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ABSTRACT

Handedness, Time Use and Early Childhood Development*

We test if there is a differential in early child development by handedness, using a comprehensive range of measures covering, learning, social, cognitive and language skills, evaluated by both interviewer conducted tests and teacher assessments. We find robust evidence that left-handed children do significantly worse in nearly all measures of development, with the relative disadvantage being larger for boys than girls. Importantly, these differentials cannot be explained by different socio-economic characteristics of the household, parental attitudes or investments in learning resources. In addition, using data from child time use diaries, we find evidence that lefthanded children spend significantly less time each day on educational activities than their righthanded peers, and significantly more time watching television. However, these behavioural differences explain less than 10% of the handedness child development differential. The results of this paper clearly show that handedness differentials are evident even in early childhood.

JEL Classification: J13, I21

Keywords: handedness, child development, child time use, parental characteristics

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1. Introduction

In most countries approximately 10% of individuals are left-handed and, as such, handedness has been widely studied in numerous disciplines ranging from psychology to medicine, as well as in certain social sciences such as anthropology (see, for example, Porac and Coren, 1977; Coren, 1992; Bishop, 1990; Corballis, 1991; Dancey et al., 2005; Ramadhani et al., 2005).[1] However, it is an area of research which has, so far, been virtually ignored in the economics literature. Two recent studies, however, investigate the relationship between left-handedness and earnings (Denny and Sullivan, 2006; Ruebeck et al., 2007). Denny and Sullivan (2006) find that left-handed men in Britain earn approximately 5% more than right-handed men, and that this premium is slightly higher for non-manual workers. Yet they find no evidence that individuals sort into different types of occupations based on handedness.[2] Their results are opposite for women, with left-handed women earning about 4% less per hour than their right-handed equivalents. Using US data, Ruebeck et al. (2007) also find a positive wage effect for left-handed men with high levels of education. Moreover, their estimated differential is quite large as left-handed males with a college level education earn 15% more than right-handed males. However, it is not clear from this analysis whether left-handed college graduates earn more money because they perform better in the labour market or because they are more likely to pursue (and be successful in) higher education. Unlike Denny and Sullivan (2006), they find no significant wage effect for women.

A related topic, important for the understanding of economic outcomes, which has been investigated to some extent by a small psychology literature, is the relationship between handedness and child development (or student performance). In discussing this literature, Faurie et al. (2006) note, however, that 'it is difficult to see a clear trend in this published literature, because the various tests performed do not measure the same intellectual skills' (p.66).[3] In their own study, Faurie et al. (2006) find weak evidence that handedness is associated with differential student performance (the correlation is only 0.1). While being left-handed is associated with lower school

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[1] This literature is large and has examined, amongst other things, the relationship between handedness and longevity, blood pressure, irritable bowel syndrome, arthritis, ulcers, immune disorders, schizophrenia, brain tumours, breast cancer and accident rates. One of the seminal papers is Geschwind and Behan (1982), who used an experimental design and found higher frequencies of immune disease, migraine and myasthenia gravis, in left-handers than right-handers. While there appears to be some consensus that left is worse than right-handedness in terms of the above relationships, looking through this literature there is a great deal of inconsistency in the results across different studies.

[2] Peterson (1979) reported that more left-handed students in the US went into architecture and arts, and fewer majored in sciences.

[3] See, for example, the studies of Williams (1987), Crow et al. (1998), Lamm and Epstein (1999) and Nettle (2003). Note that most studies in this literature are based on very small and often non-representative samples, and simple correlation analyses (e.g. Williams, 1987; van Strien and Bouma, 1995). The study by Williams (1987), for example, is widely cited but based on a sample of only 190 boys from one school in England. This study found that left-handed children were generally performing less well than right-handed children in French, science and history, but the opposite was found for English and Latin. Another example, with contrasting findings, is Annett and Manning (1989) who found, using samples of 175 boys and 173 girls in six schools in central England, that right-handed children were poorer in Matrices and English.

performance in girls, the opposite is found for boys. However, their study suffers from a very low response rate, does not control for any socioeconomic characteristics, and is not a representative sample. A further limitation is that only one general measure of child development was collected, so that no breakdown of the different aspects of performance could be investigated.[4]

In this paper, we contribute to this literature by testing whether handedness affects early child development for a nationally-representative sample of children, using eight wide ranging and comprehensive measures of child development, covering learning, social, cognitive and language aspects. We also go beyond the previous psychology studies that are based on simple correlation analyses, by estimating models of child development that control for differences in socio-economic and parental characteristics. Moreover, we believe that this research is important to economists for a number of reasons. Research in the dynamics of skill formation has found that both cognitive and non-cognitive skills are most effectively cultivated in early childhood (Cunha et al., 2006). Furthermore, the rates of return to investment in human capital are highest in the youngest age categories (Heckman, 2006). Empirically, it has been found that child test scores are also strong predictors of future wages and employment outcomes (Currie and Duncan, 1999). Therefore, understanding which factors affect human capital development at an early age, and whether there is a difference between left and right-handed children, is important for implementing policies which will improve future labour market outcomes.

