NATURE'S EXPERIMENT? HANDEDNESS AND EARLY CHILDHOOD DEVELOPMENT*

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In recent years, a large body of research has investigated the various factors affecting child development and the consequent impact of child development on future educational and labor market outcomes. In this article, we contribute to this literature by investigating the effect of handedness on child development. This is an important issue given that around 10% of the world's population is left-handed and given recent research demonstrating that child development strongly affects adult outcomes. Using a large, nationally representative sample of young children, we find that the probability of a child being left-handed is not significantly related to child health at birth, family composition, parental employment, or household income. We also find robust evidence that left-handed (and mixed-handed) children perform significantly worse in nearly all measures of development than right-handed children, with the relative disadvantage being larger for boys than girls. Importantly, these differentials cannot be explained by different socioeconomic characteristics of the household, parental attitudes, or investments in learning resources.

A large body of research has investigated the factors that affect child development and the impact that child development has on future outcomes, such as educational attainment, wages, and criminal behavior. From this literature, it has been established that early childhood cognitive development is linked to many different socioeconomic factors, such as parental income and education, welfare dependency, maternal employment, and labor force participation (see, e.g., Blau 1999; Guo 2000; Ku and Plotnick 2003; Paxson and Schady 2007; Ruhm 2004; Taylor, Dearing, and McCartney 2004; Waldfogel, Han, and Brooks-Gunn 2002). It has also been found that cognitive skills are most effectively cultivated in early childhood and that rates of return to investment in human capital are highest in the youngest age categories (Cunha et al. 2006; Heckman 2006).

One potentially important determinant of a child's cognitive development is the preference for using the left or right hand. Left- or mixed-handedness has been associated with atypical cognitive abilities, which can have both disadvantageous and advantageous outcomes (Heilman 2005). This is an important issue given that approximately 10% of the world's population is left-handed.[1] Furthermore, any child development disparity found by handedness might help explain existing and future educational and labor market differentials. Handedness has been widely studied in disciplines ranging from psychology to medicine, as well as in certain social sciences, such as anthropology (see, e.g., Annett and Manning 1989; Bishop 1990; Corballis 1991; Coren 1992; Dancey et al. 2005; Porac and Coren 1977; Ramadhani et al. 2006).[2] There has also been some very recent work by

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1. The percentage of a country's population that is measured to be left-handed depends upon the era and method of assessment, but typically the figure is around 10%. For example, the percentage who are left-handed is 11% in Canada (Bryden et al. 1997), 12% in the United States (Ruebeck, Harrington, and Moffitt 2007), and 12% in the United Kingdom (Denny and O'Sullivan 2007).

2. This literature is large and has examined, among other things, the relationship between handedness and longevity, blood pressure, irritable bowel syndrome, arthritis, ulcers, immune disorders, schizophrenia, brain tumors, breast cancer, and accident rates. See the journal *Laterality* for research on handedness and health outcomes.

economists investigating the relationship between handedness and adult wages (Denny and O'Sullivan 2007; Ruebeck et al. 2007).

In this article, we investigate the impact of handedness on children's cognitive development by using a large, nationally representative sample of children drawn from the first wave of the Longitudinal Study of Australian Children (LSAC). Besides measuring the child's handedness, this survey contains detailed information concerning the child's cognitive development, health, social adjustment, and how they spend their time, as well as the parent's socioeconomic status and attitudes. The survey therefore provides a unique opportunity to examine the relationship between hand preference and cognitive development while controlling for variables that are known to affect development. This implies that we are able to provide a clear picture of this important relationship, which has hitherto been obscured by inconsistent results (Cerone and McKeever 1999).

The survey also provides a number of other significant advantages. First, the data comprise a large sample (approximately 5,000) of 4- and 5-year-olds. Previous studies investigating the impact of hand preference on cognitive ability focused either on older children (e.g., Faurie, Vianey-Liaud, and Raymond 2006) or on adults (e.g., Halpern, Haviland, and Killian 1998; Resch et al. 1997). Testing children at a relatively young age allows us to examine the relationship between hand preference and cognitive ability before extensive schooling has begun, providing an index of the relationship that is relatively free of social conditioning. Second, a representative sampling technique was used to obtain a test population that was indicative of the population at large. Previous studies tended to focus on restricted samples from schools or other institutions (e.g., Faurie et al. 2006; Williams 1987). Finally, information concerning child development comes from a combination of interviewer-conducted tests, assessments by educationalists, and preschool or kindergarten teachers. This eliminates the possibility of bias introduced by parents' subjective assessment of their own child's abilities and gives us a wide array of assessments from various individuals.

The rest of the article is set out as follows. In the following section, we outline several theoretical explanations for the relationship between handedness and cognitive development. Next, we introduce our data, provide definitions and information about the child assessments, and present some salient characteristics relating to handedness and child development. We then present results from statistical models of handedness and child development and offer conclusions.

EXPLANATIONS FOR HANDEDNESS DIFFERENTIALS

A number of theories predict differences in the cognitive abilities of left- and right-handed individuals. Annett (1985) proposed a genetic model of handedness, stating that handedness is determined by one gene with two alleles (i.e., two alternate forms). One allele is dominant (RS+) and selects for right-handedness, while the other is recessive (RS–) and selects for both right- and left-handedness. Annett theorized that the recessive trait is maintained because of a cognitive advantage for individuals with both alleles (RS+ RS–) relative to left-handers (RS– RS–) and individuals who are very strongly right-handed (RS+ RS+).[3] For strong right-handers, a cognitive deficit, particularly for spatial processing, was observed by Annett (1992), but not by other researchers (Cerone and McKeever 1999; McManus, Shergill, and Bryden 1993). McManus and Mascie-Taylor (1983) reported evidence for a general cognitive disadvantage for non-right-handers compared with right-handers. Resch et al. (1997) also reported lower levels of achievement in left-handers: individuals on the

3. Annett (1985) made specific predictions about the type of impairment for the left-handers (RS– RS–) and strong right-handers (RS+ RS+). The recessive group (RS– RS–) has impaired left hemisphere development and is at risk for developmental delays in speech and language skills. The dominant group (RS+ RS+) has impaired right hemisphere development, affecting spatial cognition.

left side of the handedness continuum had lower scores in spelling, educational success, and nonverbal intelligence. Resch et al. (1997) noted, however, that the effect of handedness on cognitive ability is small, especially when sex and age are controlled.

In addition to genetic effects, reduced cognitive performance in left-handers could be the result of brain pathology. Bakan, Dibb, and Reed (1973) proposed that, in a perfect world, everyone would be right-handed. In reality, however, a proportion of individuals suffer some minor brain insult either prenatally or perinatally, and this causes a cognitive decline as well as a shift toward right-hemisphere dominance—leading to left-handedness. More recent and moderate models now have acknowledged that pre- or perinatal brain insult accounts for only a proportion of left-handers (Satz et al. 1985). In support of this more moderate model, an elevated incidence of left-handedness has been reported in children who have suffered severe bacterial meningitis (Ramadhani et al. 2006) and for females with early neurologic insult (Miller et al. 2005). There is also evidence that the chances of having a left-handed child are increased for older mothers (Bailey and McKeever 2004) and for infants who experienced birth asphyxia (Fox 1985). The pathological model predicts lower academic achievement in a subgroup of left-handers not as a result of their hand preference per se, but because of the brain insult that caused a shift in hand preference and decreased cognitive ability. It is interesting to note that the link between brain pathology and handedness may have a genetic component whereby mothers pass on a susceptibility to problematic births and hence left-handedness (Pipe 1987).

