our econometric model. The set of control variables X_i consists of all variables described in section 3.2. Our robustness checks include different sets of control variables.

The form of $\phi(t_i)$ is important, because it has to fulfill two roles at the same time. First, it has to fit the time trend of the outcome variable for right-handers in (4.6), the counter-factual. Second, it must correctly trace the development of switching among left-handers across cohorts ($\phi(t_i) \times L_i$) in (4.7). There exists a well-known trade-off between model precision and goodness of fit in settings like this. Using an interaction between left-handedness and a linear cohort trend as IV means that, conditional on covariates X_i , both developments have to be satisfyingly linear in order to avoid bias from model misspecification. On the plus side, imposing shape restrictions can lead to more precise estimates and hence decreases weak IV bias [Stock and Yogo, 2005]. These considerations are relevant in our study since the first stage is completely based on the group of left-handers and this group comprises only about 8% of the sample. The most flexible way which allows different trend shapes in the first stage and the counterfactual outcome would be to use dummies for every year of birth. However, as seen from figure 1, there are many cohorts which experience little variation in switching rates, in particular those born before 1950 and after 1980, and that do not contain any or only switched left-handers. Thus, including dummies for all years is likely to lead to a weak IV bias, similar as in

Angrist and Krueger [1991]. In between these two extremes are polynomials of the cohort trend (e.g. quadratic or cubic) and bunching of cohorts along quantiles of the distribution. For our analysis part, we impose linearity in cohort trends and show in robustness checks that the specific form of $\phi(t_i)$ is not driving our results.

An important advantage of the difference-in-differences approach is that it allows for a direct effect of left-handedness on the outcome. The estimated coefficient might not represent a causal effect if, for example, left-handedness is more common in families where parents are also left-handed and experienced discrimination.¹⁹ Whether the estimate of γ_1 is a causal effect or only a correlation with unobserved family characteristics or health endowments is not the focus of this paper. However, for completeness we report coefficients in our main tables.

Important for the causal interpretation of the 2SLS coefficient is that the level difference between left- and right-handers has to be constant across cohorts. Under the exclusion restriction, any differences between left- and right-handers among individuals born in the same cohort are caused by the different prevalence of switching. We are not aware of any other institutional change in schooling practices which applied only to left-handers and which occurred simultaneously to the decline in switching. The first time policymakers paid extra attention to left-handers was in 1987, when an institute for school quality published a left-hander guideline for teachers, which instructed them to help left-handed children learn to write with their preferred hand [Sattler, 1996]. How quickly these guidelines diffused or to what extent they actually changed the behavior of teachers is unknown.

Nevertheless, there might be causes outside the school context that run parallel to its time trend and explain the pattern observed in the data. For example, stigmatization and prejudices against left-handers in the family may decline, leading also the non-switched left-handers to perform better in school and develop better cognitive skills. To shed some light on these issue, we take a proxy for parental input and look at its development across cohorts. We have information on the individuals perceived parental involvement with their performance in school (N=6,036), with coding 1=not at all, 2=somewhat, 3=a lot, and 4=very much. Cohort trends for left- and right-handers are shown in figure 2, where we again use local linear regression

¹⁹To shed some light on this issue, we employ a sub-sample of individuals of which the parent's handedness is known, because their parents participated in the grip strength measurement. The sample comprises 1,827 relatively young individuals which were born around 1984. We find that among left-handed mothers, the share of left-handed children is almost twice as high as among right-handed mothers (13.33% vs 7.25%). On the other hand, in a sample of 1,509, fathers handedness is statistically unrelated to child handedness (8.47% vs 7.33%). This suggest that either a left-handed gene is inherited only via the mother, or that children are more keen to use the left hand if they observe their mother doing so. Similar observations have been made by Goodman [2014] in the US.

of degree one. Indeed, parallel to the decline of the switching practice, parents cared more about schooling from 1960 on. However, these trends are very similar between right- and left-handers. Left-handers born before 1940 report lower involvement than right-handers, but the confidence interval is large for these cohorts. From 1980 on a somewhat higher involvement for left-handers is reported, but again the precision is low. We will include this potential issue in our robustness checks by excluding very old and young cohorts from the sample.

- Figure 2 about here -

It may also be the case that the prevalence of the pathological left-hander, which is caused by brain damage in the prenatal phase, may decline over time as medical advancement makes such damage less likely. This could also lead an increase in cognitive skills without switching being the actual cause. However, this implies that the share of left-handers should actually decline which is the opposite of what we have seen.

Considering heterogenous treatment effects, Angrist et al. [1996] demonstrated that the 2SLS estimand identifies a local average treatment effect (LATE), which is the causal effect of the treatment for those individuals where the instrument causally changed the potential treatment status. An important assumption for this interpretation is that of monotonicity, meaning that the instrument weakly increases the treatment status for every individual (or decrease as in our case). Otherwise the identified effect is a weighted difference of the causal effect for compliers and defiers. Applied to our setting, this means that left-handers are monotonically less likely to become switched across time. Put differently, there is no switched individual which would have not become switched if she was born into an earlier cohort. Judging from figure 1 this assumption seems to be true at least at the aggregate level.

4.3 Treatment selection

Our theoretical model on the switching decision in section 4.1 is ambiguous whether switched children are a positively or negatively selected group. Ultimately, this is an empirical question.

- Table 3 about here -

Table 3 displays odds ratios from logit regressions on the switching (even columns) or left-handedness (uneven columns) indicator in every outcome-based subsample.

We use a quadratic cohort trend, but this specification is not crucial for our findings which are as follows. Females and individuals born in the GDR or with a direct migration background are less likely to be left-handed. Anecdotal evidence suggests that in the GDR, left-handers were suspected of being more creative than right-handers and hence as more likely to be a threat to the ruling regime. This threat was supposed to be eliminated by switching the writing hand Sattler [1996]. Even among recent cohorts that grew up in re-unified Germany, switching rates seem slightly higher in the East than in the West (results not shown). This might be caused by the persistence of different social preferences in East Germany (see also Alesina and Fuchs-Schündeln, 2007). Hence, we interpret this finding as underreporting and not as a natural difference in the prevalence of left-handers between West and East Germany. The same applies for migrants, which are mainly from Turkey and Eastern European countries. Females are also less likely to report left-handedness, a well-known fact in the laterality literature [Harris, 1990]. The explanations for this phenomenon range from a higher natural predisposition for males, females increased ability to switch handedness, and to stronger social pressure on females to align with societal norms [Porac et al., 1986, Papadatou-Pastou et al., 2008]. Thus, it is unclear whether lower left-hander rates are observed due to natural or social causes.²⁰ Across all samples, we find that left-handedness is only poorly predicted by parental education and weakly by year of birth. Pseudo R^2 's are around 1%. Low correlation of handedness with family background characteristics has been noted before by Johnston et al. [2009] in Australian data.

Turning to selection into switching, we unsurprisingly find that year of birth is the most important predictor, followed by parental education. Compared to both fathers and mothers with basic or no school degree, those with mid-level education are more likely to switch their child, with odds-ratios generally larger than one. The sign of the coefficient for high education differs between mothers and fathers. Highly educated mothers are most likely to have a switched child, while highly educated fathers are least likely. In the cognitive skill samples, we also find that being raised in a small town or rural area increases ones chance to become switched, which is consistent with stronger adherence to social norms in less urbanized areas. However, due to the low sample size, these coefficients are mostly not significantly different from zero. We find no differences in switching rates for females, but East Germans are more likely to be switched, which is again in line with stronger discrimination of left-handedness in the FDR. While the pseudo R^2 of the switching regressions are larger or equal than $1/3$, the explanatory power of the covariables other than year

²⁰Significant interactions with gender were found for direct migration, with female migrants much less likely to be left-handed than male migrants.

of birth is limited. The p-value of a joint F-test for all variables except for year of birth and year of birth squared is only 0.08 for the intermediate outcome samples and 0.18 for the cognitive skill sample. We find that the predictions of your model from section 4.1 are roughly confirmed. Nevertheless some ambiguity remains with respect to parents educational background.

5 Baseline Results

5.1 Years of Education and Grades

We first investigate mean differences in our outcome variables between left- and right-handers and between switched and non-switched left-handers, conditional on control variables. The first panel in table 4 shows differences by reported handedness. In contrast to Goodman [2014], we do not find any significant differences between left- and right-handers. We do not believe that cultural differences between Germany and the UK and US are responsible for this finding. Goodman [2014] concludes, that left-handedness may indeed be a marker of brain damage during pregnancy. It seems unlikely that such a damage occurs less often in Germany than in the UK or US. Rather, we believe that only a positively selected group of left-handers reports on their true natural handedness, which leads to an upward bias in our estimates. Of course, this assumes that the share of left-handers is also the same for these countries. In contrast to these zero differences, we see large and highly significant differences between switched and non-switched left-handers for years of education and math grades, even when controlling for cohort effects. As a somewhat surprising results, we see that switched left-hander actually have more years of education and better math grades than non-switched, though German grades and cognitive skills are not different.

- Table 4 about here -

Figure 3 shows cohort trends between left- and right handers for every outcome using the raw data. While years of education strongly increase across cohorts, math and German grades decline. We now use the full sample and include indicators for being switched and left-handed and control variables. Table 5 shows the results using our preferred IV and control specification. We discuss robustness and specifications checks in section 6.

- Figure 3 about here -

Starting with reduced form estimates in the first column, we find that across all outcomes, cohort trends between left- and right-handers do not differ significantly from each other (column 1) as also seen from figure 3. As expected, the first stage results in column 2 demonstrate that the left-hander-year of birth interaction strongly predicts switching (column 2). With every additional year, this share decreases by roughly 1.7%. Since F-statistics range between 317 and 496 we do not worry about weak IV bias.

Turning to OLS results in column 3, it can be seen that switched individuals have, compared to right-handers, about 0.16 standard deviations more years of education (almost half a year in absolute terms) and, of similar size, higher math grades, while German grades are somewhat lower but not significantly. To see how large these differences are, consider the (highly significant) gender gap which is of size -0.14, -0.10 and 0.46 standard deviations for the respective outcome. Non-switched left-handers perform worse on years of education and math grades, but not in German grades.

- Table 5 about here -

Using the cohort-left-hander interaction as IV in column 4, the formerly positive coefficients become negative, which was to be expected given the reduced form estimates. These findings confirm that switched individuals are likely to be a positively selected group of individuals. Although the 2SLS coefficients are of economic significant size, in particular for German grades, they are not statistically significant. One explanation for this finding might be that the treatment effect is very heterogenous here. Some children might benefit from the treatment as they try to overcompensate the challenges posed by the switching process by increased effort as reported by Sattler [1996]. In addition, parents or teachers know on the difficulty of this process and re-distribute additional attention to the child at home and in school. The large negative coefficient for German grades is in line with the psychological literature that language and writing skills to be most affected by switching.