We undertake this analysis using nationally-representative Australian data recently released from the first wave of the Longitudinal Study of Australian Children (LSAC) collected in 2004, which provides information on just under 5,000 children aged 4 and 5. Our measures of child development come from a combination of interviewer conducted tests as well as assessments by an educationalist and the child’s school teacher. This eliminates the possibility of bias introduced by more subjective parental assessments of their child's ability and gives us a wide array of assessments from various individuals. Moreover, handedness is determined by the interviewer following detailed and lengthy drawing and writing tasks.[5] It is also important to note that there is no social stigma attached to being left-handed in contemporary Australia (our sample was born in 2000) unlike certain developing countries (see, for example, Meng, 2007), which minimises the

[4] The survey was mailed to teachers in 339 schools in March 2001, and only 89 schools responded to the survey (26% response rate). Student performance was measured by asking teachers to report on a 4-point ordered scale how well the student was doing ‘on the basis of overall ability, on language, writing and mathematics’.

[5] In Denny and Sullivan (2006) handedness is reported by a parent when the individual was aged 7, while handedness in the Ruebeck et al. (2007) study was self-reported by the individual.

possibility that parents may to some extent 'force' their children into becoming right-handed at an early age.[6]

The main finding of this paper is that left-handed children score significantly worse than right-handed children in tests and teacher assessments. These findings demonstrate that handedness differentials are evident at a very early stage in child development. The differentials are fairly large with left-handed children rated by their teacher to be on average about 7% less likely to be 'competent' in each development aspect than right-handed children. This effect is similar in size to the effect of the role of maternal education on child development. We are also able to provide some new evidence that ambidextrous children score worse on all test outcomes, roughly twice as bad as left relative to right-handers. Interestingly, we also find evidence of gender differences with left-handed boys faring relatively worse than left-handed girls.

Controlling in our empirical models for a wide-range of child and household characteristics including household income, birth weight, parental education and sibling composition, we check whether left handed, right-handed and both-handed children are raised in different socioeconomic environments which might then influence their test scores and development. We find no significant difference along any socio-economic characteristics by handedness. We also test whether various parental attitudes related to child health, safety, and discipline differ between left and right handed children, and find no evidence of this. We check whether the child development differentials by handedness can be explained by different investment in learning resources in the household such as number of books or computers, and find no evidence of this. Using detailed child time use diaries, we do find that left-handed children spend significantly less time each day on educational activities (14 minutes) than right-handers, and significantly more time watching television (8 minutes). Importantly, however, these time use differences explain less than 10% of the child development differentials by handedness. These findings suggest that differences in socioeconomic status, parental attitudes, and investment in learning resources are not driving our results.

The paper is set-out as follows. In Section 2, we introduce our data, provide definitions and information about the child assessments, and present some salient characteristics relating to handedness and child development. Section 3 presents results from empirical models of child development indicators. We investigate whether left and right-handed children spend their time differently in Section 4, using data from child time use diaries. In Section 5, we discuss the results of a number of robustness tests, and we conclude the paper in Section 6.

[6] This would, however, tend to lead to a smaller estimated differential between left and right-handed children. We investigate this issue in Section 5 by re-estimating our models excluding children whose parents were born in Asia. The results are robust to these changes.

2. Data, Definitions and Sample Characteristics

2.1. Data

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

Data on one child from each household is collected, and currently only the 1st wave of data is available for analysis. A clustered (by postcode) sample design is used, and it is intended that the samples be representative of all Australian children in each of the selected age cohorts.[8] However, children in the remotest areas of Australia are not captured in the data. The data are collected from the child (when of an appropriate age), parents (separate questionnaires for each parent) and the child's school teacher. The interviews are conducted face-to-face by a trained interviewer in the child's home, and the interviewer also undertakes direct observations and assessment of the child. The interview for the older cohort takes on average 2.5 hours, so the interviewer is in a strong position to assess the child. Data from child care providers, preschool and primary school teachers are collected via mail questionnaires. In this paper we use information on 4,671 children aged 4 or 5 at the time of interview, and we combine data from parents, teachers as well as interviewer assessments.[9]

2.2. Definitions

Child Handedness

Information on the handedness of the children is given by the interviewer. In particular, the interviewer is asked to determine dominant handedness immediately after conducting the lengthy "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). The interviewer is asked 'Did the child use his/her' (1) right hand, (2) left hand, (3) both hands.

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[7] The LSAC website is: www.aifs.gov.au/growingup/home.html.
[8] More details of the sampling design can be found in Sanson et al. (2002).
[9] We loose about 200 children due to missing data on the AWAI score (defined later) and birth weight.

Child Development Measures

We use three sources of information for each child to define a comprehensive list of measures of child development: the interviewer, an educationalist assessment of data collected by the interviewer, and the child's school teacher.

Interviewer Assessment

The APPVT used in the LSAC is a short form of the Peabody Picture Vocabulary Test (PPVT – III). The 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'. The constructed score can range from 0 to 100, but in our sample we only observe ranges from 34.5 to 96.9.

Educationalist Assessment

The "Who am I" (AWAI) (ACER, 1999) was designed by the LSAC team to assess general cognitive abilities needed for beginning school. It is a standardised exam 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 his/her own answer booklet, and the test consists of 11 pages on which children are to write their names, copy shapes (e.g. a circle, triangle, cross, square, and diamond) and write words, sentences and numbers. What they write/draw is then assessed by experienced researchers in the Australian Council for Education Research in Melbourne. The constructed score ranges from 0 to 100, but the observed range for children in the sample is 11.03 to 84.07.

Both the AWAI and APPVT scores are increasing in relatively poor child development. In the empirical models we use the log of these measures as our dependent variables, although we note here that the main findings of this study are unchanged if we use a linear specification.