While Annett's and Bakan's theories propose that left-handers are generally disadvantaged relative to right-handers, McManus (2002) suggested that left-handedness bestows a cognitive *advantage*. Once again, this proposition is grounded on a genetic theory suggesting that handedness is controlled by a gene with two alleles, one dominant and the other recessive. In this case, however, McManus argues that the recessive gene, which causes left-handedness, persists because it is cognitively advantageous. In support of a left-handed advantage, Benbow (1986) found an excess of gifted children among individuals who are left-handed. Halpern et al. (1998) also found that left-handers have higher scores on verbal reasoning tests and that left-handers are overrepresented in the upper tail of the distribution. Piro (1998), however, found no difference in mean handedness scores between 657 gifted and nongifted children.

Besides general cognitive ability, left-handedness may be advantageous for specific activities because it brings about a shift of dominance toward the right hemisphere, enhancing visuo-spatial functioning carried out on that side of the brain (Heilman 2005). In the scientific and popular literature, there are consistent reports that left-handers are overrepresented among populations of creative artists (Preti and Vellante 2007) and architects (Peterson and Lansky 1977), though Wood and Aggleton (1991) have contested the latter finding. In relation to musical ability, a slight overrepresentation of left-handers is observed among accomplished musicians (Aggleton, Kentridge, and Good 1994), but this effect is not observed among children (Good et al. 1997). Enhanced mathematical ability, which involves a high level of visuo-spatial ability (Hermelin and O'Connor 1986), may also show an effect of hand preference. Although Annett and Kilshaw (1982) reported an increase in the prevalence of left-handedness among mathematicians, they noted that this effect may be due to a spatial/mathematical deficit for strong right-handers rather than an advantage for left-handers. Benbow (1988), however, reported an unusually large percentage of left-handers among those scoring in the top 1% of 10,000 people tested on the Scholastic Aptitude Test.[4] Tests to determine whether left-handers have a superior visuo-spatial ability

4. Peters (1991) argued that the increased prevalence of left-handedness among mathematically gifted individuals (Benbow 1988) is not higher than among the general population and may be the result of a sampling artifact. Instead, Peters suggested that the data support Annett's (1985) proposition that strongly right-handed individuals are disadvantaged for spatial/mathematical cognition.

have yielded mixed results. Although elevated levels of spatial ability (Annett 1992) and divergent thinking (Coren 1995) are reported in left-handers, Snyder and Harris (1993) found no difference between left- and right-handers for tests of mental rotation and 3D drawing ability, and McKeever (1986) reported that left-handers performed worse on a test of spatial visualization.

In contrast to theories that center on the relative abilities of left- and right-handers, some researchers have focused on individuals with mixed, or no, hand preference. The idea that mixed-handedness and weak laterality are related to learning disabilities has a long history first proposed by Orton (1937). More recently, Crow et al. (1998) argued that the evolution of laterality is the key characteristic that allowed language and higher cognitive functions to develop. Individuals without a strong hand preference are thought to suffer from "hemispheric indecision," which reduces academic ability and makes the individual more prone to psychotic disorders. Once again, evidence is mixed, with some researchers finding support for this theory (Crow et al. 1998; Nettle 2003) while others did not (Heinz and Heinz 2002). Recent large-scale studies, however, found lower levels of cognitive ability in mixed-handers. Corballis et al. (2008) used data from an IQ test administered in New Zealand as part of a nationwide television program. Data from 1,355 respondents revealed no difference in IQ between left- and right-handers. Mixed-handers, however, performed more poorly, especially on subscales measuring arithmetic, memory, and reasoning. Another large-scale study by Peters, Reimers, and Manning (2006) collected data from 250,000 respondents using the Internet. Individuals who reported no hand preference for writing had significantly lower spatial ability and a higher prevalence of dyslexia, hyperactivity, and asthma than individuals with a strong hand preference.

DATA, DEFINITIONS, AND SAMPLE CHARACTERISTICS

Longitudinal Study of Australian Children

The data we use are drawn from the recently released first wave of the Longitudinal Study of Australian Children (LSAC) collected in 2004.[5] The study aims to examine the impact of Australia's unique social and cultural environment on the next generation to further the understanding of early childhood development, inform social policy debate, and identify opportunities for early intervention and prevention strategies in policy areas concerning children. The study tracks two cohorts of infants and children over seven years: the two cohorts are (1) children aged less than 12 months in 2003–2004 who will be followed until they reach 6 to 7 years of age, and (2) children aged 4 or 5 years (83% are aged 4) in 2003–2004 who will be followed until they reach 10 or 11 years. Each cohort has just under 5,000 children in the first wave.

The children were randomly chosen using a clustered (by postcode) sample design from a database of 18,500 children who had eligible birth dates. The response rate for the Wave 1 sample was 64% for infants and 57% for 4- to 5-year-olds.[6] Information regarding the child was collected during a lengthy interview in which physical measurements were taken and tests were administered, and from an interview with the parent who knew the child best (the biological mother in 97% of families). Information from this parent and his or her partner (most often the child's other biological parent) was also obtained via separate questionnaires. Further information regarding the family and neighborhood was obtained from the interviewer's personal observations and from two time-use diaries that the interviewer left behind for the child's parents to complete. Finally, information from the child's caretaker or teacher was obtained using a mail-out questionnaire. The information collected from each of these sources has been found to be broadly representative of

5. The LSAC Web site is www.aifs.gov.au/growingup/home.html.
6. More details of the sampling design can be found in Gray and Sanson (2005).

the population, with no large differences from Australian Bureau of Statistics census data on most characteristics. In this article, we use information on 4,942 children aged 4 or 5 at the time of interview, and we combine data from parents and teachers as well as interviewer assessments.

Definitions

Child handedness. Hand preference was determined by the interviewer following the "Who am I" test. This test (described in more detail below) consists of the child writing (words and sentences) and drawing (a variety of pictures). On completion, the interviewer is asked, "Did the child use his/her" (1) right hand, (2) left hand, (3) both hands.[7] We refer to the latter children as mixed-handed throughout the article. Categorical measures of hand preference such as these are not as sensitive as multiple-item questionnaires, such as the Edinburgh Inventory (Oldfield 1971). Nevertheless, hand preference for using a pencil or pen provides a relatively accurate categorization of an individual's hand preference (Chapman and Chapman 1987).