5.2 Cognitive skills

Next, we turn to cognitive skills at adult age in table 6. We pool all observations from 2006 and 2012 and cluster standard errors at the individual level.²¹ The reduced form estimate suggests a linear cohort trend among left-handers for the SDT that is

²¹For the SDT, we have 1,854 observations from 2006 and 3,359 from 2012. 961 individuals participated in both years. The respective figures are 1,870, 610 and 595 for the ANT.

steeper than those of right-handers. As before, the first stage relationship is very strong, with F-statistics of about 310 and 76. The F-statistic in the ANT sample is considerably smaller than for the previous outcomes, but still does not raise concerns about weak IV bias. Neither for the SDT nor the ANT do we find a statistically significant difference between switched left-handers and the remaining population using OLS. In contrast, the 2SLS estimate shows a large negative effect on the SDT of about one-third of a standard deviation. The effect for the ANT is also large with -0.14 standard deviations, but not statistically significant. This could come from the fact that this sample contains only 182 observations from left-handers, resulting in low power. This finding is consistent with brains scans that found less gray matter in the putamen of switched individuals, compared to non-switched [Klöppel et al., 2010].

- Table 6 about here -

6 Robustness Checks

6.1 Control variables and sub-samples

In tables 7 and 8 we check the sensitivity of our OLS and IV results with respect to different control variables and exclusion of possibly problematic sub-populations. Column pair 1 corresponds to our preferred specification from tables 5 and 6. Column pair 2 only controls for linear cohort trend, while column pair 3 adds only basic demographic variables such as Gender, migration background and whether one is being born in the GDR. While we lose statistical significance for years of education, our qualitative results remain unchanged for all outcomes. The addition of parental education and place of living at age 15 in column pair 1 increases the adjusted R^2 by a considerable amount, but leaves our coefficients of interest largely unchanged. We expected our controls to be important if they predict reported left-handedness. However, this seems not to be the case. Column pair 4 includes interactions all control variables with left-handedness. As a result the 2SLS coefficient for the SDT becomes smaller and insignificant. The fifth column pair uses our preferred set of covariates but excludes individuals born before 1940 and after 1979 for the intermediate outcome set, and allows only observations made between the age of 25 to 65 for cognitive skills outcomes. We do this for two reasons. First, positive survival and reporting bias might be strongest among very old cohorts. Second, from section 4.2 we were worried that left-handers in the youngest cohort received more attention by their families or teachers than right-handers due to changes in attitudes. If our worries

where true the first exclusion would lead to an increase in our 2SLS estimates and the second to a decrease. While precision decreases due to a considerable loss in observations, 2SLS estimates become large in absolute terms, which indicates that positive sample selection might be more of a problem than violation of the exclusion restriction among young cohorts. In the last column pair, we exclude individuals with migration background. The reasoning is that this groups composition is strongly selective and that different social norms might apply to them. Section 4.3 already showed that individuals with a direct migration background are roughly only half as likely to report left-handedness than those without. Also, the grades of foreigners might not be comparable with native those of Germans and migrants might have language problems unrelated to switching or left-handedness. Both OLS and 2SLS estimates are similar to those from the full sample. Table 14 in the appendix repeats these robustness checks for the cognitive skill outcomes using random effects panel models with virtually no difference in the coefficients to pooled OLS and 2SLS.

- Table 7 about here -

- Table 8 about here -

6.2 IV Specification

We first assess graphically whether linearity is an appropriate assumption on the shape of the cohort trends using years of education as example. Figure 4 is similar to figure 1 by displaying a local linear regression for the share of switched individuals among right-handers, but also contains the linear fit used in our baseline regression, and a simple non-parametric fit using dummies. We bunch cohorts along 10 quantiles of the distribution and find that this tracts the local regression satisfyingly well. The linear fit somewhat overpredicts switching for very old and young cohorts and underpredicts in between. In the appendix, figure 6 repeats the same exercise for the other outcomes where we find slightly different trends. However, in neither sample does linearity seem to be an unreasonable assumption.

- Figure 4 about here -

Figure 5 considers the cohort trend of education among right-handers. It is important that our model fits this development well, because it is implicitly used to predict counterfactual values for left-handers. Again, cohort dummies seem to fit this data somewhat better than a linear trend. Appendix figure 7 shows graphs for all other outcomes.

- Figure 5 about here -

We now check the robustness of our estimates from section 5 with respect to different model specifications of the DiD strategy. We consider linear, quadratic, and cubic cohort trends, as well as quantile-based bunching of cohorts. Throughout, we use our preferred set of control variables. Table 9 shows these robustness checks for the intermediate outcome set. The first column corresponds to the baseline results from tables 5 and 7. The first panel uses the full sample. We find that our baseline estimates are fully robust to different IV specifications, with only little changes in the coefficients. The first stage F-statistic generally decreases when going from a linear to a quadratic or cubic specification, as expected. However, we also see that even when using cohort dummies, the F-statistic never falls below 37 in the full sample, while the Kleibergen and Paap [2006] underidentification test statistic is even larger than the Wald statistic if the latter is rather low.²²

- Table 9 about here -

Table 9 also contains two additional robustness checks in the second and third panels. The second panel repeats the exercise in the sample which is restricted to individuals born between 1940 and 1979. While none of the coefficients becomes significant, the negative coefficients for years of education become larger in absolute terms. Coefficients for math grades actually increase to economic significant sizes. Next we exclude individuals with a direct or indirect migration background in the third panel. While the statistical significance remains unchanged, the coefficients for years of education are similar to the second panel and significant for two specifications. However, these may very well be false positives, given our amount of tests. Coefficients for grades are unchanged, compared to the full sample.

Table 10 performs the same IV robustness checks for our cognitive skill outcomes. Among all polynomials considered, the linear actually delivers the lowest estimates in the full sample (first panel). The coefficients also change very little when using cohort dummies which are bunched along quantiles. In panel two we include again only individuals born between 1940 and 1979 and furthermore allow only observations at age 25 to 65 to exclude potentially age-selective observations. Our results remain qualitatively unchanged, but the precision decreases considerably. Note that the F-statistic come close to the Stock and Yogo [2005] critical values for both bias and size distortion in this subsample. Hence, these coefficients may be inflated by weak

²²Stock and Yogo [2005]’s critical value for 9 IVs is 20.53 for a relative OLS bias of 5% and 36.19 for a distortion of the test size from 5% to 10%.

IVs. When we alternatively exclude individuals with migration backgrounds (panel three) effect sizes for the SDT are even larger than in the full sample. The ANT coefficients increase considerably in size, but remain insignificant. Again, we check in appendix table 15 whether using a random effects instead of a pooled panel model changes our conclusions for the long-term outcome set.

- Table 10 about here -

7 Conclusion

The use of the right hand for writing, eating and human interaction was a social norm in many of today's developed countries. Left-handers involuntarily diverge from to this norm and were seen as inferior with respect to physical, mental and social abilities by scientists and large parts of society alike. To save their children from this fate, parents decided to switch their child's writing hand from the left to the right and teachers encouraged their students to only write with the right hand. Unknowingly or deliberately taken in account, this switching of the writing hand can damage the child's brain and psychological well-being. The practice of forced right-hand writing is still common in developing countries today, where stigmatization of left-handers origins in traditions, social conventions and religion.

In this paper we estimate the causal effect of this early childhood intervention on human capital in the mid and long run. Our sample is a subset from the German SOEP that participated in grip strength measurements from 2006 to 2014 and report on both their innate and writing hand. These data are a rare opportunity to observe switching of the writing hand, while also providing educational and cognitive skill measures as outcome variables. We first consider a simple investment decision model in which it is optimal for altruistic parents to adopt an exogenously given social norm for their children in order to avoid stigmatization. While this norm influences the treatment decision, it has no direct effect on the child's future human capital. This motivates our identification strategy. We find in our data that the share of switched individuals was nearly 90% among those born before 1950. From this year on, and most rapidly in the 1960's and 70's, switching rates decreased to less than 10% in the 1990's cohorts. This change in attitudes towards the importance of the writing hand came along with a dramatic change in other social norms during these years. We use the fact that right-handers were never affected by this treatment in a difference-in-differences approach in the first stage of a two-stage least-squares regression. Assuming that in the absence of switching cohort trends of our outcome

variables would have evolved parallel between left- and right-handers, we can identify the causal effect of switching.

OLS estimates show that treated individuals actually achieved half a year more education and better math grades compared to right-handers, while non-switched left-handers perform worse. The 2SLS estimates deliver a negative but non-significant or zero effect for these outcomes, however. This corroborates our theoretical and empirical findings that the treated group is actually a positively selected group among left-handers. We then turn to cognitive skills in adult age, as proxied by the symbol-digit task, which captures fluid intelligence, and the animal-naming task, which measures word fluency. While OLS estimates are (insignificant) slightly negative for the SDT and near zero for the ANT, the 2SLS estimates show a large negative effect of one-third of a standard deviation on the STD and 0.14 on the ANT (the latter being not significant). Our findings are robust to various robustness checks, in particular the specification of the first-stage difference-in-difference model. When we exclude older individuals, which are likely to be positively selected, or those with a migration background, we uncover even stronger effects for cognitive skills and suggestively negative effects for educational outcomes. These findings are in line with brain scans that show reduced gray matter in the putamen of switched German adults. This part of the forebrain is responsible for motor control skills but also cognitive functions like the working memory.

While future research will focus on non-cognitive skills, such as personality traits and social preferences, our results so far already have clear policy implications. Institutions, in particular schools, should inform parents and teachers on the negative consequences of switching and discourage it. This is important for policy makers, in particular in developing countries, for which Hanushek and Woessmann [2008] stress the role of cognitive skills for economic growth and where switching is still a common practice.

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Tables and Figures

Measure	$i = 1$	$i = 2$	$i = 3$
$P(L_i)$ in %	7.61	8.79	5.64
$P(S_i L_i)$ in %	52.30	55.97	44.53
$N = 12,863$			

Table 1: Share of left-handers and switched in full sample by different measures

	Right-handers	All Left-handers	Switched Left-handers	Total
<i>Full sample</i>				
Years of education	12.46 (2.68)	12.53 (2.83)	12.49 (2.84)	12.46 (2.70)
Mathgrade	4.39 (0.98)	4.35 (0.97)	4.48 (0.88)	4.39 (0.98)
Germangrade	4.48 (0.83)	4.43 (0.83)	4.44 (0.78)	4.48 (0.83)
SDT (90s)	29.69 (9.32)	30.05 (10.26)	27.21 (9.55)	29.72 (9.40)
ANT (90s)	27.05 (11.10)	26.25 (10.85)	25.15 (10.34)	26.99 (11.08)
Year of birth	1963.42 (17.89)	1964.37 (17.89)	1953.73 (13.67)	1963.49 (17.89)
Female	0.53	0.46	0.46	0.52
Eastgerman	0.22	0.18	0.22	0.22
Migration background				
none	0.80	0.83	0.86	0.80
direct	0.11	0.08	0.07	0.11
indirect	0.09	0.09	0.07	0.09
Fathers education				
Basic	0.66	0.65	0.74	0.66
Middle/other	0.19	0.18	0.14	0.19
High	0.15	0.17	0.11	0.15
Mothers education				
Basic	0.67	0.66	0.77	0.67
Middle/other	0.23	0.23	0.17	0.23
High	0.10	0.11	0.06	0.10
Primary place of living until age 15				
Largecity	0.20	0.21	0.21	0.20
Mid-size city	0.17	0.20	0.19	0.18
Smalltown	0.23	0.24	0.21	0.23
Countryside	0.39	0.34	0.39	0.39
N	9,878	833	437	10,711

Table displays means of variables by treatment group. Standard deviations of non-binary variables are displayed in parenthesis below respective means. Table uses all available observations. Sample excludes individuals born before 1930 and after 1997. Refer to table 11, 12 and 13 for outcome based analysis samples. Grades range from 1 (very good) to 6 (insufficient) in Germany and the scale is reversed here. Variable SDT (90s) is the sum of correct (not total) entries in the symbol digit task within 90 seconds, see text for further information. ANT (90s) refers to the sum of uniquely (not total) named animals within 90 seconds. SDT and ANT values are means from years 2006 and 2012.