Teacher Assessment

A teacher questionnaire was completed for around 65% of the children. On page 6 (Section C: Child Skills and Competencies of the teacher questionnaire), the teachers were asked:

‘Please think about the skills and competencies of the study child as described in the next statements. Rate how this child has compared with other children of a similar age over the past few months’

1. Social / emotional development (e.g. adaptability, co-operation, responsibility, self-control)
2. Approaches to learning (e.g. attention, observation, organisation, problem-solving)
3. Gross motor skills (e.g. running, catching and throwing 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, ability to communicate ideas)
6. Receptive language skills (e.g. understanding, interpreting and listening)

The responses were on the following four-point ordinal scale coded as follows:

(3) Much less competent

(2) Less competent than others

(1) As competent as others

(0) More competent than others

2.3. Sample Characteristics

In Table 1, we describe the handedness of children in the sample. Approximately 10% of the children are left-handed. Disaggregated by gender, about 11% of the boys are left-handed and 9% of the girls are left-handed. This gender difference is statistically significant. The summary statistics reported in Table 1 are consistent with findings in the literature on handedness. While the incidence of left-handedness obviously varies across cultures and over time, 10% of the population would be classified (or classify themselves) as left-handed on average (Denny and Sullivan, 2006). In addition, studies find that males have a somewhat higher incidence of left-handedness than females.

Approximately 4% of our sample is assessed by the interviewer to be both-handed (or ambidextrous). Again there are more both-handed boys than girls: 6% compared to 3%. The both-handed children may still develop a preference for one hand over another 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 AWAI and APPVT scores are reported as average scores, where the higher the score, the lower the development outcome. The next six measures are reported as the percentage of children assessed by teachers as less or much less competent than others. The raw data indicates that left-handed and both-handed children score worse than right-handed children in all eight measures. We then test the scores of left and both-handed children relative to right-handed children to check if the scores are significantly different. The test scores on the APPVT 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 APPVT scores and the teacher assessed expressive English scores are not significantly different between both and right-handed children. Therefore, left and both-handed children score worse in all measures of development except for their expressive English skills. In Section 3, we check to see if these patterns in the data hold after controlling for various household, parental and child characteristics.

2.4. Are Right, Left and Both-handed Children Different along Socio-Economics?

The notion of genetic basis for handedness has waxed and waned in popularity over time. Research has shown that left handed parents are more likely to have left handed children. However, there is still a long history of debate between researchers who believe left-handedness is determined by a gene inherited from parents (McManus, 2006) and those who believe environmental and cultural factors shape this result. For example, left handed parents could simply be providing a left handed model for children to imitate. These days it does seem that a genetic link is borne out by the statistics (Bishop, 1990). Therefore, we can claim that handedness is exogenously determined. However, we still do some statistical tests to check whether left handed children are raised in different socioeconomic environments or whether parental attitudes may differ.

One concern that may arise from our study is whether left-handed, both-handed, and right-handed children are simply raised in different socioeconomic environments which might influence their development outcomes and test scores. For example, if right-handed children come from richer households, they will be more likely to score better on child development tests as household income is correlated with educational outcomes. Attributing handedness to test scores in this case would lead to biased results. In fact, some researchers have even argued that left- and right-handers might differ in socio-economic status (Faurie et al., 2006).

In Table 3, we test whether left, both, and right-handed children differ along observable characteristics such as birth weight, family demographics, parent's education, and household income. We report results from the estimation of a multinomial logit model of handedness in Table 3. We find absolutely no evidence of significant difference along any of the observable characteristics between left, both and right-handed children. We cannot reject that the coefficients on birth weight, family demographics, parental education, and household income are significantly different from zero. The only coefficient which is significant at the .01 level is the dummy variable male, indicating that boys are more likely to be left and both-handed. This difference is reflected in the raw data as there are more left and both-handed boys in our sample relative to girls, as reflected in the general population. Therefore, we can conclude that the differences in child test scores are not due to any observable differences in socio-economic status between left, right, and both-handed children.

3. Estimation Results

3.1. General Results

We estimate fairly standard models to test whether handedness affects child development measures. The regression results are presented in Table 4. In columns (1)-(2) of Table 4, we estimate linear regression models where the dependent variables are the log test scores from the interviewer assessed AWAI and the educationalist assessed APPVT. For both the AWAI and the APPVT, higher scores indicate worse child development outcomes. 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. In columns (3)-(8), we estimate 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 that Others’ or as ‘Much Less Competent than Others’ (scoring a 0 or 1). Again, we first report coefficients from the base model and then report estimates of the same model including the additional covariates.

In column (1) of Table 4, the regression results indicate that left-handed children score approximately 3% less on the AWAI than right-handed children. This result is statistically significant at the .01 level and is robust to the additional 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, for example, Haverman 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 (Carneiro et al., 2005; Haverman and Wolfe, 1995). While we do not want to ignore or downplay the possibility of unobserved factors which 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 column (2), we report that handedness is not significantly related to APPVT test scores.[10] In columns (3)-(8), 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 1% level of significance and robust to the specification with the additional covariates. Expressive English is the only skill where right and left-handed children do not score differently. This is interesting as the APPVT also measures expressive English skills and the coefficient on left-handedness in that regression is also not statistically significant. Therefore, left-handed children are no further behind 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.

Table 4 also shows that both-handed children do worse than right-handed children in all areas, except for expressive English skills. In addition, the coefficients for both-handed children are larger than those of the left-handed children. This implies that both-handed children are doing worse than left-handed children in terms of child development. For example, both-handed children score 8% less than right-handed children on the AWAI. In terms of the teacher assessed social/emotional skills, gross and fine motor skills, and receptive English skills, both-handed children are 5-10 percentage points more likely to be classified as less competent than right-handed children In both the linear regression and ordered probit models, the coefficients on both-handedness do not change significantly when we include the additional controls.