Child development measures. We comprehensively characterize child development by using three different measures. The first is a short form of the Peabody Picture Vocabulary Test (PPVT–III). This test measures a child's knowledge of the meaning of spoken words and his or her receptive vocabulary for Standard English. It involves the child showing what words mean by saying or pointing to a picture that best represents the meaning of a word using plates of displayed pictures. Examples of the words are *wrapping*, *fountain*, *nest*, *envelope*, *target*, *dripping*, *exercising*, and *delivering*. For ease of comparison, we standardize the scores so that the mean equals 50 and the standard deviation equals 10.

The second measure is the "Who am I" (WAI) test, which was designed by the Australian Council for Education Research (ACER) to assess general cognitive abilities needed for beginning school. It is a standardized test designed to measure a child's ability to perform a range of tasks, such as reading, writing, copying, and symbol recognition. Each child is given an 11-page answer booklet in which children are to write their names, copy shapes (circle, triangle, cross, square, and diamond), and write words, sentences, and numbers. What they write/draw is then assessed by experienced researchers from ACER. Again, the score is standardized to have a mean of 50 and a standard deviation of 10.

Our third source of information on child development comes from teacher assessments. Around 65% of children were enrolled in an educational program (preschool, kindergarten, and the like) and had a teacher willing to complete a questionnaire.[8] On page 6 of the questionnaire, teachers were asked to think about the skills and competencies of the study child as described in the next statements, and to rate how this child compared with other children of a similar age over the past few months. The areas of assessed competency are: (1) social/emotional development (e.g., adaptability, cooperation, responsibility, and self-control); (2) approaches to learning (e.g., attention, observation, organization, problem-solving); (3) gross motor skills (e.g., running, catching and throwing

7. The interviewer is also able to respond that he or she is unsure which hand the child (dominantly) used. We classify children as mixed-handed if the interviewer is sure the child is both-handed or if the interviewer is unsure whether the child is either both-handed or right-/left-handed. In both instances, the child has demonstrated no dominant hand preference to the interviewer throughout the lengthy testing procedures. We believe that this is also reasonable because for seven of the eight outcome measures used in this article (WAI, PPVT, and the six teacher measures), there is no statistical difference between the group classified both-handed and the group classified as unsure. There is a statistical difference only for the WAI measure, with those classified as both-handed doing worse than those classified as unsure.

8. More specifically, 5% of children in the sample did not attend school, kindergarten, or preschool, 2% of the parents did not give permission for the survey organizers to contact the child's teacher, and 28% of the children had teachers who did not return a completed survey. Importantly, having a completed teacher questionnaire is unrelated to handedness.

balls, strength, and balance); (4) fine motor skills (e.g., manual dexterity, using writing and drawing tools); (5) expressive language skills (e.g., using language effectively, and ability to communicate ideas); and (6) receptive language skills (e.g., understanding, interpreting, and listening). The responses were on the following four-point ordinal scale: (3) much less competent; (2) less competent than others; (1) as competent as others; and (0) more competent than others.

Sample Characteristics

In Table 1, we describe the handedness of children in the sample. Approximately 10% of all children are left-handed: about 11% of boys and 9% of girls. These statistics are consistent with findings in the literature on handedness. While the incidence of left-handedness obviously varies across cultures and over time, on average, 10% of the population would be classified (or classify themselves) as left-handed (Denny and O'Sullivan 2007). In addition, studies have found that males have a somewhat higher incidence of left-handedness than females.

Approximately 4% of our sample is assessed by the interviewer to be mixed-handed. Again, there are more mixed-handed boys than girls: 6% compared to 3%. The mixed-handed children may still develop a preference for one hand as they become older, or they may remain ambidextrous. However, it has been documented that the majority of children have already developed a clear hand preference at 6 months of age. On the other hand, a small minority of children will show no strong preference until later in life (see Bishop 1990).

Table 2 describes how children scored on the eight different measures of child development, disaggregated by hand preference. The WAI and PPVT scores are reported as average scores, where the higher the score, the better the development outcome. In the empirical models, we use the log of these measures as our dependent variables, although the main findings of this study are unchanged if we use a linear specification. The next six measures are reported as the percentage of children whom teachers assessed as less or much less competent than others. The raw data indicate that left- and mixed-handed children score worse than right-handed children in all eight measures. We then test the scores of left- and mixed-handed children relative to right-handed children to check whether the scores are significantly different. The test scores on the PPVT and the teacher-assessed expressive English, the two measures of expressive English skills, are not significantly different for left- and right-handed children. Similarly, the PPVT scores and the teacher-assessed expressive English scores are not significantly different between mixed- and right-handed children. Therefore, left- and mixed-handed children score worse in all measures of development except for their expressive English skills. In the next section, we check to see whether these patterns in the data hold after we control for various household, parental, and child characteristics.

Table 1. Sample Handedness

Sample	Right-Handed (1)	Left-Handed (2)	Mixed-Handed (3)
All	85.85	9.85	4.30
	(0.51)	(0.44)	(0.30)
Boys	83.56	10.82	5.62
	(0.76)	(0.64)	(0.49)
Girls	88.23	8.83	2.93
	(0.67)	(0.59)	(0.35)

Note: Standard errors are shown in parentheses.

Table 2. Summary of Child Development Measures by Handedness

Measure	Right-Handed (1)	Left-Handed (2)	Mixed-Handed (3)
WAI Score	50.58	49.27**	45.91**
PPVT Score	50.11	49.88	48.73
Sample Size	3,746	425	183
Social/Emotional Development	20.44	26.35*	35.97**
Learning	16.30	23.81**	30.49*
Gross Motor Skills	9.14	17.14**	20.12**
Fine Motor Skills	14.88	25.71**	34.76**
Expressive English Skills	20.25	20.32	28.05
Receptive English Skills	14.43	20.00**	24.39**
Sample Size	2,681	315	164

Notes: Average scores are shown for WAI and PPVT. Percentage of children assessed by teachers as "less competent than others" or as "much less competent than others" are shown for teacher-assessed measures.

*Significantly different from right-handed children at $p < .05$.

**Significantly different from right-handed children at $p < .01$.

STATISTICAL ANALYSIS

Is Handedness Exogenously Determined?

As discussed in the introduction, it is theorized that handedness might be pathological in origin. This implies that there may be a positive association between left- and mixed-handedness and variables representing birth complications. To investigate this theory, we estimate a multinomial logit model of handedness and include as covariates birth weight, mother's age, and indicators of an intensive care birth, a premature birth, and a multiple birth (i.e., twins or triplets). We rely on these proxy variables for birth complications because the LSAC data set does not contain more specific information (e.g., caesarean birth). Within this multinomial logit framework, we also investigate whether handedness is associated with socioeconomic status (SES). The presence of such an association has important ramifications: if SES influences development outcomes, estimates of the impact of handedness on child development will be biased. For example, if right-handed children come from richer households, then right-handed children might be more developed, even in the absence of a causal effect. Ideally, we would also estimate how parents' handedness affects child handedness, but unfortunately, the data set does not contain information on parents' handedness. The definitions and means of the variables we use are presented in Appendix Table A1.

