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THE ECONOMIC CONSEQUENCES OF BEING LEFT-HANDED : SOME SINISTER RESULTS

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Abstract

This paper provides the first estimates of the effects of handedness on hourly earnings. Augmenting a conventional earnings equation with an indicator of left handedness shows there is a well determined positive effect on male earnings with non-manual workers enjoying a slightly larger premium. These results are inconsistent with the view that left-handers in general are in some sense handicapped either innately or through experiencing a world geared towards right-handers. It is consistent with some psychological evidence which suggests that left-handers have particular talents such as enhanced creativity. The results for females however reveal the opposite, left-handed females are paid significantly less.

Keywords: earnings, brain, left-handed, laterality

The economic consequences of being left-handed: some sinister results

1. Introduction

This paper presents the first estimates of the impact of left-handedness on earnings. In the canonical model of the determinants of an individual's earnings associated principally associated with Becker, Mincer and many other human capital theorists, earnings are determined by a relatively small number of variables notably education and work experience or age. However it has long been the practise to augment the empirical models with a variety of covariates. Some of these are uncontentious such as controls for cognitive ability while others raise deeper theoretical questions. Recent work on the returns to schooling (e.g. Carneiro & Heckman 2004) has argued that economists have over-emphasized the importance of cognitive skills at the expense of non-cognitive abilities. In general economists have avoided the use of other psychometric measures in earnings equations partly due to lack of data but also because they lack an appropriate theoretical framework.

While the use of behavioural variables and/or psychometric measures is unusual it is becoming less esoteric: Bowles, Gintis and Osbourne (2001) survey the growing research on behavioural determinants of wages. Some of the literature analyses the effects of character traits such as withdrawal and aggression on earnings as well as psychometric indices such as the Rotter index of locus of control as well as *Machiavellian intelligence*- the ability of manipulate other people[1]. While the notion that temperament or behavioural characteristics matter for an individual will come as no surprise to psychologists (amongst others) it has been relatively slow in having an impact on empirical economics.

A parallel recent development has been the rise of neuroeconomics, which involves applying neuroscience to the study of economic decisions. For example functional Magnetic Resonance Imaging (fMRI) has been used to see which parts of the brain are activated while a subject plays simple Prisoner Dilemma games[2]. There is strong evidence of the plasticity of the brain, that is its ability to adapt to circumstances such as neurological insult i.e. it can to some extent re-wire itself. This raises the possibility that the structure of the brain may respond to economic circumstances. In fact some recent evidence shows that the posterior hippocampus (an area of the brain

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[1] Turner and Martinez (1977) find positive returns to this characteristic for high educated individuals and negative returns for those with low education. Mueller and Plug (2004) look at the returns to personality.

[2] For example Montague and Berns(2002), Glimcher (2002).

associated with spatial representation) in a sample of London taxi drivers is larger on average and this appears to be a *response* to their occupation, as it is positively correlated with the time spent in the occupation (see Maguire *et al* (2000)).

This paper contributes to work linking the brain with economics by looking at one particular feature of individuals which relates to the brain: *laterality*. In particular we ask whether left-handed people are paid more or less than right-handers controlling for the usual variables that appear in a conventional earnings equation. Our reasons for focusing on left-handedness are partly data-driven: aside from other measures of laterality, it is the only characteristic available in a large dataset with the labour market data necessary for the investigation. Secondly, left-handedness has generated a significant body of scientific research and as discussed below there are grounds for arguing that there may be a connection between it and the labour market. In the next section we discuss some of the scientific background to left-handedness and why it might matter in the labour market.

It might be argued that the inclusion of laterality in an earnings equation is *ad hoc* since it lacks a strong theoretical foundation. If so, the same argument applies to the inclusion of variables such as stature, beauty and sexual orientation which have been increasingly used in earnings studies. The idea that features of the brain should influence one's experiences in economic and social life, 'though currently untested, is hardly controversial. Recent work on lifecycle skill formation builds directly on neuroscientific findings on how brains learn and are influenced by their environment, see Cunha *et al* (2005).

2. Laterality

Laterality is the scientific term for "sidedness", the characteristic of many objects and living things in which there is an asymmetry between one side and the other. The most obvious examples are in the animal kingdom where many species have important asymmetries. While humans and other primates appear symmetric from the front or back their inner organs are arranged asymmetrically. External asymmetries in humans are more subtle: the left and right side of the face are not quite mirror images and there are systematic differences in, amongst other things, feet, gonads and fingerprints.

In terms of biology, especially human, there is a very large literature examining the incidence, causes and correlates of laterality. The form that most people are familiar with is handedness. While most people identify this with whether an individual writes with their left or right hand, researchers stress the existence of a continuum of handedness since many people will use different hands for different tasks. Aside from handedness, other forms of laterality exist such as footedness as well as eye dominance and the inter-relationship between different lateralities is the subject of much research, see for example Bourassa, McManus and Bryden(1996)).