3.2. Results by Gender

In this section, we test for gender differences in child development outcomes by handedness. We split up the sample by gender and then estimate the same regressions as described in Table 4. Table 5 reports the regression results from this exercise. On average the results indicate that left and both-handed boys do worse than left and both-handed girls in most measures.

However, it is important to highlight a few issues with respect to these results. We know that boys are more likely to be left-handed than girls (see Table 1). We also find that boys perform poorly on all tests relative to girls. These results are highly significant at the 1% level of significance and are shown in Table 4. This means we must interpret the gender findings in Table 5 with some caution due to the relationship between gender and handedness. In addition, some of the coefficients on left-handedness lose significance in Table 5. By splitting the sample by gender, we lose some precision in the point estimates, probably due to smaller sample sizes particularly for

[10] We have also estimated equivalent models for AWAI and APPVT 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.

both-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.

4. Handedness and Child Time Use

One novel feature of the LSAC data is that it asks parents to complete time use diaries for their child for two days. We observe this data for 78% of the sample, and there is no significant difference in the response rate by handedness. In this section, we consider the hypothesis that the development differentials we find by handedness might be explained by differences in the way children spend their time. For example, do right-handed children spend more time on educational activities or playing on a computer, or perhaps less time watching television, than their left-handed peers? To test this hypothesis we average the two days of activities recorded in the child diaries, and we estimate models using OLS where the dependent variable in each model is the daily minutes the child spends on each activity. As expected, parents record that children undertake a great variety of activities each day, and so we have combined the activities into eight broad categories. These are: (1) sleep, (2) being held or cuddled, (3) watching TV, (4) using the computer, (5) educational activities such as reading, (6) other play, (7) exercise and (8) organised lessons.[11]

The results from the model are shown in Table 6, and it is clear that there are a number of interesting aspects to understanding child time use. Here we will focus, however, only on the handedness estimates. Overall, there appears to be no significant difference in the way left-handed, right-handed and both-handed children spend their time, with four interesting exceptions. Firstly, left-handed children spend significantly more time (about 8 minutes per day) watching TV than right-handed children. Secondly, left-handed children spend significantly less time undertaking educational activities (mainly reading). Thirdly, both-handed children have more time each day being held or cuddled by their parents (11 minutes). Fourthly, there is no significant difference in the time spent in organised lessons by handedness.

These results therefore appear to offer a behavioural explanation for why left-handed children are doing worse than right-handed children. They simply choose to do different activities. To test this we first look to see if there is any significant difference in the learning resources provided in the household by handedness. Such differences may reflect the level of interest that parents have in their child's educational development. No significant difference in the number of books or computers in the household is found, which suggests that left, right and both-handed children have

[11] Note that the sum of minutes over these activities does not equal the total available in a 24 hour period because children can do more than one activity at any given time.

the same access to learning resources in the household. Secondly, we re-estimate each of the child development models (shown in Table 4) including explanatory variables such as the number of books and computers in the household, as well as variables for the minutes the child spends per day watching the television, using a computer and undertaking educational activities such as reading. Importantly, while the inclusion of these additional controls reduced the estimated differences in child development between right, left and both-handed children, it only explains 10% of the differential. Therefore 90% of the differentials found in Table 4 remain, which suggests that it is not only behavioural differences that are explaining these differences.

5. Some Robustness Tests

There might be some tendency for left-handed individuals to have a higher (e.g. immune disease, deafness, asthma) or lower prevalence (e.g. brain tumours) of certain health conditions, although most of this research has focused on adults (see, for example, Geschwind and Behan, 1982; Fry, 1990; Dane and Gumustekin, 2002; Inskip et al., 2003; Bryden et al., 2005). However, if any such health differential already exists by childhood, this might help to explain the differences in development by handedness. Therefore, we investigate whether controlling for additional variables which might be associated with child health influence the findings reported in Table 4.[12] We include controls for whether the child needs prescription medicine and whether the child uses more medical services than other children (note we already control for birth-weight and whether the child was in intensive care when born in Table 4). Our results are robust to these changes. Another concern might be that participating in structured activities, especially when led by a qualified teacher, and socialising with other children will have a positive impact on development. We include controls for whether the child attends day care, kindergarten or school, and find that the estimated marginal effects of left-handedness and both-handedness remain substantively unchanged.

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 especially be the case if left-handed children, for example, are more likely to have left-handed parents. Although we have shown that socio-economic characteristics are not correlated with handedness of children, we must test whether parents of left, right and both-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 between the parents by child handedness; about 80% of parents praised and 7.5% scolded their child. We also

[12] The full set of parameter estimates for these additional models are available from the authors on request.

find no significant 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 immunisation or using sun protection for their child every day.

Finally, we test the robustness of our results by re-estimating the models without children who have parents born in Asia. Historically, there has been a tendency towards 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 both-handedness could be biased (probably downwards). Again, our main results remain substantively unchanged. Left-handedness and both-handedness have a negative impact on all child development measures, except APPVT test scores and the teacher's assessment of expressive English ability.