The marginal effect estimates from the multinomial logit model of handedness are reported in Table 3. Only a few variables have a significant effect at the .05 level. One is the dummy variable male, indicating that boys are more likely to be left- or mixed-handed. This difference is reflected in the raw data: there are more left- and mixed-handed boys in our sample relative to girls, which is characteristic of the general population. Another is mother's age: older mothers are more likely to have left-handed children and less likely to have mixed-handed children. This significant effect provides some evidence in favor of the pathological theory of handedness; however, all other variables representing birth complications are insignificant in the left- and mixed-handed equations, so the evidence is weak at

Table 3. Multinomial Logit Model of Handedness

	Left-Handed (1)		Mixed-Handed (2)	
Variable	ME	*t* Statistic	ME	*t* Statistic
Age 5	–0.007	–0.69	–0.018	–0.81
Male	0.019	2.26	0.033	5.58
Birth Weight	–0.002	–0.25	–0.005	–0.88
Intensive Care When Born	0.021	1.54	0.016	1.57
Premature Birth	0.014	0.85	–0.004	–0.43
Multiple Birth	0.005	0.21	0.019	0.94
Older Sibling in Household	0.010	0.76	–0.001	–0.09
Younger Sibling in Household	0.003	0.23	–0.008	–1.02
Number of Siblings	–0.006	–1.00	0.005	1.37
Mother's Age	0.002	2.54	–0.001	–2.32
Father's Age	–0.003	–3.09	0.001	0.93
Mother Has a Degree	–0.009	–0.88	0.009	1.11
Father Has a Degree	0.006	0.51	–0.009	–1.28
Mother Works Full-Time	0.007	0.58	–0.012	–1.55
Father Works Full-Time	0.013	1.32	–0.001	–0.16
Single Mother	–0.008	–0.33	0.009	0.53
English Is Second Language	0.002	0.15	0.014	1.57
Income $400–$599 per week	–0.015	–0.83	0.008	0.47
Income $600–$799 per week	–0.019	–1.02	0.028	1.19
Income $800–$999 per week	–0.022	–1.20	0.050	1.70
Income $1,000–$1,499 per week	–0.047	–2.81	0.017	0.87
Income $1,500–$1,999 per week	–0.025	–1.34	0.023	1.03
Income > $2,000 per week	–0.031	–1.70	0.048	1.66
Pseudo R^2		0.021		
Sample Size		4,942		

Notes: ME is the estimated marginal change in the probability of being classified as left-handed or mixed-handed, relative to being right-handed, calculated at sample mean values. The omitted (base) categories are age 4, female, not in intensive care when born, not a premature birth, not part of a multiple birth, mother/father has less than a degree-level qualification, mother/father does not work full-time, both parents in household, English is first language, and household income is less than $400 per week. Each model also has controls for missing observations on household income, birth weight, and parental characteristics.

best.[9] In addition, one of the income category coefficients is significant in the left-handed equation, but joint tests of the income effects suggest that income does not impact handedness. This result, coupled with the insignificant coefficients on education and employment status, suggests that handedness is not strongly associated with SES. Overall, we can conclude that handedness in our sample is not strongly associated with birth complications or

9. We also estimated a model in which birth weight was replaced with low birth weight (< 2.5 kg) and very low birth weight (< 2.0 kg) dummy variables. In these specifications, both dummy variables were insignificant in the left- and mixed-handed equations.

with observable differences in SES. This implies that any differences in test scores among right-, left-, and mixed-handed children are caused by handedness and not by confounding variables. Furthermore, the apparent exogeneity of handedness points to the potential use of handedness as an "instrument" in empirical applications.

What Are the Distributional Effects of Handedness?

From the four models described at the beginning of the article, a number of predictions regarding the impact of handedness on the distribution of cognitive ability can be made. If Annett's (1985) model is correct, there should be a general shift in the distribution of cognitive ability toward lower performance. Similarly, for Crow et al.'s (1998) model, there should be a generally lower level of performance for mixed-handers compared with both right- and left-handers. In contrast, models predicting a cognitive advantage for left-handers (e.g., Benbow 1986) did not predict a general shift in the distribution. Instead, there should be a subgroup of left-handers who perform particularly well on the tests. That is, there should be an overrepresentation of left-handers in the upper tail of the distribution. The pathological theory (Satz et al. 1985) predicts the opposite. In this case, a subgroup of the children acquired their left-handedness from brain damage. Therefore, there should be an overrepresentation of left-handers in the lower tail of the cognitive ability distribution.

We examine the distributional effects by comparing kernel density estimates by handedness. The estimated densities are presented in Figure 1 for WAI scores and Figure 2 for PPVT scores. Figure 1 clearly demonstrates that handedness has a negative impact on WAI scores: the mixed-handed distribution is left of the left-handed distribution, which is left of the right-handed distribution. Most important, however, is that left- and mixed-handedness appears to shift the distribution leftward without changing the shape of the distribution. This result supports Annett's and Crow's models for handedness but is in disagreement with the theory that especially gifted children are more likely to be left-handed and the theory that some children acquire their handedness through brain damage. Figure 2 demonstrates that handedness has little impact on PPVT scores. The left-handed and mixed-handed distributions appear to have the same mean as the right-handed distribution, and a roughly similar shape.

This kernel density analysis suggests that left- and mixed-handedness have a similar impact across the distribution. For this reason, in the forthcoming section, we focus solely on the impact that handedness has on the mean of cognitive ability, rather than on the spread or certain quantiles of the distribution.

What Is the Effect of Handedness on Children's Development?

To quantify the affect of handedness on child development, we first obtain estimates from linear regression models in which the dependent variables are the log test scores from the educationalist-assessed WAI and the interviewer-assessed PPVT. For both the WAI and the PPVT, higher scores indicate better child development outcomes.[10] We first report a base model with very few controls and then include results from an extended model in which household, parent, and child characteristics are included as regressors. A comparison of estimates across the basic and extended specifications provides evidence on the extent to which the handedness-development relationship is mediated by family characteristics.

In column 1 of Table 4, the regression results indicate that left-handed children's scores on the WAI are approximately 2.6% lower than those of right-handed children. This result is statistically significant at the .01 level and is robust to the additional

10. We also estimated equivalent models for WAI and PPVT using quantile regressions, and the parameter estimates at the median were almost identical to those presented in Table 4. Moreover, the difference in estimates across quantiles was insignificant in both models, suggesting that the effect of handedness on development does not differ across the conditional distribution.