Table 2: Full sample: Descriptive statistics by handedness group

Sample: Dependent variable:	Years of education		Grades		Cognitive skills	
	Left-handed	Switched	Left-handed	Switched	Left-handed	Switched
Year of birth	1.00 (0.00)	0.90*** (0.01)	1.00 (0.00)	0.89*** (0.01)	1.01 (0.00)	0.90*** (0.01)
Year of birth ²	1.00 (0.00)	0.99** (0.01)	1.00 (0.00)	0.99 (0.01)	1.00 (0.00)	0.99 (0.01)
Eastgerman	0.73*** (0.08)	1.51 (0.45)	0.63*** (0.08)	2.09* (0.78)	0.76* (0.11)	1.68 (0.72)
Female	0.77*** (0.06)	0.95 (0.19)	0.83** (0.08)	0.87 (0.20)	0.79** (0.09)	0.74 (0.21)
Migration background						
direct	0.56*** (0.09)	0.62 (0.27)	0.58*** (0.11)	1.93 (1.03)	0.55*** (0.12)	1.06 (0.72)
indirect	1.10 (0.17)	0.76 (0.29)	1.00 (0.16)	0.55 (0.22)	0.93 (0.19)	0.58 (0.27)
Mother's education						
middle	1.09 (0.14)	1.00 (0.33)	1.11 (0.15)	1.86* (0.66)	1.17 (0.20)	1.35 (0.63)
high	1.17 (0.20)	2.38 (1.34)	1.09 (0.20)	2.54* (1.21)	0.91 (0.22)	4.59** (3.14)
Father's education						
middle	0.89 (0.12)	2.15** (0.75)	0.86 (0.12)	1.30 (0.43)	0.89 (0.16)	1.32 (0.59)
high	0.87 (0.13)	0.60 (0.23)	0.95 (0.14)	0.60 (0.23)	0.99 (0.20)	0.35** (0.19)
Primary place of living until age 15						
mid-size city	1.13 (0.15)	1.06 (0.33)	1.09 (0.15)	1.10 (0.36)	0.95 (0.17)	1.80 (0.75)
small town	0.90 (0.11)	0.88 (0.26)	0.91 (0.13)	0.69 (0.23)	1.05 (0.17)	1.62 (0.61)
countryside	0.85 (0.10)	1.18 (0.33)	0.87 (0.11)	1.08 (0.34)	0.87 (0.13)	1.33 (0.48)
Constant	0.12*** (0.01)	1.99** (0.55)	0.12*** (0.02)	2.11** (0.61)	0.12*** (0.02)	1.91* (0.63)
N	8,449	642	6,552	531	4,252	361
Pseudo R ²	0.010	0.264	0.009	0.338	0.009	0.354

Outcome variable is a dummy for being left-hander or, conditional on being left-handed, a dummy for being switched. Table displays odds-ratios. Robust standard errors in parentheses. Reference category for migration background is none. Reference category for mothers and fathers education is basic/none. Middle category includes other education. Reference category for primary place of living until age 15 is large city. Grade sample refers to individuals with non-missing math grades. Cognitive skill sample refers to individuals with non-missing symbol-digit test values in either 2006 or 2012. Year of birth is centered at 1960. Year of birth squared is divided by 10. Sample restricted to individuals born in or after 1930 and before 1997. *** p<0.01, ** p<0.05, * p<0.1.

	Education	Math grade	German grade	SDT	ANT
Difference between left- and right-handers	-0.01 (0.04)	-0.01 (0.04)	-0.01 (0.04)	-0.00 (0.05)	-0.08 (0.08)
N	8,449	6,552	6,319	5,213	2,480
Difference between switched and non-switched left-handers	0.26*** (0.10)	0.28*** (0.11)	-0.06 (0.11)	0.06 (0.11)	0.15 (0.23)
N	642	531	513	428	182

Robust or clustered standard errors in parentheses. *** $p < 0.01$. Each pair of coefficients and standard errors come from separate regressions. Table shows effect sizes in standard deviation units of the full sample. All regression control for a linear cohort trend, being East German, female, having a migration background (none, direct and indirect), mothers' and fathers' education (low/none, middle and high) and primary place of living until the age of 15 (large city, mid-size city, small town and countryside). Regressions for symbol-digit task (SDT) and animal-naming task (ANT) pool observations from 2006 and 2012. Number of clusters in SDT (ANT) sample is 4252/361 (1885/137). Sample generally restricted to individuals born in or after 1930 and before 1997. Years of education sample excludes individuals younger than 25 at last observation.

Table 4: Mean differences between left/right-handers and switched/non-switched left-handers conditional on covariates

Outcome:	Years of education			Math grades			German grades						
	Reduced Form	1 st Stage	OLS	Endo- genous	IV	2SLS	Reduced Form	1 st Stage	OLS	Endo- genous	IV	2SLS	
Switched				0.16** (0.08)	-0.13 (0.15)					0.18** (0.09)	-0.07 (0.14)		
Left-handed	-0.00 (0.04)	0.61*** (0.02)		-0.11* (0.07)	0.08 (0.11)		-0.01 (0.04)	0.62*** (0.02)		-0.11 (0.07)	0.03 (0.10)		0.05 (0.10)
Left-handed × Year of birth	0.00 (0.00)	-0.02*** (0.00)					0.00 (0.00)	-0.02*** (0.00)		0.00 (0.00)	-0.02*** (0.00)		-0.09 (0.09)
N	8,449	8,449	8,449	8,449	8,449		6,552	6,552	6,552	6,552	6,552		6,319
Adj. R ²	0.217	0.725		0.218	0.216		0.032	0.711		0.033	0.0315		0.116
Wald F-statistic		316.9						486.7					496.3
Kleibergen-Paap		174.7						212.2					210.7

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Table shows effect sizes in standard deviation units. Year of birth is centered at 1960. Control variables are a linear cohort trend and dummies for being East German, female and having a migration background (none, direct and indirect), mothers' and fathers' education (low/none, middle and high) and primary place of living until the age of 15 (large city, mid-size city, small town and countryside). Variable switching indicates difference between natural and writing hand. Dependent variable in column 1st stage is indicator for switching. Sample generally restricted to individuals born in or after 1930 and before 1997. Years of education sample excludes individuals younger than 25 at last observation in panel.

Table 5: Results for years of education and grades

Outcome:	Symbol-Digit Test (90s)			Animal-Naming Task (90s)				
	Pooled OLS		P2SLS	Pooled OLS		P2SLS		
Description:	Reduced Form	1 st Stage	Endo-geous	IV	Reduced Form	1 st Stage	Endo-geous	IV
Switched			-0.11 (0.09)	-0.37** (0.15)			-0.05 (0.16)	-0.14 (0.27)
Left-handed	-0.01 (0.05)	0.61*** (0.02)	0.06 (0.07)	0.22** (0.10)	-0.07 (0.08)	0.59*** (0.04)	-0.04 (0.13)	0.01 (0.17)
Left-handed × Year of birth	0.01** (0.00)	-0.02*** (0.00)			0.00 (0.00)	-0.02*** (0.00)		
N	5,213	5,213	5,213	5,213	2,480	2,480	2,480	2,480
N(cluster)	4,252	4,252	4,252	4,252	1,885	1,885	1,885	1,885
Adj. R ²	0.288	0.741	0.287	0.286	0.079	0.719	0.079	0.079
Wald F-statistic		309.9				76.36		
Kleibergen-Paap		134.7				39.20		

Standard errors clustered at individual level (in parentheses). *** p<0.01, ** p<0.05, * p<0.1. Table shows effect sizes in standard deviation units. Year of birth is centered at 1960. Regressions pool observations for outcome variables from 2006 and 2012. Control variables are a linear cohort trend and dummies for being East German, female and having a migration background (none, direct and indirect), mothers' and fathers' education (low/none, middle and high) and primary place of living until the age of 15 (large city, mid-size city, small town and countryside). Variable switching indicates difference between natural and writing hand. Dependent variable in column 1st stage is indicator for switching. Sample restricted to individuals born in or after 1930 and before 1997.

Table 6: Results for years of symbol-digit (SDT) and animal naming (ANT) tests

Sample	Full sample				Born between 1940 and 1979				Without migration background			
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Estimation:	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Outcome:	Years of education											
Switched	0.16** (0.08)	-0.13 (0.15)	0.14 (0.09)	-0.21 (0.17)	0.13 (0.09)	-0.18 (0.17)	0.18** (0.08)	-0.10 (0.17)	0.15* (0.09)	-0.29 (0.21)	0.13 (0.09)	-0.27 (0.16)
Left-handed	-0.11* (0.07)	0.08 (0.11)	-0.07 (0.07)	0.16 (0.12)	-0.09 (0.07)	0.11 (0.12)	-0.12* (0.07)	0.05 (0.25)	-0.11 (0.07)	0.18 (0.15)	-0.10 (0.07)	0.16 (0.12)
N	8,449	8,449	8,449	8,449	8,449	8,449	8,449	8,449	8,449	8,449	8,449	8,449
Adj. R ²	0.218	0.216	0.026	0.023	0.048	0.046	0.217	0.216	0.207	0.204	0.207	0.204
Outcome:	Math grades											
Switched	0.18** (0.09)	-0.07 (0.14)	0.21** (0.09)	-0.06 (0.14)	0.18** (0.09)	-0.08 (0.14)	0.19** (0.09)	-0.01 (0.15)	0.29*** (0.11)	0.18 (0.22)	0.23** (0.10)	-0.04 (0.16)
Left-handed	-0.11 (0.07)	0.03 (0.10)	-0.15** (0.07)	-0.00 (0.10)	-0.12 (0.07)	0.03 (0.10)	-0.13* (0.07)	-0.32 (0.26)	-0.21** (0.09)	-0.14 (0.15)	-0.12 (0.08)	0.03 (0.11)
N	6,552	6,552	6,552	6,552	6,552	6,552	6,552	6,552	4,762	4,762	5,390	5,390
Adj. R ²	0.033	0.032	0.007	0.005	0.026	0.025	0.033	0.032	0.034	0.034	0.031	0.029
Outcome:	German grades											
Switched	-0.09 (0.09)	-0.21 (0.14)	-0.07 (0.09)	-0.19 (0.15)	-0.10 (0.09)	-0.24 (0.14)	-0.08 (0.09)	-0.14 (0.15)	-0.07 (0.11)	-0.05 (0.20)	-0.06 (0.10)	-0.21 (0.15)
Left-handed	0.05 (0.07)	0.11 (0.10)	-0.02 (0.07)	0.05 (0.10)	0.05 (0.07)	0.13 (0.10)	0.04 (0.07)	-0.10 (0.25)	0.03 (0.09)	0.01 (0.14)	0.01 (0.08)	0.10 (0.11)
N	6,319	6,319	6,319	6,319	6,319	6,319	6,319	6,319	4,569	4,569	5,396	5,396
Adj. R ²	0.116	0.116	0.007	0.007	0.087	0.086	0.117	0.117	0.129	0.129	0.115	0.115
Basic controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Parental controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Interaction												