6. Conclusion

In this paper we use newly released data on approximately 5,000 Australian children aged 4 and 5, to test whether there is any evidence of differential early child development by handedness. In contrast to the small literature on handedness and child development in psychology, our paper has a number of clear advantages. Firstly, the data is a large nationally-representative sample of children rather than, for example, children from one or a few schools. Secondly, we use measures which contain comprehensive and wide-ranging information on child development assessed from three sources: the interview, an educationalist and the child's teacher. Therefore we do not have any of the usual biases associated with parental assessments of their children. Importantly, our assessment measures cover a wide range of areas including learning, social, cognitive, and language skills, as being left-handed, for example, might mean that a child is better than her right-handed peers at some tasks but worse in others. Thirdly, given the rich information of parental and the socio-economic circumstances of the household in the survey, we are able to go beyond simple correlation analyses and construct multivariate models by which we can test a number of interesting hypotheses.

We start by arguing that handedness is exogenously determined as socio-economic and demographic characteristics have no explanatory power in predicting if a child is left, right or both-handed. Our models of child development find robust evidence that left-handed children do significantly worse in nearly all measures of development. This difference is large and of the same magnitude as the effect of maternal education on child development. Moreover, the largest differential between left-handed and right-handed children is for 'fine' and 'gross' motor skills. We provide new evidence that both-handed children do worse than left and right-handed children, about roughly double the disadvantage of left-hander relative to right-handers. Interestingly, the disadvantage for left-handed children relative to their right-handed peers is bigger for boys than girls. We show that these differentials cannot be explained by different socio-economic characteristics of parents or different investment in learning resources in the household. Using information for child time use diaries, however, we find new evidence that left-handed children spend significantly less time each day on educational activities than their right-handed peers, and significantly more time watching television. However, this time use difference explains less than 10% of the child development differentials by handedness. Overall, these findings suggest that differentials in child development by handedness start at an early age, and do not appear to be driven by differences in socio-economics characteristics, parental attitudes, or investment in learning resources. As more waves of the data become available, we will be able to test if handedness differentials increase or decrease as children age.

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Table 1: Sample Handedness

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

Note: Standard errors shown in brackets.

Table 2: Summary of Child Development Measures by Handedness

	Right-Handed	Left-Handed	Both-Handed
Interviewer Assessed Measure			
AWAI (score ranges from 34.5 to 96.9)	35.64	36.97**	39.50**
Educationalist Assessed Measure			
APPVT (score ranges from 11.03 to 84.07)	35.80	35.85	36.89
Sample	4010	460	201
Teacher Assessment Measures (%)			
Social / Emotional	20.61	25.65*	29.93*
Learning	16.55	23.38**	24.82*
Gross Motor	9.16	17.21**	16.06**
Fine Motor	14.93	25.32**	29.20**
Expressive English	19.99	19.81	22.63
Receptive English	14.42	19.16*	23.36**
Sample	2586	308	137

Note: * means indicates a significant difference compared to right-handed children at the 95% level of confidence. Average score by handedness for AWAI and APPVT tests shown. Percentage of children assessed by teachers as ‘Less Competent than Others’ or as ‘Much Less Competent than Others’ by handedness shown.

Table 3: Multinomial Logit Model of Handedness

	Left-Handed		Both-Handed	
	ME	*t*-stat	ME	*t*-stat
Age 5	-0.008	-0.72	-0.012	-1.90
Male	0.020	2.28	0.026	4.56
Birth weight	-0.002	-0.25	-0.004	-0.77
Intensive care when born	0.024	1.73	0.014	1.51
Multiple birth	-0.093	-0.75	-0.090	-0.96
Older sibling in household	0.008	0.58	0.001	0.11
Younger sibling in household	0.007	0.60	-0.003	-0.46
Number of siblings	-0.007	-1.09	0.003	0.74
English 2^{nd} language	0.005	0.41	0.011	1.22
Mother has degree	-0.010	-0.98	0.011	1.46
Father has degree	0.003	0.23	-0.007	-1.07
Mother's age	0.001	1.47	-0.001	-2.14
Father's age	-0.001	-1.80	0.000	0.51
Father works full-time	0.023	1.75	-0.003	-0.31
Mother works full-time	0.012	0.87	-0.007	-0.94
Father not in household	-0.001	-0.09	-0.001	-0.09
Mother not in household	0.003	0.22	-0.003	-0.40
Income $20-31k	-0.021	-1.20	0.002	0.14
Income $31-42k	-0.021	-1.16	0.016	0.75
Income $42-52k	-0.021	-1.07	0.035	1.31
Income $52-78k	-0.045	-2.64	0.005	0.28
Income $78-104k	-0.025	-1.31	0.014	0.69
Income $104+	-0.028	-1.47	0.027	1.11
Pseudo R^2			0.019	
χ^2 test of joint significance (*p*-value)	0.080		0.000	
χ^2 test of joint significance apart from male (*p*-value)	0.226		0.058	
χ^2 test of joint significance of income (*p*-value)	0.237		0.115	
Sample			4670	

Notes: ME is estimated marginal change in the probability of being classified as left-handed or both-handed, relative to being right-handed, for each variable calculated at the sample mean values. The omitted categories are female, did not go into intensive care when born, not part of a multiple birth, no older sibling, no younger sibling, was not breast fed, English is main language spoken in household, mother does not have a degree or equivalent level qualification, father does not have a degree or equivalent level qualification, father does not work full-time, mother does not work full-time, father lives in household, mother lives in household, annual pre-tax household income is less than $20,000. The constant term from the model is not shown. Each model also has a control for a small number of missing observations on household income.