Figure 1. Kernel Density Estimates of WAI Scores by Handedness

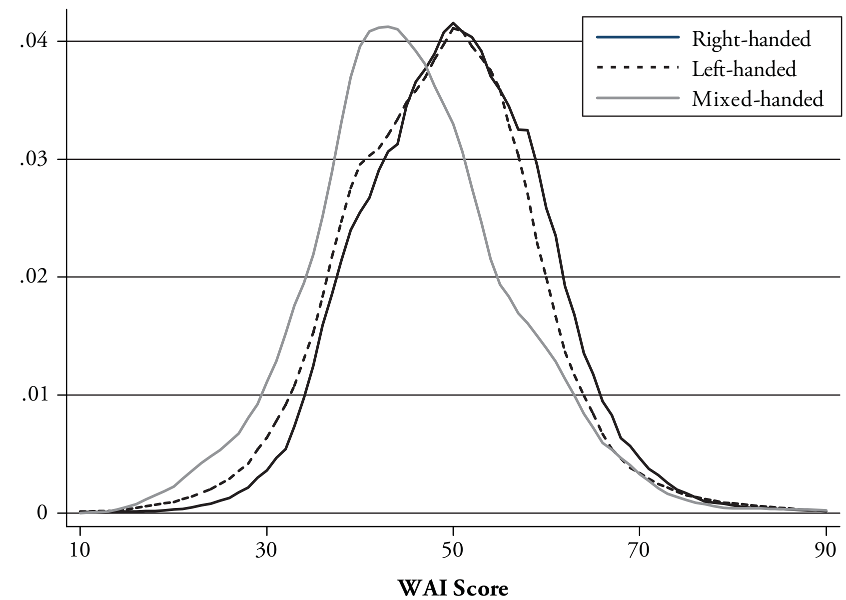

Figure 2. Kernel Density Estimates of PPVT Scores by Handedness

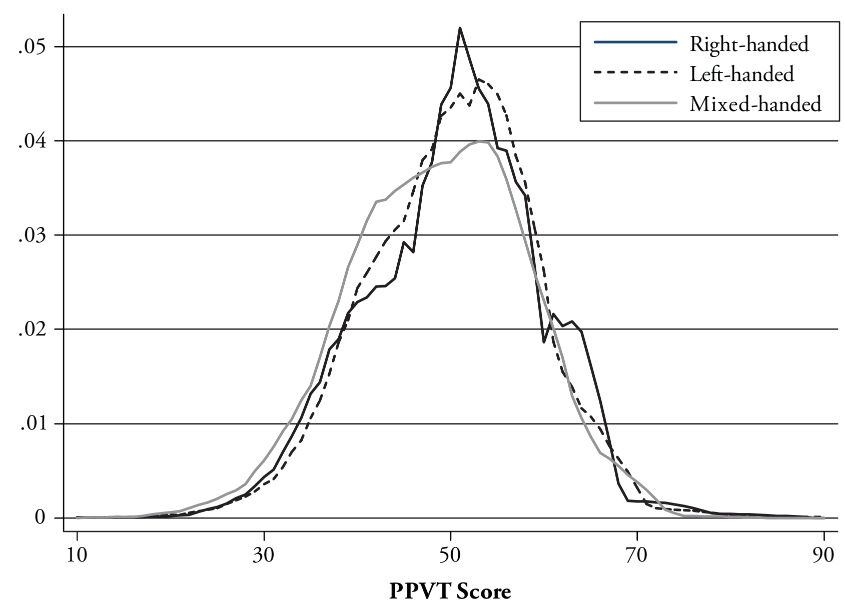

Table 4. OLS Estimates of the Effect of Handedness on Test Scores

	Log WAI (1)		Log PPVT (2)	
Variable	ME	*t* Statistic	ME	*t* Statistic
Basic Specification				
Left-handed	–0.026	–2.74	0.005	0.51
Mixed-handed	–0.083	–6.04	–0.023	–1.55
Age 5	0.126	16.98	0.056	6.68
Male	–0.116	–20.71	–0.031	–5.07
R^2	0.141		0.017	
Extended Specification				
Left-handed	–0.023	–2.52	0.005	0.55
Mixed-handed	–0.075	–5.63	–0.014	–1.05
Age 5	0.127	17.62	0.057	7.54
Male	–0.119	–21.68	–0.034	–5.97
Birth weight	0.027	4.92	0.019	3.34
Intensive care when born	–0.016	–1.83	–0.002	–0.20
Premature birth	–0.015	–1.43	–0.011	–1.05
Multiple birth	–0.030	–1.73	–0.085	–4.68
Older sibling in household	0.011	1.36	0.003	0.31
Younger sibling in household	0.025	3.19	0.017	2.17
Number of siblings	–0.024	–6.25	–0.033	–8.35
Mother's age	0.002	2.78	0.003	5.36
Father's age	0.000	0.06	0.000	0.40
Mother has a degree	0.023	3.39	0.043	6.09
Father has a degree	0.037	5.01	0.027	3.50
Mother works full-time	0.018	2.18	–0.008	–0.92
Father works full-time	0.015	2.25	0.014	1.98
Single mother	0.000	–0.02	–0.054	–3.02
English is second language	0.033	4.26	–0.157	–19.07
Income \$400–\$599 per week	–0.003	–0.19	0.012	0.75
Income \$600–\$799 per week	–0.008	–0.56	0.053	3.34
Income \$800–\$999 per week	–0.001	–0.05	0.052	3.14
Income \$1,000–\$1,499 per week	0.010	0.70	0.062	3.97
Income \$1,500–\$1,999 per week	0.017	1.10	0.076	4.62
Income > \$2,000 per week	0.017	1.07	0.079	4.68
R^2	0.201		0.194	
Sample Size	4,868		4,355	

Notes: The omitted (base) categories are age 4, female, not in intensive care when born, not a premature birth, not part of a multiple birth, mother/father has less than a degree-level qualification, mother/father does not work full-time, both parents in household, English is first language, and household income is less than \$400 per week. Each model also has controls for missing observations on household income, birth weight, and parental characteristics.

covariates. The magnitude of the coefficient on left-handedness is roughly equivalent to the child's mother having a bachelor's degree or higher. Many studies in the economics literature have shown the high correlation between parental schooling and their children's school outcomes (see, e.g., Haveman and Wolfe 1995; Paxson and Schady 2007). There is also broad evidence that mother's human capital is more closely related to children's schooling outcomes than father's human capital (see Haveman and Wolfe 1995). While we do not want to ignore or downplay the possibility of unobserved factors that might influence both mother's educational decisions and children's test outcomes, it appears that the effect of handedness is at least as important as maternal education. Therefore, in terms of child development, if we believe the effect of maternal education on child development is important, then so is handedness.

In Table 5, we present estimates from ordered probit models since the dependent variable is a teacher-assessed score taking the value of 0, 1, 2, or 3. We report the marginal effects, defined as the marginal change in the probability of being classified by the teacher as "less competent than others" or as "much less competent than others" (scoring a 0 or 1). Again, we first report estimates from the base model and then report estimates of the same model but include the additional covariates. We find that left-handed children are 4–6 percentage points more likely to be classified as "less competent" than right-handed children in the areas of social/emotional skills, gross and fine motor skills, and receptive English skills. These coefficients are all significant at the .01 level of significance and are robust to the inclusion of additional covariates.

In column 2 of Table 4 and column 6 of Table 5, we find that left-handedness is not significantly related to PPVT scores or expressive English skills. These are the only skills for which right- and left-handed children do not score differently—an interesting result considering that they both measure expressive English skills. Therefore, left-handed children are not significantly different from right-handed children in expressive English skill development. Again, it is interesting to note that, in most of these regressions, the coefficient on "mother has a higher degree" offsets the coefficient on left-handedness.