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Each pair of coefficients and standard errors for switching and left-hander indicator come from separate regressions. 2SLS coefficient uses interaction of left-hander and linear cohort trend as IV for switching. All regression control for linear cohort trend. Table shows effect sizes in standard deviation units of respective sample. Basic Controls are dummies for being East German, female and having a migration background (none, direct and indirect). Parental controls are mothers' and fathers' education (low/none, middle and high) and primary place of living until the age of 15 (large city, mid-size city, small town and countryside). Interaction refers to basic and parental controls interacted with left-hander indicator. Sample generally restricted to individuals born in or after 1930 and before 1997. Years of education sample excludes individuals younger than 25 at last observation.

Sample	Full sample				Born between 1940 and 1979		Without migration background					
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS				
Estimation	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS				
Outcome:	Symbol-Digit Test (90s)											
Switched	-0.11 (0.09)	-0.37** (0.15)	-0.12 (0.09)	-0.38** (0.15)	-0.11 (0.09)	-0.37** (0.15)	-0.04 (0.09)	-0.26 (0.17)	-0.14 (0.12)	-0.51* (0.26)	-0.16* (0.10)	-0.45*** (0.17)
Left-handed	0.06 (0.07)	0.22** (0.10)	0.08 (0.07)	0.24** (0.10)	0.06 (0.07)	0.22** (0.10)	0.02 (0.07)	-0.25 (0.27)	0.03 (0.10)	0.27 (0.18)	0.08 (0.08)	0.27** (0.11)
N	5,213	5,213	5,213	5,213	5,213	5,213	5,213	5,213	3,224	3,224	4,276	4,276
N(cluster)	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	2,644	2,644	3,460	3,460
Adj. R ²	0.287	0.286	0.274	0.273	0.282	0.281	0.288	0.287	0.125	0.123	0.293	0.292
Outcome:	Animal-Naming Task (90s)											
Switched	-0.05 (0.16)	-0.14 (0.27)	0.01 (0.16)	-0.09 (0.26)	-0.04 (0.16)	-0.13 (0.27)	0.05 (0.18)	-0.24 (0.30)	-0.08 (0.21)	-0.15 (0.41)	-0.11 (0.19)	-0.21 (0.30)
Left-handed	-0.04 (0.13)	0.01 (0.17)	-0.08 (0.13)	-0.02 (0.17)	-0.06 (0.13)	0.00 (0.17)	-0.13 (0.15)	0.01 (0.15)	-0.06 (0.17)	-0.01 (0.26)	-0.08 (0.16)	-0.00 (0.21)
N	2,480	2,480	2,480	2,480	2,480	2,480	2,480	2,480	1,648	1,648	2,065	2,065
N(cluster)	1,885	1,885	1,885	1,885	1,885	1,885	1,885	1,885	1,292	1,292	1,565	1,565
Adj. R ²	0.079	0.079	0.039	0.039	0.069	0.069	0.080	0.079	0.075	0.075	0.064	0.064
Basic controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Parental controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Interaction					✓	✓	✓	✓				

Standard errors clustered at individual level. *** p<0.01, ** p<0.05, * p<0.1. Regressions pool observations from 2006 and 2012. Each pair of coefficients and standard errors for switching and left-hander indicator come from separate regressions. 2SLS coefficient uses interaction of left-hander and linear cohort trend as IV for switching. All regression control for linear cohort trend. Table shows effect sizes in standard deviation units of respective sample. Basic Controls are dummies for being East German, female and having a migration background (none, direct and indirect). Parental controls are mothers' and fathers' education (low/none, middle and high) and primary place of living until the age of 15 (large city, mid-size city, small town and countryside). Interaction refers to basic and parental controls interacted with left-hander indicator. Sample generally restricted to individuals born in or after 1930 and before 1997.

Table 8: Robustness check: OLS and 2SLS estimates for cognitive outcomes using different sets of covariates and exclusion of subpopulations

Outcome:	Years of education				Math grades				German grades			
	Linear	Quadratic	Cubic	Dummies	Linear	Quadratic	Cubic	Dummies	Linear	Quadratic	Cubic	Dummies
<i>Sample:</i>	<i>Full sample</i>											
Cohort trend:	Linear	Quadratic	Cubic	Dummies	Linear	Quadratic	Cubic	Dummies	Linear	Quadratic	Cubic	Dummies
Switched	-0.13 (0.15)	-0.12 (0.15)	-0.13 (0.15)	-0.19 (0.15)	-0.07 (0.14)	-0.08 (0.14)	-0.07 (0.14)	-0.05 (0.14)	-0.21 (0.14)	-0.21 (0.14)	-0.17 (0.14)	-0.15 (0.14)
N	8,449	8,449	8,449	8,449	6,552	6,552	6,552	6,552	6,319	6,319	6,319	6,319
Adj. R ²	0.216	0.232	0.231	0.231	0.032	0.031	0.032	0.033	0.116	0.116	0.117	0.119
N(Instruments)	1	2	3	9	1	2	3	8	1	2	3	8
Wald F-statistic	316.94	165.90	114.10	37.41	486.66	246.87	189.56	70.15	496.30	250.72	190.10	68.86
Kleibergen-Paap	174.74	175.68	179.00	183.42	212.22	212.77	215.70	213.08	210.71	211.38	214.73	211.57
<i>Sample:</i>	<i>Born between 1940 and 1979</i>											
Switched	-0.29 (0.21)	-0.25 (0.20)	-0.26 (0.20)	-0.28 (0.20)	0.18 (0.22)	0.18 (0.21)	0.20 (0.21)	0.24 (0.21)	-0.05 (0.20)	-0.06 (0.20)	-0.03 (0.20)	-0.04 (0.20)
N	6,337	6,337	6,337	6,337	4,762	4,762	4,762	4,762	4,569	4,569	4,569	4,569
Adj. R ²	0.204	0.209	0.209	0.209	0.034	0.034	0.035	0.034	0.129	0.130	0.132	0.133
N(Instruments)	1	2	3	9	1	2	3	8	1	2	3	8
Wald F-statistic	150.78	77.10	52.53	19.77	149.21	76.63	51.88	21.31	148.12	76.01	51.44	20.80
Kleibergen-Paap	100.25	100.47	100.70	108.63	96.82	97.07	97.79	104.73	94.93	95.22	95.87	101.40
<i>Sample:</i>	<i>Without migration background</i>											
Switched	-0.27 (0.16)	-0.26 (0.16)	-0.27* (0.16)	-0.30* (0.16)	-0.04 (0.16)	-0.04 (0.16)	-0.03 (0.16)	-0.00 (0.16)	-0.21 (0.15)	-0.21 (0.16)	-0.17 (0.15)	-0.19 (0.15)
N	6,952	6,952	6,952	6,952	5,390	5,390	5,390	5,390	5,396	5,396	5,396	5,396
Adj. R ²	0.204	0.221	0.220	0.219	0.029	0.029	0.030	0.032	0.115	0.115	0.117	0.119
N(Instruments)	1	2	3	9	1	2	3	8	1	2	3	8
Wald F-statistic	307.32	163.91	114.67	37.66	443.90	227.35	167.31	62.54	458.99	234.60	172.27	63.30
Kleibergen-Paap	159.06	160.21	163.51	166.60	187.51	188.12	192.53	190.81	189.92	190.52	195.53	193.45

Table 9: Robustness check: IV specifications of years of education and grades

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Table shows effect sizes in standard deviation units of respective sample. Year of birth is centered at 1960. Control variables are dummies for being East German, female and having a migration background (none, direct and indirect), mothers' and fathers' education (low/none, middle and high) and primary place of living until the age of 15 (large city, mid-size city, small town and countryside). Year of birth is including as control variable as in row "2SLS Specification". Sample generally restricted to individuals born in or after 1930 and before 1997. Years of education sample excludes individuals younger than 25 at last observation in panel.

Outcome:	Symbol-Digit Test (90s)			Animal-Naming Task (90s)				
<i>Sample:</i>	<i>Full sample</i>							
Cohort trend:	Linear	Quadratic	Cubic	Dummies	Linear	Quadratic	Cubic	Dummies
Switched	-0.37** (0.15)	-0.40*** (0.15)	-0.39*** (0.15)	-0.39*** (0.15)	-0.14 (0.27)	-0.26 (0.27)	-0.25 (0.27)	-0.29 (0.28)
N	5,213	5,213	5,213	5,213	2,480	2,480	2,480	2,480
N(cluster)	4,252	4,252	4,252	4,252	1,885	1,885	1,885	1,885
Adj. R ²	0.286	0.287	0.287	0.279	0.079	0.096	0.097	0.094
N(Instruments)	1	2	3	7	1	2	3	5
Wald F-statistic	309.89	157.40	118.52	45.49	76.36	40.82	28.50	14.17
Kleibergen-Paap	134.66	135.45	136.73	140.17	39.20	39.83	40.44	37.73
<i>Sample:</i>	<i>Born between 1940 and 1979 and observations between age 25 and 65.</i>							
Switched	-0.51* (0.26)	-0.36 (0.25)	-0.42* (0.25)	-0.35 (0.23)	-0.15 (0.41)	-0.19 (0.39)	-0.18 (0.39)	-0.32 (0.39)
N	3,224	3,224	3,224	3,224	1,648	1,648	1,648	1,648
N(cluster)	2,644	2,644	2,644	2,644	1,292	1,292	1,292	1,292
Adj. R ²	0.123	0.124	0.123	0.122	0.075	0.082	0.081	0.075
N(Instruments)	1	2	3	6	1	2	3	4
Wald F-statistic	61.69	31.12	24.42	18.26	34.75	17.17	13.01	7.74
Kleibergen-Paap	45.03	45.48	47.30	52.48	20.02	20.02	20.17	19.72
<i>Sample:</i>	<i>Without migration background</i>							
Switched	-0.45*** (0.17)	-0.48*** (0.16)	-0.46*** (0.16)	-0.45*** (0.15)	-0.21 (0.30)	-0.37 (0.28)	-0.36 (0.29)	-0.44 (0.29)
N	4,276	4,276	4,276	4,276	2,065	2,065	2,065	2,065
N(cluster)	3,460	3,460	3,460	3,460	1,565	1,565	1,565	1,565
Adj. R ²	0.292	0.292	0.292	0.286	0.064	0.086	0.086	0.082
N(Instruments)	1	2	3	7	1	2	3	5
Wald F-statistic	290.80	151.75	105.64	45.78	62.78	31.66	21.22	16.01
Kleibergen-Paap	119.33	120.28	124.37	129.31	30.00	30.45	31.43	32.61

Standard errors clustered at individual level (in parentheses). *** p<0.01, ** p<0.05, * p<0.1. Table shows effect sizes in standard deviation units of respective sample. Regressions pool observations from 2006 and 2012. For control variables see table 9. Sample generally restricted to individuals born in or after 1930 and before 1997.