Table 4: Regression and Ordered Probit Models of Child Development Indicators

	Linear Regression Models				Ordered Probit Models											
	(1) ln(AWAI)		(2) ln(APPVT)		(3) Social / Emotional		(4) Learning		(5) Gross Motor		(6) Fine Motor		(7) Expressive English		(8) Receptive English	
	β	*t*-stat	β	*t*-stat	ME	*t*-stat	ME	*t*-stat	ME	*t*-stat	ME	*t*-stat	ME	*t*-stat	ME	*t*-stat
Basic Model																
Left-Handed	**0.026**	**2.13**	**0.001**	**0.06**	**0.042**	**2.01**	**0.056**	**2.88**	**0.043**	**2.71**	**0.062**	**3.27**	**0.006**	**0.34**	**0.042**	**2.36**
Both-Handed	**0.076**	**4.26**	**0.023**	**1.38**	**0.076**	**2.33**	**0.071**	**2.39**	**0.074**	**2.76**	**0.099**	**3.26**	**0.054**	**1.79**	**0.064**	**2.30**
Age 5	-0.174	-18.36	-0.065	-7.08	0.015	0.96	0.017	1.24	-0.007	-0.71	-0.001	-0.11	0.012	0.81	0.002	0.14
Male	0.138	19.29	0.031	4.63	0.129	11.02	0.090	8.65	-0.025	-3.12	0.165	16.25	0.067	6.04	0.061	6.42
Adjusted R^2 (or Pseudo R^2)	0.140		0.017		0.054		0.038		0.014		0.124		0.017		0.023	
Extended Model																
Left-Handed	**0.023**	**1.96**	**-0.001**	**-0.13**	**0.041**	**1.97**	**0.051**	**2.68**	**0.040**	**2.56**	**0.059**	**3.19**	**0.006**	**0.30**	**0.038**	**2.19**
Both-Handed	**0.072**	**4.18**	**0.018**	**1.14**	**0.082**	**2.49**	**0.073**	**2.45**	**0.071**	**2.67**	**0.098**	**3.24**	**0.048**	**1.62**	**0.060**	**2.22**
Age 5	-0.177	-19.18	-0.065	-7.76	0.009	0.60	0.012	0.91	-0.008	-0.81	-0.004	-0.35	0.004	0.29	-0.003	-0.29
Male	0.141	20.13	0.034	5.43	0.131	11.18	0.093	9.08	-0.023	-2.98	0.168	16.60	0.071	6.50	0.064	6.92
Birth weight	-0.032	-4.97	-0.030	-5.29	-0.022	-2.05	-0.033	-3.58	-0.010	-1.48	-0.036	-4.13	-0.033	-3.36	-0.029	-3.43
Intensive care when born	0.015	1.40	0.008	0.91	0.010	0.57	0.021	1.30	0.027	2.06	0.006	0.43	0.007	0.42	0.003	0.23
Multiple birth	-0.124	-1.62	-0.126	-1.86	0.061	0.62	-0.072	-0.56	-0.059	-0.57	-0.113	-0.82	-0.222	-1.36	-0.105	-0.79
Older sibling in household	-0.004	-0.38	0.004	0.37	-0.018	-1.00	-0.018	-1.12	-0.037	-2.90	-0.040	-2.65	0.014	0.82	-0.002	-0.13
Younger sibling in household	-0.019	-1.97	-0.012	-1.43	-0.028	-1.74	-0.056	-4.02	-0.010	-0.97	-0.046	-3.56	-0.024	-1.60	-0.032	-2.55
Number of siblings	0.022	4.45	0.030	6.74	0.009	1.01	0.020	2.66	0.004	0.67	0.026	3.81	0.034	4.27	0.019	2.82
English 2nd language	-0.066	-6.56	0.153	16.65	0.014	0.78	0.029	1.77	0.001	0.07	-0.018	-1.38	0.115	5.70	0.077	4.46
Mother has degree	-0.024	-2.68	-0.048	-6.11	-0.028	-2.01	-0.040	-3.35	-0.003	-0.34	-0.015	-1.29	-0.062	-4.96	-0.048	-4.51
Father has degree	-0.061	-6.49	-0.024	-2.91	-0.008	-0.55	-0.026	-2.03	0.009	0.83	-0.017	-1.43	-0.015	-1.07	-0.025	-2.13
Mother's age	0.000	-0.58	-0.003	-5.56	0.000	-0.26	0.000	0.09	0.000	0.39	-0.001	-1.18	-0.002	-2.16	0.000	-0.44
Father's age	0.000	-0.82	0.000	-0.28	0.001	0.96	0.000	-0.36	0.000	0.62	0.000	0.72	0.002	3.21	0.000	0.20
Father works full-time	0.011	1.05	0.005	0.55	-0.074	-3.89	-0.037	-2.27	-0.010	-0.83	-0.048	-3.09	-0.051	-2.87	-0.040	-2.63
Mother works full-time	-0.024	-2.25	0.010	1.09	0.023	1.27	0.007	0.47	0.009	0.74	-0.025	-1.95	-0.002	-0.10	0.001	0.09
Father not in household	0.022	2.20	0.012	1.35	0.015	0.85	0.047	2.83	0.029	2.24	0.025	1.69	0.014	0.84	0.026	1.78
Mother not in household	0.024	2.09	0.027	2.60	-0.017	-0.90	-0.011	-0.66	-0.017	-1.40	-0.013	-0.84	0.011	0.62	-0.016	-1.08

Table 4: (Continued)