Tables 4 and 5 also show that mixed-handed children perform worse than right-handed children in almost all areas. For example, mixed-handed children score 8% less than right-handed children on the WAI. In terms of the teacher-assessed measures, mixed-handed children are 5–10 percentage points more likely to be classified as "less competent" than are right-handed children. In both the linear regression and ordered probit models, the coefficients on mixed-handedness do not change significantly when we include the additional controls. In addition, the coefficients for mixed-handed children are larger than those of the left-handed children, implying that mixed-handed children are faring worse than left-handed children in terms of child development. This result provides some support for the theory that individuals without a strong hand preference suffer from "hemispheric indecision," which limits academic ability compared with both right- and left-handed children.

Previous studies have found that the effects of handedness on child development are different for males and females (Bianki et al. 1996). We investigate whether this holds true for our sample by reestimating the models presented in Tables 4 and 5 separately by gender. Table 6 reports the results from this exercise.[11] On average, the results indicate that left- and mixed-handed boys fare worse than left- and mixed-handed girls in most measures; however, it is important to highlight a few issues with respect to these results. We know that girls are less likely to be left-handed than boys (see Table 1), and we also find that girls typically perform better than boys on our development measures (see Tables 4 and 5). These interconnected relationships mean we must interpret the gender findings in Table 6 with some caution. In addition, some of the coefficients on left-handedness lose significance in

11. Only marginal effect estimates of handedness on development are shown. Full results are available on request.

Table 5. Ordered Probit Estimates of the Effect of Handedness on Teacher Assessments

Variable	Social/ Emotional Development (1)	Learning (2)	Gross Motor Skills (3)	Fine Motor Skills (4)	Expressive English Skills (5)	Receptive English Skills (6)
Basic Specification						
Left-handed	0.047	0.059	0.042	0.065	0.006	0.046
	(2.25)	(3.01)	(2.69)	(3.45)	(0.34)	(2.56)
Mixed-handed	0.117	0.116	0.101	0.134	0.084	0.081
	(3.70)	(3.90)	(3.78)	(4.51)	(2.85)	(3.02)
Age 5	0.010	0.016	–0.008	–0.003	0.006	–0.002
	(0.64)	(1.17)	(–0.78)	(–0.25)	(0.44)	(–0.19)
Male	0.127	0.088	–0.027	0.164	0.068	0.058
	(10.99)	(8.60)	(–3.39)	(16.35)	(6.12)	(6.15)
Extended Specification						
Left-handed	0.045	0.052	0.038	0.062	0.004	0.041
	(2.17)	(2.74)	(2.49)	(3.30)	(0.23)	(2.38)
Mixed-handed	0.119	0.114	0.097	0.131	0.078	0.074
	(3.75)	(3.87)	(3.68)	(4.42)	(2.68)	(2.83)
Age 5	0.005	0.012	–0.009	–0.005	0.000	–0.006
	(0.30)	(0.94)	(–0.93)	(–0.41)	(0.03)	(–0.54)
Male	0.129	0.090	–0.026	0.167	0.071	0.061
	(11.15)	(8.94)	(–3.39)	(16.64)	(6.55)	(6.60)
Birth weight	–0.018	–0.032	–0.008	–0.033	–0.023	–0.026
	(–1.55)	(–3.21)	(–0.99)	(–3.58)	(–2.19)	(–2.90)
Intensive care when born	0.011	0.016	0.028	0.006	0.006	0.011
	(0.60)	(0.99)	(2.05)	(0.42)	(0.36)	(0.77)
Premature birth	0.007	0.021	0.017	0.035	0.027	0.010
	(0.31)	(0.98)	(0.97)	(1.63)	(1.16)	(0.54)
Multiple birth	0.041	–0.005	0.011	–0.018	0.117	0.015
	(1.00)	(–0.16)	(0.42)	(–0.63)	(2.64)	(0.48)
Older sibling in household	–0.018	–0.020	–0.038	–0.040	0.022	0.000
	(–0.98)	(–1.24)	(–3.00)	(–2.63)	(1.30)	(–0.02)
Younger sibling in household	–0.022	–0.056	–0.010	–0.046	–0.014	–0.026
	(–1.34)	(–3.96)	(–0.87)	(–3.44)	(–0.89)	(–2.03)
Number of siblings	0.008	0.020	0.004	0.026	0.033	0.018
	(0.92)	(2.75)	(0.72)	(3.87)	(4.19)	(2.79)
Mother's age	0.000	0.001	0.001	–0.001	–0.002	–0.001
	(–0.19)	(0.80)	(0.83)	(–0.90)	(–1.90)	(–1.08)
Father's age	0.001	–0.001	0.000	0.000	0.002	0.001
	(1.00)	(–1.34)	(–0.21)	(–0.07)	(1.63)	(1.03)
Mother has a degree	–0.031	–0.045	–0.006	–0.019	–0.068	–0.051
	(–2.23)	(–3.86)	(–0.66)	(–1.65)	(–5.47)	(–4.92)
Father has a degree	–0.009	–0.026	0.009	–0.019	–0.018	–0.020
	(–0.63)	(–2.08)	(0.84)	(–1.58)	(–1.24)	(–1.73)
Mother works full-time	0.027	0.010	0.011	–0.022	0.002	0.002
	(1.50)	(0.62)	(0.88)	(–1.64)	(0.13)	(0.14)
Father works full-time	–0.068	–0.046	–0.010	–0.047	–0.059	–0.039
	(–4.55)	(–3.59)	(–1.05)	(–3.86)	(–4.21)	(–3.31)

(continued)

(Table 5, continued)

Variable	Social/ Emotional Development (1)	Learning (2)	Gross Motor Skills (3)	Fine Motor Skills (4)	Expressive English Skills (5)	Receptive English Skills (6)
Extended Specification (cont.)						
Single mother	0.069	0.047	0.093	0.024	0.081	0.050
	(1.66)	(1.30)	(2.69)	(0.73)	(2.03)	(1.49)
English is second language	0.009	0.033	–0.001	–0.019	0.123	0.078
	(0.53)	(2.06)	(–0.07)	(–1.47)	(6.25)	(4.67)
Income \$400–\$599 per week	–0.062	–0.038	–0.039	–0.035	–0.048	–0.053
	(–2.30)	(–1.57)	(–2.36)	(–1.56)	(–1.85)	(–2.70)
Income \$600–\$799 per week	–0.070	–0.050	–0.041	–0.042	–0.068	–0.053
	(–2.57)	(–2.09)	(–2.45)	(–1.85)	(–2.72)	(–2.60)
Income \$800–\$999 per week	–0.079	–0.063	0.042	–0.049	–0.094	–0.063
	(–2.86)	(–2.67)	(–2.45)	(–2.15)	(–3.95)	(–3.08)
Income \$1,000–\$1,499 per week	–0.066	–0.054	–0.056	–0.056	–0.099	–0.072
	(–2.26)	(–2.14)	(–3.19)	(–2.42)	(–3.91)	(–3.39)
Income \$1,500–\$1,999 per week	–0.096	–0.070	–0.057	–0.051	–0.114	–0.081
	(–3.54)	(–2.95)	(–3.52)	(–2.18)	(–4.96)	(–4.14)
Income > \$2,000 per week	–0.103	–0.079	–0.061	–0.056	–0.123	–0.079
	(–3.79)	(–3.33)	(–3.79)	(–2.37)	(–5.34)	(–3.90)
Sample Size			3,160			