Table 10: Robustness check: IV specifications of cognitive skill outcomes

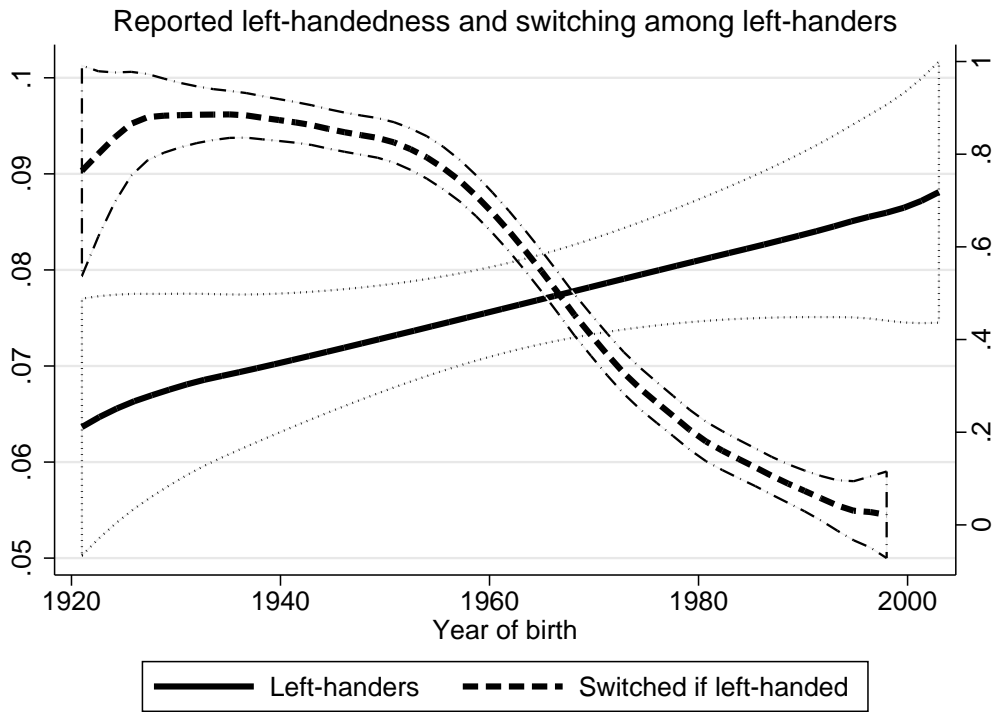


Figure 1: Share of left-handers (left axis) and switched among left-handers (right axis) by year of birth. Includes 95% confidence intervals.

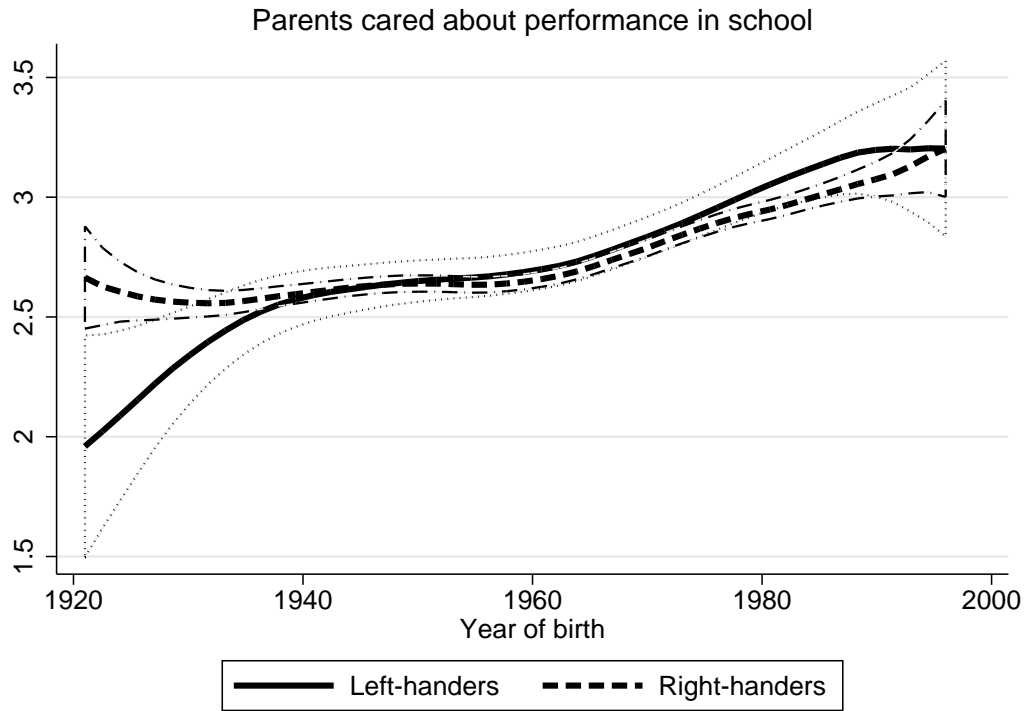
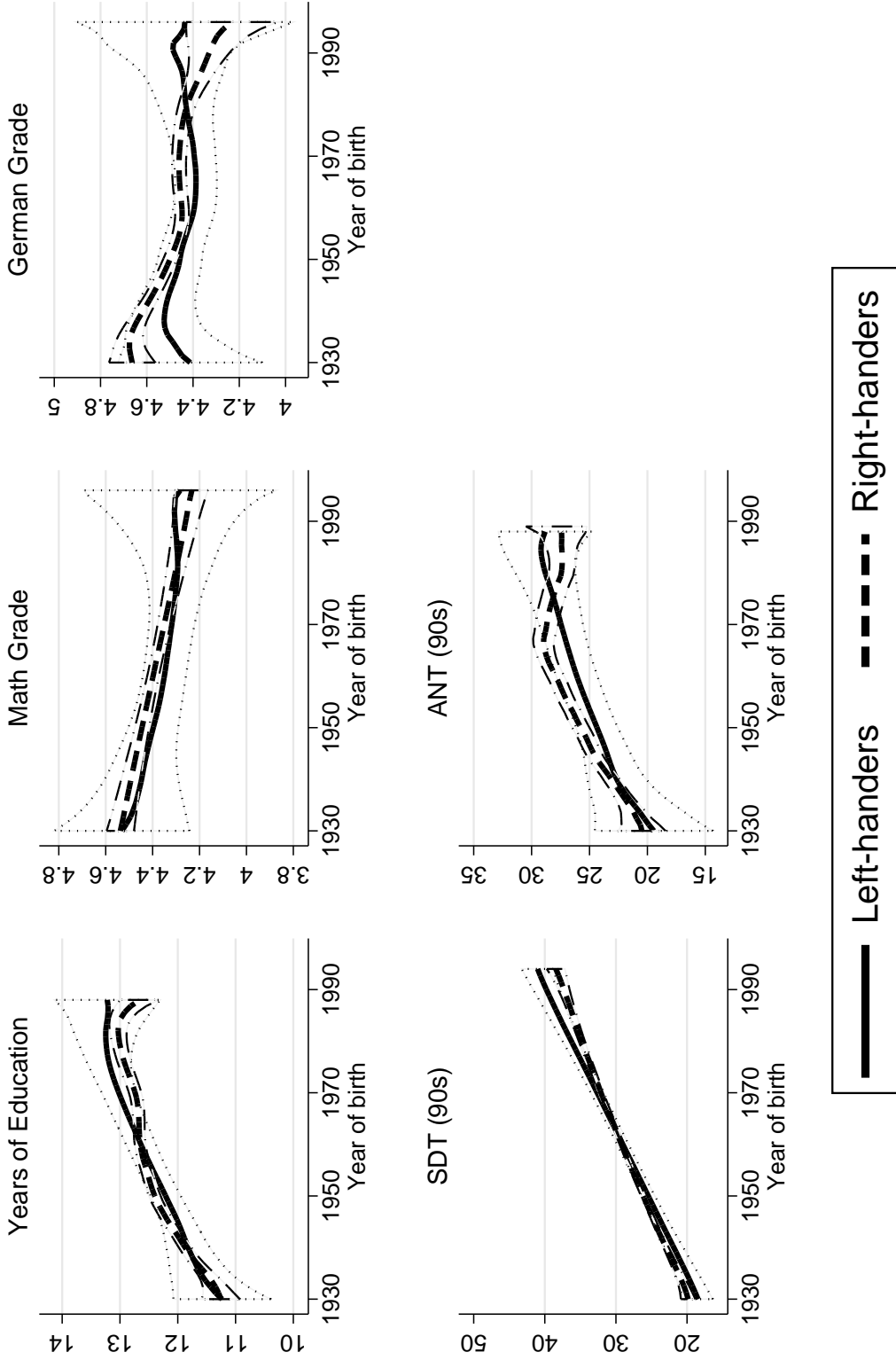


Figure 2: Local linear regression. Parents cared about performance in school by handedness and year of birth (coding: 1=not at all, 2=somewhat, 3=a lot, 4=very much). Includes 95% confidence intervals.

Cohort trends between left- and right-handers



Source: GSOEP. Local linear regression.

Figure 3: Cohort trends between left- and right-handers. Includes 95% confidence intervals.