Income $20-31k	0.002	0.09	-0.007	-0.41	-0.059	-2.09	-0.036	-1.40	-0.035	-1.98	-0.038	-1.69	-0.045	-1.65	-0.049	-2.38
Income $31-42k	0.009	0.45	-0.039	-2.23	-0.076	-2.81	-0.049	-2.01	-0.035	-1.95	-0.050	-2.30	-0.061	-2.37	-0.052	-2.47
Income $42-52k	-0.007	-0.38	-0.031	-1.73	-0.074	-2.64	-0.056	-2.29	-0.032	-1.69	-0.049	-2.19	-0.082	-3.31	-0.057	-2.74
Income $52-78k	-0.020	-1.07	-0.051	-3.03	-0.063	-2.11	-0.046	-1.79	-0.046	-2.49	-0.056	-2.43	-0.088	-3.42	-0.067	-3.08
Income $78-104k	-0.027	-1.39	-0.062	-3.46	-0.095	-3.45	-0.068	-2.81	-0.050	-2.89	-0.055	-2.42	-0.108	-4.61	-0.082	-4.21
Income $104+	-0.025	-1.25	-0.068	-3.69	-0.100	-3.62	-0.075	-3.08	-0.054	-3.17	-0.061	-2.69	-0.115	-4.89	-0.074	-3.58
Adjusted R^2 (or Pseudo R^2)	0.191		0.166		0.088		0.102		0.040		0.165		0.119		0.097	
Sample	4680		4197		3037		3037		3037		3037		3037		3037	

Notes: ME is estimated marginal change in the probability of being classified by the teacher as ‘Less Competent that Others’ or as ‘Much Less Competent than Others’ for each variable calculated at the sample mean values. Pseudo R^2 for ordered probit models is McKelvey and Zavoina’s statistic. The omitted categories are right-handed, female, did not go into intensive care when born, not part of a multiple birth, no older sibling, no younger sibling, English is main language spoken in household, mother does not have a degree or equivalent level qualification, father does not have a degree or equivalent level qualification, father does not work full-time, mother does not work full-time, father lives in household, mother lives in household, annual pre-tax household income is less than $20,000. The constant term from the regressions and the estimated cut-off points from the ordered probit models are not shown. Each model also has a control for a small number of missing observations on handedness, and household income.

Table 5: Regression and Ordered Probit Models of Child Development Indicators by Gender

	Linear Regression Models				Ordered Probit Models											
	(1) AWAI		(2) APPVT		(3) Social / Emotional		(4) Learning		(5) Gross Motor		(6) Fine Motor		(7) Expressive English		(8) Receptive English	
	β	*t*-stat	β	*t*-stat	ME	*t*-stat	ME	*t*-stat	ME	*t*-stat	ME	*t*-stat	ME	*t*-stat	ME	*t*-stat
Extended Model																
Boys																
Left-Handed	0.018	1.23	-0.006	-0.43	0.062	1.86	0.089	2.83	0.05	2.26	0.087	2.67	-0.012	-0.45	0.05	1.82
Both-Handed	0.080	4.11	0.004	0.21	0.106	2.29	0.116	2.65	0.079	2.33	0.135	2.91	0.06	1.44	0.084	2.1
Adjusted R^2 (or Pseudo R^2)	0.131		0.151		0.050		0.096		0.054		0.063		0.113		0.093	
Sample	2390		2139		1549		1549		1549		1549		1549		1549	
Girls																
Left-Handed	0.033	1.73	0.003	0.18	0.025	1.02	0.017	0.85	0.03	1.37	0.034	1.92	0.023	0.95	0.023	1.16
Both-Handed	0.067	2.10	0.045	1.66	0.068	1.43	0.035	0.91	0.06	1.38	0.086	2.16	0.036	0.85	0.042	1.14
Adjusted R^2 (or Pseudo R^2)	0.148		0.166		0.049		0.066		0.051		0.085		0.112		0.099	
Sample	2290		2057		1488		1488		1488		1488		1488		1488	

Notes: Extended model specification (see Table 3 for details) estimates separately for boys and girls. For brevity, we do not here present the full set of parameter estimates for each of the models. ME is estimated marginal change in the probability of being classified by the teacher as 'More Competent that Others' or as 'Much Less Competent than Others' for each variable calculated at the sample mean values. Pseudo R^2 for ordered probit models is McKelvey and Zavoina's statistic. The omitted categories are right-handed, female, did not go into intensive care when born, not part of a multiple birth, no older sibling, no younger sibling, English is main language spoken in household, mother does not have a degree or equivalent level qualification, father does not have a degree or equivalent level qualification, father does not work full-time, mother does not work full-time, father lives in household, mother lives in household, annual pre-tax household income is less than $20,000. The constant term from the regressions and the estimated cut-off points from the ordered probit models are not shown. Each model also has a control for a small number of missing observations on handedness (10 cases), and household income (6.4% of cases).