The existence of handedness has a long historical tradition with references to it appearing in the works of Socrates and the Old Testament for example. A consistent feature is the association between left-handedness and either abnormality or evil. The clearest example is the Latin word for left, *sinister*, and its French equivalent, *gauche*. Such associations occurs in numerous languages. By contrast, to be *dextrous* (literally right handed) is to be physically adept and a key aide is likely to be one's "right hand man". The idea of left-handers being clumsy is widespread. The British psychologist Sir Cyril Burt declared, "Not infrequently the left handed child shows widespread difficulties in almost every form of fine muscular coordination…Awkward in the house and clumsy in their games, they are fumblers and bunglers in almost everything they do"[3]. One explanation for this could be that left-handers tend to turn in the opposite direction to right-handers (anti-clockwise and clockwise respectively) so they are more likely to

[3] Quoted in Coren(1993) p 244.

bump into people. The former US President (and left-hander), Gerald Ford's reputation for clumsiness has been attributed to this. More scientific evidence comes from a recent study of several species of fish where it was found that population lateralisation (the tendency for a group to turn in the same direction) is found particularly in gregarious species since there are obvious gains from coordination, see Bizazza *et al* (2000).

The degree to which left-handedness is stigmatised varies from culture to culture and also depends on religion but is virtually universal. Children who wish to write with their left hand have often been forced to use the other hand. Prejudices aside, that the world is geared towards the needs of right-handers since the vast majority of people are right handed it is not surprising. The extent to which it is so can be surprising as it is often subtle however and most right-handers are oblivious to it. Although left-handers are invariably aware of the disadvantages accruing to their situation, they seldom highlight the issue. Many tools and basic pieces of equipment such as corkscrews, knives, surgical instruments, computer keyboards and pencils are designed for right-handers. Power-tools and firearms are generally designed with right-handers in mind by the location of the key switches and safety catches. So it may be the difficulty of left-handers using right handed equipment that has given rise to the idea that they are clumsy.

The incidence of left-handedness varies across culture, sex and over time. Typically 10% of the population would be classified (or classify themselves) as left handed with a somewhat higher incidence amongst males than females. There is a lower incidence in eastern cultures, which may reflect greater cultural resistance to left-handers. Some ingenious analysis of paintings and sculptures suggest that this incidence hasn't changed much over the last 5000 years (Coren and Porac 1977) although there is evidence that it has risen in the twentieth century[4]. This appears to reflect the diminishing

[4] See McManus(2003) figures 9.1 and 9.2.

tendency for left-handed children to be forced to write with their right hand. Anthropological evidence suggests that right dominance is over a million years old, preceding *homo sapiens*.

The scientific literature on laterality is extensive and only a few aspects will be touched on here[5]. One issue that should be mentioned is the debate on the causes of left-handedness since this has direct implications for how it might influence earnings. There are a variety of possible explanations for left-handedness. It is well known that left-handedness partly runs in families which suggests a possible genetic basis. Bryden *et al* (1997) discuss several genetic models of inheritability of handedness 'though others such as Coren(1992) are sceptical of a genetic explanation and the influence of testosterone *in utero* has also been argued for, see Geschwind and Galaburda (1987).

One of the earliest theories of handedness is the argument associated with Bakan, that birth stress plays a key role, see Bakan *et al* (1973). The argument is that if, during birth, there is damage to the left side of the skull as it passes through the birth canal then this may be sufficient to cause an individual to switch from being a right-hander since the left hemisphere is normally responsible for the right hand and vice versa. Damage to the right side would have no effect except in the small number of left-handed individuals. Not surprisingly, the suggestion that left-handers are, in effect, brain damaged, is controversial. If true, it would suggest that left-handedness is a marker for the presence of neurological impairment and this is consistent with evidence on various other conditions that have a higher incidence amongst left-handers. However it is difficult to reconcile this theory with the wide variation in obstetric practice, which would influence birth stress, does not predict the incidence of left-handedness. A more recent environmental theory is

[5] The books by Coren (1993) and McManus(2003) provide accessible introductions to the area.

that exposure to ultrasound *in utero,* may increase the incidence of left-handedness, see Rothman (2001).

Why might laterality in general and handedness in particular matter for economic outcomes such as earnings? There are two basic reasons for thinking that left-handedness may be associated with bad outcomes in life; *environmental*: the world is geared towards left-handers, or *biological*: left-handedness is a marker for some underlying deficit. The environmental theory is based on a long tradition of historical and scientific evidence that left-handers experience prejudice and also practical difficulties largely because they are a small minority and many aspects of the environment are constructed to suit right-handers. Coren and Previc (1989) show a higher incidence of accidents occurring to left-handers in a sample of US military personnel and Coren (1996) also finds a higher incidence in a sample of university students ‘though this finding has not been found in more recent studies e.g. Porac *et al* (1998) and Pekkarinen, Salminen and Järvelin (2003) so it is far from clear that this holds generally.