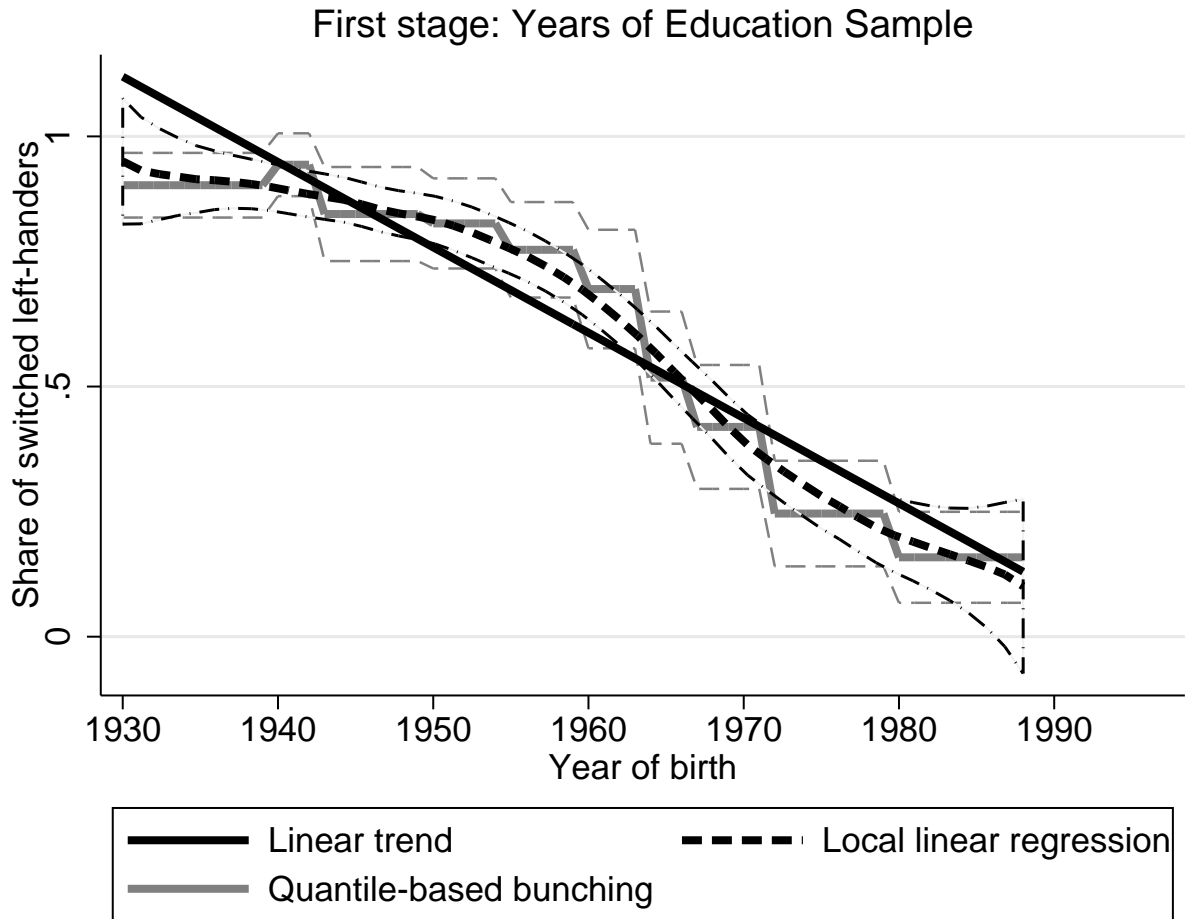


Figure 4: First stage relationship (Education sample). Includes 95% confidence intervals.

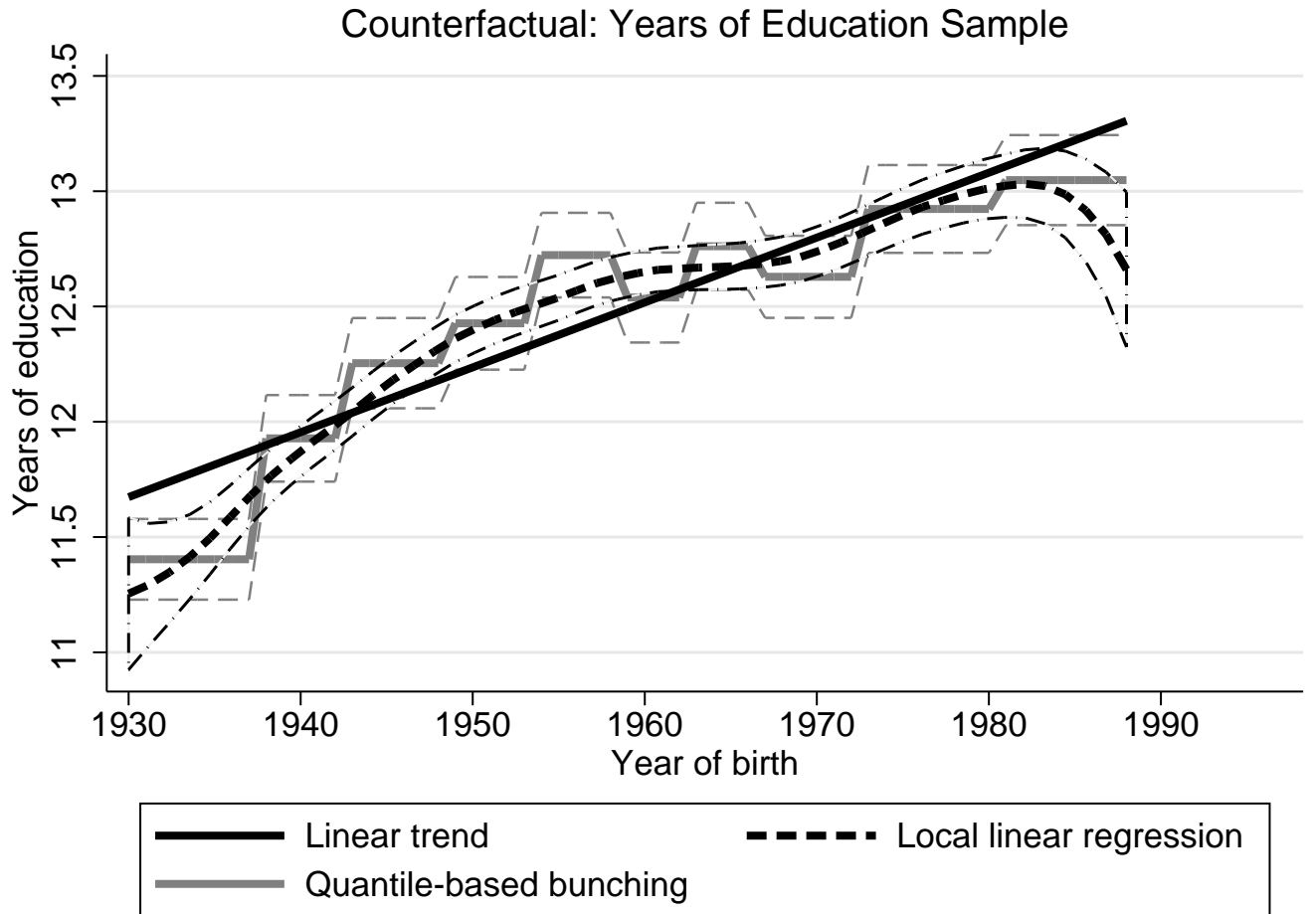


Figure 5: Counterfactual cohort trends (right-hander sample): other outcomes. Includes 95% confidence intervals.

Appendix

	Right-handers	All Left-handers	Switched Left-handers	Total
<i>Years of Education Sample</i>				
Years of education	12.46 (2.73)	12.53 (2.90)	12.49 (2.85)	12.46 (2.75)
Year of birth	1957.87 (15.25)	1958.18 (14.80)	1952.34 (12.55)	1957.90 (15.22)
Female	0.53	0.46	0.46	0.52
Eastgerman	0.24	0.20	0.23	0.24
Migration background				
none	0.82	0.85	0.87	0.82
direct	0.11	0.07	0.06	0.11
indirect	0.07	0.08	0.07	0.07
Father's education				
Basic	0.71	0.71	0.76	0.71
Middle/other	0.16	0.15	0.14	0.16
High	0.13	0.13	0.10	0.13
Mother's education				
Basic	0.74	0.73	0.80	0.74
Middle/other	0.19	0.19	0.15	0.19
High	0.07	0.08	0.05	0.08
Primary place of living until age 15				
Largecity	0.20	0.22	0.21	0.21
Mid-sizecity	0.17	0.20	0.19	0.17
Smalltown	0.23	0.22	0.21	0.22
Countryside	0.40	0.36	0.39	0.40
<i>N</i>	7,807	642	410	8,449

Table displays means of variables by treatment group. Standard deviations of non-binary variables are displayed in parenthesis below respective means. Sample restricted to individuals with age 25 or older. See table 2 for further descriptions.

Table 11: Years of education sample: Descriptive statistics by handedness group

	Right-handers	All Left-handers	Switched Left-handers	Total
<i>Grade Sample</i>				
Mathgrade	4.39 (0.98)	4.35 (0.97)	4.48 (0.88)	4.39 (0.98)
Germangrade	4.48 (0.83)	4.43 (0.83)	4.45 (0.78)	4.48 (0.83)
Yearofbirth	1961.63 (16.14)	1962.60 (16.01)	1954.30 (13.61)	1961.71 (16.13)
Female	0.53	0.49	0.48	0.53
Eastgerman	0.20	0.14	0.17	0.20
Migration background				
none	0.82	0.85	0.85	0.82
direct	0.10	0.07	0.07	0.10
indirect	0.08	0.09	0.07	0.08
Father's education				
Basic	0.67	0.67	0.72	0.67
Middle/other	0.18	0.16	0.15	0.18
High	0.16	0.17	0.13	0.16
Mother's education				
Basic	0.69	0.68	0.75	0.69
Middle/other	0.21	0.21	0.18	0.21
High	0.10	0.11	0.07	0.10
Primary place of living until age 15				
Largecity	0.21	0.22	0.22	0.21
Mid-sizecity	0.17	0.20	0.19	0.17
Smalltown	0.23	0.22	0.20	0.23
Countryside	0.39	0.36	0.38	0.39
<i>N</i>	6,021	531	303	6,552

Table displays means of variables by treatment group. Standard deviations of non-binary variables are displayed in parenthesis below respective means. Grade sample refers to sample with non-missing grades in math. Sample size for non-missing German grades is 6,319. Grades range from 1 (very good) to 6 (insufficient) in Germany. Grade variables are reversed here, for easy of interpretation. See table 2 for further descriptions.