Table 6: Regression Models of Child Time Use

	(1) Sleeping		(2) Held/Cuddled		(3) Television		(4) Computer		(5) Educational Activities		(6) Other Play/Activities		(7) Exercise		(8) Organised Lessons	
	β	*t*-stat	β	*t*-stat	β	*t*-stat	β	*t*-stat	β	*t*-stat	β	*t*-stat	β	*t*-stat	β	*t*-stat
Left-Handed	**-1.674**	**-0.32**	**0.515**	**0.21**	**8.428**	**1.89**	**0.821**	**0.49**	**-14.109**	**-2.17**	**-0.043**	**-0.01**	**0.638**	**0.15**	**0.063**	**0.01**
Both-Handed	**-0.037**	**0.00**	**10.522**	**3.00**	**8.154**	**1.28**	**3.556**	**1.48**	**8.638**	**0.93**	**-3.829**	**-0.48**	**-7.777**	**-1.24**	**-5.900**	**-0.86**
Age 5	-12.272	-2.94	-1.573	-0.80	-7.008	-1.97	1.534	1.14	-4.626	-0.89	-13.581	-3.06	-2.513	-0.71	23.135	5.99
Male	-6.737	-2.16	-0.139	-0.09	8.519	3.20	7.429	7.37	-16.310	-4.20	14.714	4.44	8.438	3.21	-3.969	-1.37
Birth weight	0.727	0.26	1.139	0.85	2.255	0.93	-0.174	-0.19	3.897	1.10	-0.881	-0.29	2.582	1.08	0.213	0.08
Intensive care when born	-4.829	-1.03	1.179	0.53	-0.542	-0.14	-1.828	-1.21	-2.684	-0.46	-10.371	-2.09	3.120	0.79	4.942	1.14
Multiple birth	-21.149	-0.68	-1.559	-0.11	31.627	1.18	-7.037	-0.70	-35.855	-0.92	76.706	2.30	14.206	0.54	17.402	0.60
Older sibling in household	1.924	0.39	-11.660	-4.98	0.377	0.09	0.882	0.55	-15.960	-2.59	-3.760	-0.71	2.559	0.61	7.660	1.67
Younger sibling in household	9.133	2.06	-8.689	-4.14	5.629	1.49	-2.747	-1.92	6.601	1.19	1.607	0.34	6.282	1.68	7.343	1.79
Number of siblings	-3.731	-1.58	2.770	2.48	1.562	0.77	0.763	1.00	0.675	0.23	2.238	0.89	3.986	2.00	-5.184	-2.37
English 2nd language	-12.649	-2.61	-0.196	-0.09	-0.785	-0.19	3.923	2.51	15.488	2.56	-31.793	-6.17	-17.702	-4.33	-9.942	-2.22
Mother has degree	4.239	1.12	6.555	3.66	-17.831	-5.50	0.076	0.06	32.420	6.87	15.143	3.76	5.003	1.57	11.386	3.24
Father has degree	2.593	0.65	-1.616	-0.85	-10.405	-3.04	-0.025	-0.02	22.048	4.43	8.103	1.91	4.331	1.28	3.802	1.03
Mother's age	-0.663	-2.18	0.056	0.39	-0.389	-1.50	0.204	2.08	0.235	0.62	0.801	2.48	0.544	2.12	1.068	3.80
Father's age	0.013	0.07	-0.016	-0.20	0.098	0.68	-0.042	-0.77	-0.073	-0.34	0.309	1.71	-0.157	-1.10	-0.082	-0.52
Father works full-time	-0.456	-0.10	2.768	1.23	-1.081	-0.26	-1.389	-0.90	0.542	0.09	-2.210	-0.44	-1.452	-0.36	-1.004	-0.23
Mother works full-time	-8.814	-1.84	-1.065	-0.47	-2.241	-0.55	2.101	1.36	-5.633	-0.95	-10.390	-2.04	-2.937	-0.73	12.056	2.72
Father not in household	-3.048	-0.54	0.038	0.01	2.911	0.60	-0.121	-0.07	-6.769	-0.96	2.890	0.48	0.148	0.03	5.831	1.11
Mother not in household	6.251	1.19	2.998	1.21	3.431	0.76	-3.965	-2.34	-7.305	-1.12	-3.689	-0.66	-0.688	-0.16	-7.106	-1.46
Income \$20-31k	-6.894	-0.75	-1.412	-0.33	-3.900	-0.50	0.201	0.07	-9.310	-0.82	-5.745	-0.59	-15.631	-2.03	1.837	0.22
Income \$31-42k	2.999	0.33	-4.114	-0.95	-4.917	-0.62	-4.164	-1.40	-7.558	-0.66	2.047	0.21	-9.338	-1.20	-2.322	-0.27
Income \$42-52k	-2.921	-0.31	-1.183	-0.27	-9.401	-1.17	-4.855	-1.60	-13.394	-1.15	12.438	1.25	-9.628	-1.22	3.746	0.43
Income \$52-78k	4.414	0.49	-3.318	-0.78	-9.686	-1.26	-5.683	-1.95	-14.591	-1.30	9.003	0.94	-4.839	-0.64	-0.218	-0.03
Income \$78-104k	-0.211	-0.02	-2.849	-0.64	-18.452	-2.30	-4.039	-1.33	-11.136	-0.95	7.853	0.79	-0.983	-0.12	9.739	1.12
Income \$104+	-3.806	-0.40	-5.825	-1.28	-24.683	-3.00	-3.382	-1.09	-26.451	-2.20	5.125	0.50	-3.864	-0.48	10.363	1.16
Adjusted R^2	0.027		0.020		0.056		0.031		0.052		0.063		0.031		0.062	
Sample	3615		3615		3615		3615		3615		3615		3615		3615	

Notes: The omitted categories are right-handed, female, did not go into intensive care when born, not part of a multiple birth, no older sibling, no younger sibling, English is main language spoken in household, mother does not have a degree or equivalent level qualification, father does not have a degree or equivalent level qualification, father does not work full-time, mother does not work full-time, father lives in household, mother lives in household, annual pre-tax household income is less than $20,000. The constant term from the regressions are not shown. The model has day of the week controls, a dummy for if the parents says that the day for not 'normal', and also controls for a small number of missing observations on handedness, and household income.