Notes: ME is the estimated marginal change in the probability of being classified by the teacher as "less competent than others" or as "much less competent than others" for each variable calculated at the sample mean values. Numbers in parentheses are *t* statistics. The estimated cut-off points from the ordered probit models are not shown. The omitted (base) categories are age 4, female, not in intensive care when born, not a premature birth, not part of a multiple birth, mother/father has less than a degree-level qualification, mother/father does not work full-time, both parents in household, English is first language, and household income is less than \$400 per week. Each model also has controls for missing observations on household income, birth weight, and parental characteristics.

Table 6, probably due to smaller sample sizes, particularly for mixed-handedness. Therefore, while we highlight the possibility of development differences between left-handed boys and left-handed girls, we must also highlight the importance of interpreting these results with some caution.

Are the Results Robust?

There are several alternative explanations for our main finding that left-handed and mixed-handed children are less developed than right-handed children. First, there exists a slight tendency for left-handed individuals to have higher (e.g., immune disease, deafness, asthma) and lower (e.g., brain tumors) prevalence of certain health conditions (see, e.g., Bryden, Bruyn, and Fletcher 2005; Dane and Gumustekin 2002; Fry 1990; Geschwind and Behan 1982; Inskip et al. 2003). Although most of the evidence concerns adults, if any health differences already exist by childhood, this might partially explain the differences in development by handedness. We investigate this possibility by determining whether the addition of variables that are associated with child health influence the findings reported in Tables 4 and 5. Specifically, we include controls for whether the child needs prescription medicine and whether the child uses more medical services than other children. (Note that we already control for birth weight and whether the child was in intensive care when born.) Our results are robust to these changes.

Second, development differences may arise from differences in the preferences of children in how they spend their time. For example, do right-handed children spend more

Table 6. Regression and Ordered Probit Models of Child Development Indicators by Gender

	Males		Females	
Measure	Left-Handed	Mixed-Handed	Left-Handed	Mixed-Handed
WAI	–0.015	–0.086	–0.035	–0.060
	(–1.18)	(–4.97)	(–2.67)	(–2.74)
PPVT	0.011	–0.006	–0.001	–0.036
	(0.82)	(–0.35)	(–0.08)	(–1.60)
Social/Emotional Development	0.063	0.142	0.032	0.107
	(1.91)	(3.33)	(1.32)	(2.19)
Learning	0.084	0.151	0.021	0.079
	(2.72)	(3.68)	(1.04)	(1.88)
Gross Motor Skills	0.046	0.097	0.033	0.104
	(2.12)	(3.00)	(1.49)	(2.20)
Fine Motor Skills	0.087	0.173	0.038	0.106
	(2.66)	(4.04)	(2.10)	(2.62)
Expressive English Skills	–0.013	0.095	0.022	0.056
	(–0.48)	(2.40)	(0.94)	(1.30)
Receptive English Skills	0.052	0.091	0.029	0.062
	(1.89)	(2.49)	(1.45)	(1.64)

Notes: The extended model specification is presented. For brevity, we do not here present the full set of parameter estimates. Figures for WAI and PPVT models are changes in log test scores. Figures for all other models are marginal changes in the probability of being classified by the teacher as "less competent than others" or as "much less competent than others" for each variable calculated at the sample mean values. Figures in parentheses are *t* statistics. Sample sizes are 2,401 for females and 2,467 for males in WAI models; 2,144 for females and 2,211 for males in PPVT models; and 1,488 for females and 1,549 for males in all other models.

time on educational activities or playing on a computer, or perhaps less time watching television, than their left-handed peers? According to information from time-use diaries that parents completed for their children as part of the LSAC, there appears to be no significant difference in the way left-handed, right-handed, and mixed-handed children spend their time, with three interesting exceptions. First, left-handed children spend significantly more time (about 8 minutes per day) watching TV than right-handed children. Second, left-handed children spend significantly less time undertaking educational activities (mainly reading). Third, mixed-handed children have more time each day being held or cuddled by their parents (11 minutes). We examine whether these differences explain any of the development-handedness differences by including in our models variables that denote the minutes the child spends per day watching television, using a computer, undertaking educational activities such as reading, being cuddled, playing, exercising, and at organized lessons. Although the inclusion of these additional controls reduced the estimated differences in child development between right-, left- and mixed-handed children, it explains only about 10% of the difference.[12]

Another possible difference in the child development outcomes by handedness may be due to parental attitudes. For example, left-handed children may watch more television because their parents have different attitudes about time use. This might be the case if left-handed children, for example, are more likely to have left-handed parents. Although we have shown that socioeconomic characteristics are not strongly correlated with handedness

12. Results from time-use models can be found in Johnston, Shah, and Shields (2007: Table 5). Recent work has also noted some concerns with the quality of the time-use data in terms of missing and imputed values (see Baxter 2007).

of children, we must test whether parents of left-, right-, and mixed-handed children differ in their beliefs about parenting and their parenting practices. At the end of each interview, the interviewer is asked to state if the parent spontaneously praised the child at least twice through the interview and also if the parent scolded (or shouted or hit) their child in the interview. There is no significant difference among the parents by child handedness; about 80% of parents praised and 7.5% scolded their child. We also find no significant difference in parental developmental inputs, such as the frequency the child is read to and played with, or the number of books and computers in the household. Moreover, there is no difference in the percentage of parents who strongly agree that parents should know where their child is and what he/she is doing at all times, nor in the percentage who strongly agree with child immunization or using sun protection for their child every day. In addition, when we include all these variables as controls in our models, we find that they do not diminish the estimated handedness effects.

It is possible that participation in structured activities, especially when led by a qualified teacher, and socializing with other children will have a positive impact on development. If differences exist in the probability that left-handed children are enrolled in day care or preschool or in the quality of care received, our estimated development differences may be exaggerated. We examine this explanation by including controls in our models for whether the child attends day care, kindergarten, or preschool, and whether their instructor is university educated. In addition, we include neighborhood SES controls in the regressions to control for the fact that wealthier areas might hire teachers that are more qualified. The resulting estimated effects of left-handedness and mixed-handedness remain substantively unchanged. Therefore, it does not appear that left-handed children are being taught less efficiently.

Finally, we test the robustness of our results by reestimating the models without children who have parents born in Asia. Historically, there has been a tendency toward cultural censorship of left-handedness in certain Asian countries (e.g., Meng 2007). If left-handed children are still being persuaded to use their right hand, which we believe is very unlikely in contemporary Australia, then the estimated impacts of left-handedness and mixed-handedness could be biased (probably downward). Again, our main results remain substantively unchanged.