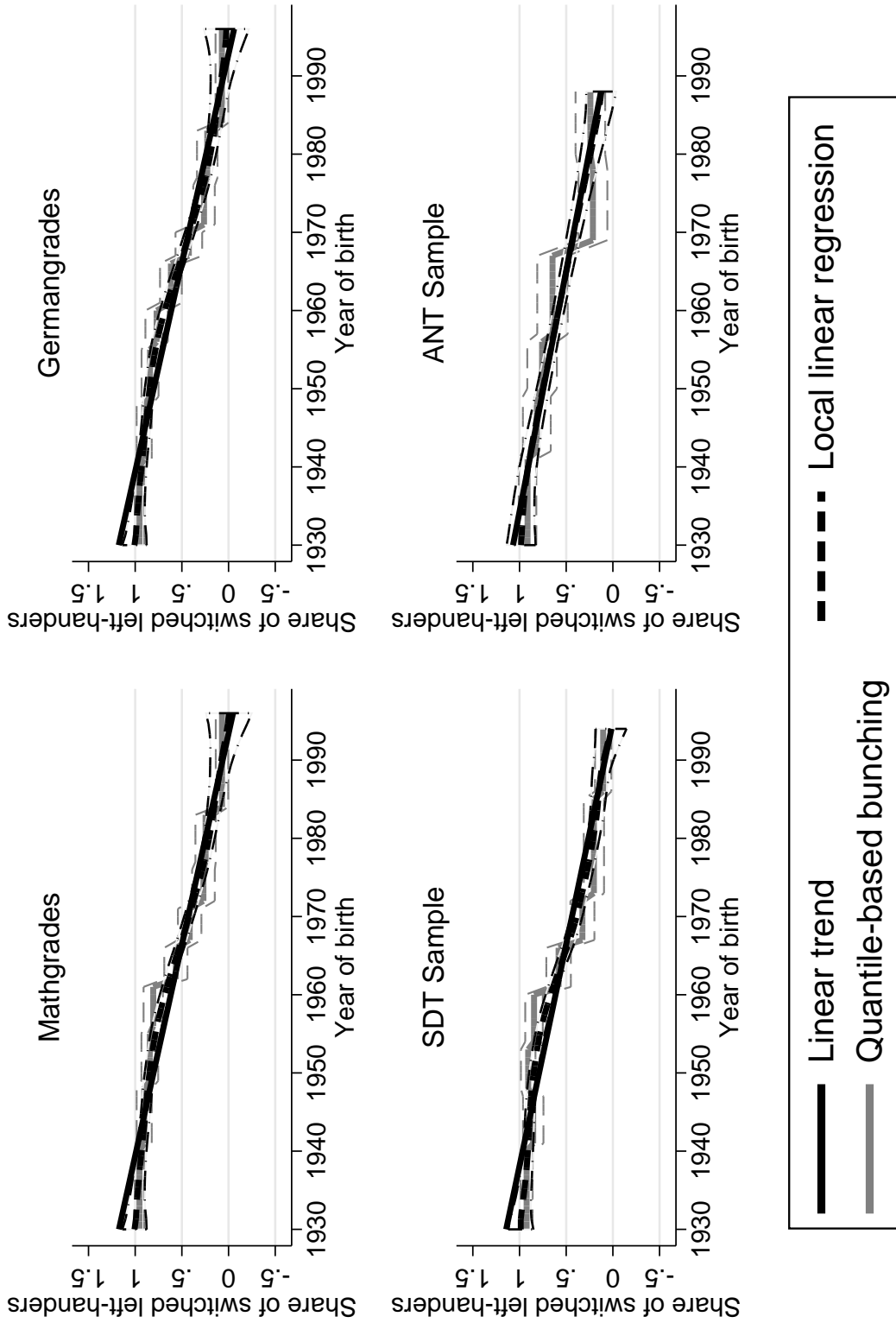
Table 12: Grades sample: Descriptive statistics by handedness group

	Right-handers	All Left-handers	Switched Left-handers	Total
	<i>Cognitive skills sample</i>			
SDT (90s)	29.69 (9.32)	30.05 (10.26)	27.21 (9.55)	29.72 (9.40)
ANT (90s)	27.21 (11.02)	26.34 (10.84)	25.29 (10.33)	27.14 (11.01)
Year of birth	1959.76 (16.94)	1961.28 (17.20)	1952.78 (13.42)	1959.89 (16.97)
Female	0.54	0.48	0.49	0.53
Eastgerman	0.21	0.18	0.21	0.21
Migration background				
none	0.81	0.85	0.87	0.81
direct	0.11	0.07	0.06	0.11
indirect	0.08	0.08	0.06	0.08
Father's education				
Basic	0.70	0.68	0.76	0.69
Middle/other	0.17	0.17	0.14	0.17
High	0.13	0.15	0.10	0.14
Mother's education				
Basic	0.71	0.68	0.78	0.71
Middle/other	0.20	0.23	0.15	0.20
High	0.09	0.09	0.06	0.09
Primary place of living until age 15				
Largecity	0.22	0.23	0.20	0.22
Mid-sizecity	0.17	0.17	0.17	0.17
Smalltown	0.23	0.25	0.26	0.23
Countryside	0.39	0.35	0.38	0.39
<i>N</i>	3,891	361	218	4,252

Table displays means of variables by treatment group. Standard deviations of non-binary variables are displayed in parenthesis below respective means. Cognitive skill sample refers to individuals with non-missing values of the symbol digit task (SDT) in 2006 or 2012. Sample size for animal naming task (ANT) is 2,413. Variable SDT (90s) is the sum of correct (not total) entries in the symbol digit task within 90 seconds, see text for further information. ANT (90s) refers to the sum of uniquely (not total) named animals within 90 seconds. See table 2 for further descriptions.

Table 13: Cognitive skills sample: Descriptive statistics by handedness group

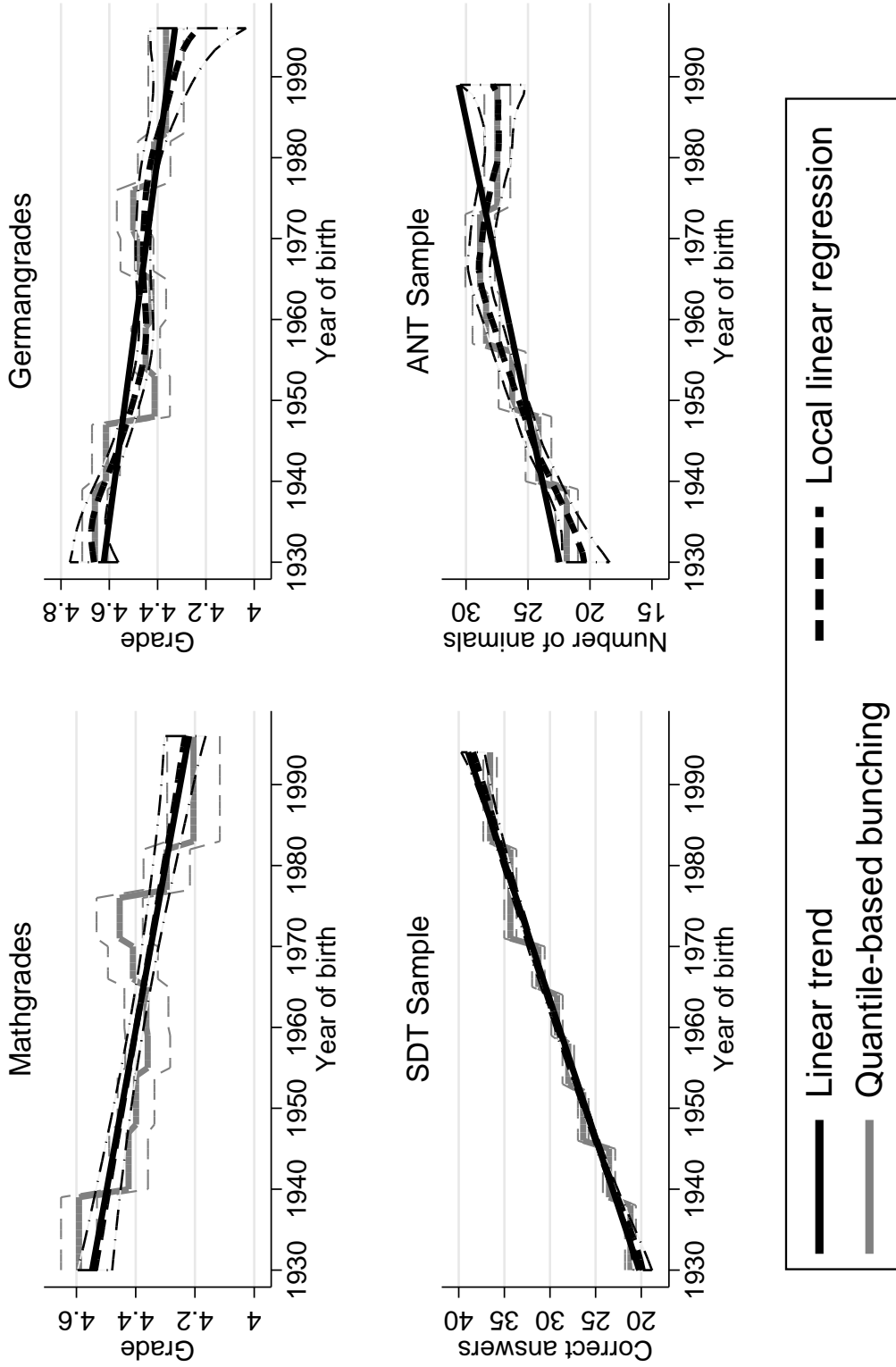
First stage: Other outcomes



Source: GSOEP.

Figure 6: First stage relationships (all other outcomes). Includes 95% confidence intervals.

Counterfactual trends: Other outcomes



Source: GSOEP.

Figure 7: Counterfactual cohort trends (right-hander sample): other outcomes. Includes 95% confidence intervals.

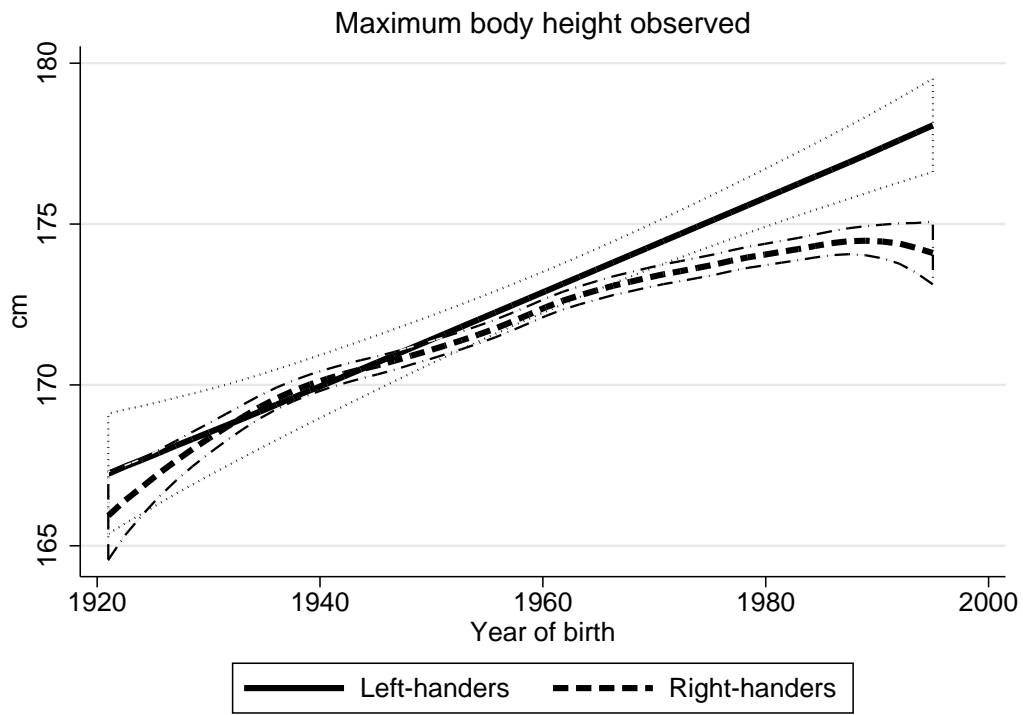


Figure 8: Maximum observed height by handedness by year of birth.