CONCLUSION

In this article, we investigate the role of handedness in explaining early childhood development differentials. Some theories relating to the development of hand preference have suggested that left-handedness is associated with a cognitive advantage (McManus 2002), whereas others have proposed that left-handedness is associated with a cognitive disadvantage (Annett 1985; Resch et al. 1997). We find considerable evidence that left-handedness is associated with lower levels of cognitive ability. We establish that this cognitive disadvantage is not the result of the parents' socioeconomic status, demographic characteristics, or behavior. Cognitive disadvantage in left-handers is an important finding given that approximately 10% of the world's population is dominantly left-handed, and given recent research demonstrating that child development strongly affects adult outcomes (Cunha et al. 2006; Heckman 2006).

While left-handers performed more poorly than right-handers, the most disadvantaged group was children with no hand preference (mixed-handers). The degree of disadvantage for mixed-handers was roughly double the disadvantage of left-handers relative to right-handers. These lower levels of performance corroborate the findings of recent large-scale studies of adults using television audiences (Corballis et al. 2008) and the Internet (Peters et al. 2006). The current results therefore support Crow et al.'s (1998) proposition that mixed-handedness and hemispheric indecision result in a suboptimal state in which cognitive abilities do not develop normally. Another possibility, however, is that children with mixed-handedness are developmentally delayed. Although hand preference may develop in the first year of life, the rate of development is variable (Michel et al. 2006). The children with mixed-handedness may therefore be developmentally delayed in relation to their hand preference *and* cognitive ability, and this has little to do with laterality per se. For this reason, it would be interesting to follow up with these children in the second wave of testing to determine whether their hand preference has been established and whether they are still at a cognitive disadvantage.

The cognitive disadvantages of being left- or mixed-handed were observed irrespective of whether the assessment was made by the teacher or a trained assessor, suggesting a reliable and robust effect. A broad range of skills were assessed, including vocabulary, reading, writing, copying, social development, and gross and fine motor skills. Left- and mixed-handed children performed worse than right-handed children on nearly all of these measures. The broad deficit in cognitive ability contradicts suggestions that left-handedness results in a specific language disability (Annett 1985). Conversely, two measures showed no effect of hand preference: the PPVT and expressive language skills. Both measures reflect a child's vocabulary and ability to express ideas and do not require a written response. It could be argued, therefore, that the cognitive disadvantage is limited to tasks that require a fine motor response, such as writing. Although there is some support in the literature for an impairment of fine motor skills in left-handers (Giagazoglou et al. 1997; but see Gurd et al. 2006), the data do not support this proposition. The fact that a disadvantage was observed for social/emotional development, approaches to learning, and receptive skills, which do not require written responses, demonstrates that the left-/mixed-handedness deficit extends beyond measures requiring fine motor skills. Thus, it would appear that, despite being disadvantaged in most areas of cognitive achievement, left- and mixed-handers have the same ability for verbal expression as right-handers.

Left- or mixed-handedness could be the result of brain pathology acquired around the time of birth (Satz et al. 1985). If a subgroup of left- or mixed-handers acquired their hand preference from perinatal brain insult, there should be an overrepresentation of these individuals in the lower end of the distribution. Examination of the distribution of cognitive ability for left- and mixed-handers, as measured by the WAI test, reveals a general leftward shift (i.e., reduction) in ability relative to right-handers, without any change in the shape of the distribution. The effect of brain pathology on handedness was investigated further by assessing the effect of known risk factors. Proxy variables for birth complications included birth weight, intensive care when born, premature birth, multiple birth, and mother's age. The majority of the variables had no impact on the child's hand preference. The only exception was mother's age: older mothers were more likely to have left-handed children and less likely to have mixed-handed children. Support for a pathological model of hand preference therefore appears to be weak at best.

Examination of the distribution of cognitive abilities in left-handers is also relevant to the debate concerning giftedness. If left-handers are overrepresented among gifted children (Benbow 1986), there should be an excess of left-handers in the upper tail of the distribution. Once again, the spread of cognitive ability was normally distributed, with no sign of increased frequency of left-handers in the upper end. Note, however, that the WAI measures general cognitive ability related to reading, writing, copying, and symbol recognition. None of these skills are closely related to the specific spatial/mathematical skills that may be enhanced in left-handers (Benbow 1988). The current study, therefore, cannot rule out the possibility that a subgroup of left-handers exists with an exceptional ability in this domain.

In summary, this research demonstrates a broad-based cognitive deficit in left- and mixed-handers relative to right-handers. Using multivariate models, we show that these differences cannot be explained by different socioeconomic characteristics of parents or different investment in learning resources in the household. In relation to the development of the child's hand preference, we demonstrate that it is largely exogenously determined in our data and does not appear to be a result of their social environment or brain pathology. This finding points to the potential use of handedness as an instrumental variable in empirical applications. In future work, we plan to examine whether our findings are also evident when using data from other countries.

Appendix Table A1. Description of Control Variables Used in the Analysis

Variable	Description	Mean
Age 5	Child is age 5 (dv)	0.17
Male	Child is male (dv)	0.51
Birth Weight	Child's birth weight in kilograms	3.40
Intensive Care When Born	Child spent time in intensive care unit or special care nursery (dv)	0.15
Premature Birth	Child born 36 or fewer weeks or into pregnancy (dv)	0.10
Multiple Birth	Child is a twin or triplet (dv)	0.03
Older Sibling in Household	Child lives with an older sibling (dv)	0.58
Younger Sibling in Household	Child lives with a younger sibling (dv)	0.47
Number of Siblings	Child's number of siblings	1.46
Mother's Age	Mother's age at last birthday	34.6
Father's Age	Father's age at last birthday[a]	37.6
Mother Has a Degree	Mother's highest educational attainment is a university degree (dv)	0.29
Father Has a Degree	Father's highest educational attainment is a university degree (dv)[a]	0.30
Mother Works Full-Time	Mother works full-time (dv)	0.14
Father Works Full-Time	Father works full-time (dv)[a]	0.68
Single Mother	Child's father not in household (dv)	0.16
English Is Second Language	Primary language spoken at home is not English (dv)	0.15
Income < $400 per week	Combined yearly income before tax is less than $20,000 (dv) (base category)	0.12
Income $400–$599 per week	Combined income before tax is less than $400 per week (dv)	0.10
Income $600–$799 per week	Combined income before tax is $400–$599 per week (dv)	0.11
Income $800–$999 per week	Combined income before tax is $600–$799 per week (dv)	0.11
Income $1,000–$1,499 per week	Combined income before tax is $800–$999 per week (dv)	0.24
Income $1,500–$1,999 per week	Combined income before tax is $1,000–$1,999 per week (dv)	0.16
Income > $2,000	Combined income before tax is more than $2,000 per week (dv)	0.16

Notes: All variables are obtained from the LSAC. The abbreviation dv denotes a dummy variable.

[a]Calculated conditional on the father being a survey respondent.

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