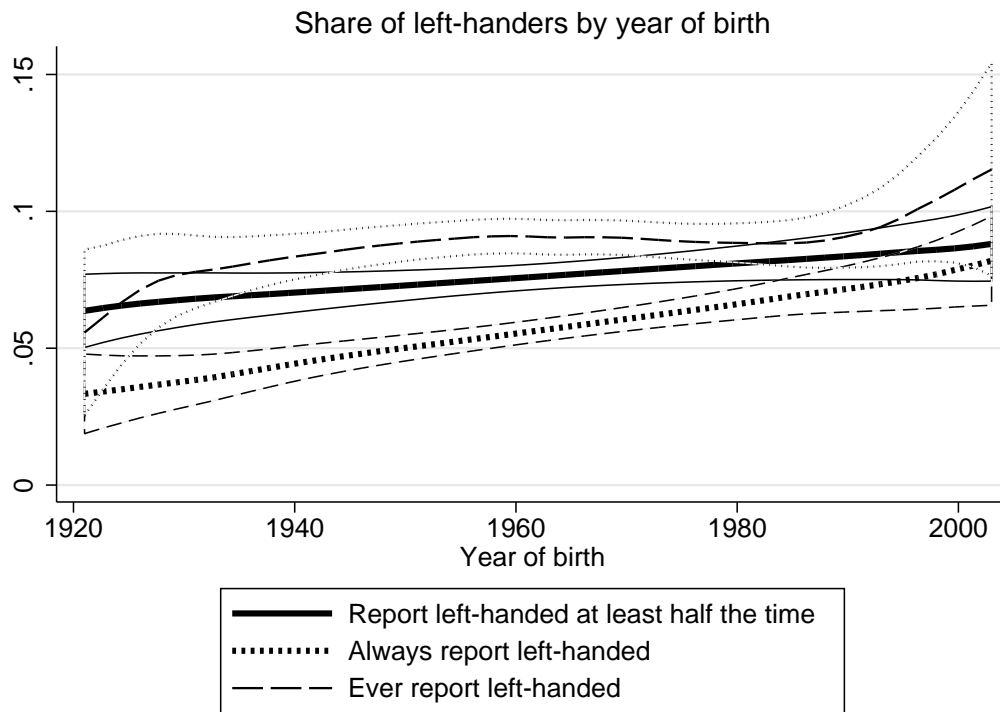


Figure 9: Share of left-handed by measure across cohorts.

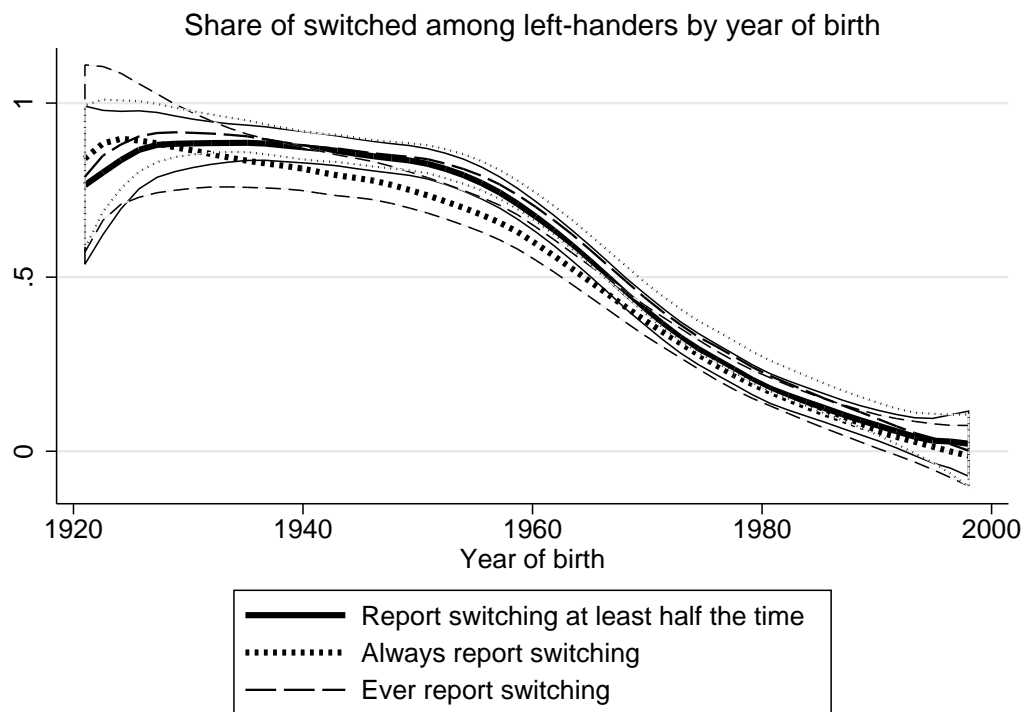


Figure 10: Share of switched individuals among left-handed by measure and conditional on same left-handed measure across cohorts.

Sample	Full sample				Born between 1940 and 1979				Without migration background					
	GLS	2GLS	GLS	G2SLS	GLS	G2SLS	GLS	G2SLS	GLS	G2SLS	GLS	G2SLS	GLS	G2SLS
Estimation														
Outcome:	Symbol-Digit Test (90s)													
Switched	-0.09 (0.09)	-0.35** (0.15)	-0.10 (0.09)	-0.36** (0.15)	-0.09 (0.09)	-0.35** (0.15)	-0.02 (0.09)	-0.24 (0.16)	-0.12 (0.12)	-0.51* (0.27)	-0.10 (0.09)	-0.32** (0.15)		
Left-handed	0.05 (0.07)	0.21** (0.10)	0.07 (0.07)	0.23** (0.10)	0.05 (0.07)	0.20** (0.10)	0.00 (0.07)	-0.14 (0.11)	0.01 (0.10)	0.27 (0.19)	0.05 (0.07)	0.19* (0.10)		
N	5,213	5,213	5,213	5,213	5,213	5,213	5,213	5,213	3,224	3,224	4,679	4,679		
N(cluster)	4,252	4,252	4,252	4,252	4,252	4,252	4,252	4,252	2,644	2,644	3,790	3,790		
Overall R ²	0.289	0.288	0.275	0.274	0.283	0.282	0.291	0.291	0.129	0.127	0.290	0.290		
Outcome:	Animal-Naming Task (90s)													
Switched	-0.07 (0.16)	-0.18 (0.32)	-0.01 (0.16)	-0.15 (0.32)	-0.06 (0.16)	-0.18 (0.32)	-0.01 (0.18)	-0.32 (0.36)	-0.09 (0.21)	-0.20 (0.43)	-0.14 (0.17)	-0.09 (0.31)		
Left-handed	-0.05 (0.13)	0.02 (0.21)	-0.08 (0.13)	0.01 (0.22)	-0.06 (0.13)	0.01 (0.21)	-0.11 (0.15)	0.09 (0.24)	-0.07 (0.17)	-0.00 (0.29)	0.00 (0.14)	-0.03 (0.22)		
N	2,480	2,480	2,480	2,480	2,480	2,480	2,480	2,480	1,648	1,648	2,239	2,239		
N(cluster)	1,885	1,885	1,885	1,885	1,885	1,885	1,885	1,885	1,292	1,292	1,696	1,696		
Overall R ²	0.084	0.083	0.040	0.040	0.072	0.071	0.089	0.087	0.083	0.082	0.064	0.064		
Basic controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Parental controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Interaction														

Standard errors clustered at individual level. *** p<0.01, ** p<0.05, * p<0.1. Regressions pool observations from 2006 and 2012. Each pair of coefficients and standard errors for switching and left-hander indicator come from separate regressions. 2SLS coefficient uses interaction of left-hander and linear cohort trend as IV for switching. All regression control for linear cohort trend. Table shows effect sizes in standard deviation units of respective sample. Basic Controls are dummies for being East German, female and having a migration background (none, direct and indirect). Parental controls are mothers' and fathers' education (low/none, middle and high) and primary place of living until the age of 15 (large city, mid-size city, small town and countryside). Interaction refers to basic and parental controls interacted with left-hander indicator. Sample generally restricted to individuals born in or after 1930 and before 1997.

Table 14: Robustness check: Random effects and REIV estimates for cognitive outcomes using different sets of covariates and exclusion of subpopulations

Outcome:	Symbol-Digit Test (90s)				Animal-Naming Task (90s)			
<i>Sample:</i>	<i>Full sample</i>							
Cohort trend:	Linear	Quadratic	Cubic	Dummies	Linear	Quadratic	Cubic	Dummies
Switched	-0.35 ** (0.15)	-0.38*** (0.15)	-0.37*** (0.14)	-0.37*** (0.14)	-0.18 (0.32)	-0.31 (0.31)	-0.31 (0.31)	-0.32 (0.31)
N	5,213	5,213	5,213	5,213	2,480	2,480	2,480	2,480
N(cluster)	4,252	4,252	4,252	4,252	1,885	1,885	1,885	1,885
Overall R ²	0.288	0.289	0.289	0.282	0.083	0.101	0.102	0.101
N(Instruments)	1	2	3	7	1	2	3	5
<i>Sample:</i>	<i>Born between 1940 and 1979 and observations between age 25 and 65.</i>							
Switched	-0.51 * (0.27)	-0.37 (0.26)	-0.42 (0.26)	-0.34 (0.24)	-0.20 (0.43)	-0.24 (0.42)	-0.22 (0.42)	-0.37 (0.41)
N	3,224	3,224	3,224	3,224	1,648	1,648	1,648	1,648
N(cluster)	2,644	2,644	2,644	2,644	1,292	1,292	1,292	1,292
Overall R ²	0.127	0.128	0.128	0.127	0.082	0.090	0.090	0.084
N(Instruments)	1	2	3	6	1	2	3	4
<i>Sample:</i>	<i>Without migration background</i>							
Switched	-0.43*** (0.16)	-0.46*** (0.16)	-0.44*** (0.15)	-0.43*** (0.15)	-0.28 (0.36)	-0.45 (0.35)	-0.44 (0.34)	-0.50 (0.33)
N	4,276	4,276	4,276	4,276	2,065	2,065	2,065	2,065
N(cluster)	3,460	3,460	3,460	3,460	1,565	1,565	1,565	1,565
Overall R ²	0.294	0.295	0.295	0.289	0.069	0.091	0.092	0.089
N(Instruments)	1	2	3	7	1	2	3	5

Standard errors clustered at individual level (in parentheses). *** p<0.01, ** p<0.05, * p<0.1. Table shows effect sizes in standard deviation units of respective sample. Regressions pool observations from 2006 and 2012. For control variables see table 9. Sample generally restricted to individuals born in or after 1930 and before 1997.

Table 15: Robustness check: Random Effects IV specifications of cognitive skill outcomes