The biological argument comes in several forms. Firstly, there are numerous findings that left-handedness is associated with various undesirable outcomes such as low cognitive ability (e.g. Hardyck, Petrinovich, & Goldman 1976, McManus & Mascie-Taylor 1983) as well as a number of unusual and sometimes pathological conditions. For example a higher incidence of left handedness is found amongst groups with a history of alcoholism, autism, being an architect, blondeness, criminality, depression, homosexuality, immune diseases, psychosis and schizophrenia to mention but a few[6]. One theory then is that left-handedness is a marker for the presence of other pathologies

[6] See Coren (1993), chapter 9. The list is not definitive and some of these associations are disputed. An exception to the trend is the finding that left-handers have lower levels of arthritis; see McManus and Wysocki (2005).

in the individual that have been caused by some other means such as the “birth stress” idea of Bakan discussed above. In effect then, a negative relationship between left-handedness and earnings may not be causal but point to the existence of some other underlying condition. Porac and Searlman (2002) find that left-handers do not experience a lower quality of life in terms of psychological health, physical health or cognitive performance.

So far, so bad for the southpaw. Is there an upside? Given the persistence of left-handedness over a long period of time then Darwinian natural selection would predict that some benefit must accrue to it assuming that it is heritable. There is some evidence that left-handedness conveys some advantages. Benbow (1986) finds a higher incidence of left-handers among the extremely intellectually precocious, based on those in the .01% of students taking the American Scholastic Aptitude Test before age 13. The difference (relative to a control group) was greater for those who were verbally precocious rather than mathematically precocious. Similarly, Hicks and Dusek (1980) examine the handedness of gifted and non-gifted children (gifted being defined as having an I.Q. greater than 131) and find a lower incidence of right-handedness amongst the gifted children. However given the small numbers involved this is unlikely to have much effect on earnings especially if one conditions on cognitive ability. There are advantages in certain competitive situations precisely because left-handers are in a minority for example cricket and fighting, see Brooks *et al* (2004), Faurie and Raymond (2004) respectively.

A recurring theme in the folklore of left-handers is that they are more creative or talented. Numerous web sites listing famous left-handers attest to the prevalence of this view. Is there more systematic evidence for this relationship? Conventional intelligence testing is not suited to answering this question since it relies on solving questions to which there are unique well-defined answers - that is, it tests “convergent thinking”.

Divergent thinking, by contrasts, requires an individual to work outwards towards some unexplored association, for example asking someone to think of novel uses of a household object. A number of other papers find evidence that creativity is higher amongst left-handers e.g. Newland (1981) and Coren (1995). The former paper uses the Torrance tests of Creative Thinking and finds a higher score for left-handers in all four domains (fluency, flexibility, originality and elaboration). A disadvantage of the approach taken in this paper (and others) is that these tests are "figural"; they depend on processing visual information and hence may be confounded by spatial abilities, which are known to be higher amongst left-handers.

Coren (1995) uses tests which do not involve spatial reasoning or drawing. This paper makes the important finding that creativity (specifically "divergent thinking") is associated with left-handedness in males only. If there is such an advantage it could be either inherited or as a response to a more difficult environment which forces them to be more creative. These findings on creativity are also consistent with a significant body of evidence that, particularly in males, the right frontal lobes are critical for *cognitive novelty*: dealing with new tasks or situations where the brain's existing "repertoire" cannot be applied where as the left lobes deal with *cognitive routinization* : situations that the brain is familiar with and has pre-existing strategies to use[7].

Another candidate explanation for left-handed advantage relates to brain morphology. The main connection between the two hemispheres of the brain is a thick band called the *corpus callosum*; this is about 7cm in length and contains about 200-250 million axons that allow the cortical regions of two hemispheres to communicate. In a series of papers Witelson (1985,1989) and Witelson and Goldsmith (1991) found that it is significantly larger in left-handers (more precisely, non-consistent right-handers compared to consistent right-handers) amongst males but not females. In particular it was found that these size differences arose in segments of the corpus callosum connecting those regions of the cortex associated with functional asymmetry (such as handedness).

It is has been hypothesized that this callosal size difference could allow more rapid inter-hemispheric processing. This is based on the assumption that the difference in size was due to a greater number of axons – these are the fibres leading from the nucleus' of neurons which transmit signals to other neurons. There are other explanations for this finding: axons are usually covered in a fatty sheath called myelin that acts as electrical insulation. It is possible that differences in callosal size are due to greater myelination or to thicker axons. However what evidence exists suggest that callosal size is a good proxy for the number of axons, see Aboitiz *et al* (1992).

If such advantages exist, one manifestation of it could be superior memory and there is evidence that those with familial left-handedness have advantages in some form of memory, see Christman and Propper (2001). Direct evidence of a relationship between callosal size and superior verbal fluency was shown, for a sample of women, by Hines *et al* (1992). However it is a long way from neurons to the labour market and the existence of the effects on earnings is clearly speculative at present.

The above arguments may be summarized as follows: environmental effects, if any, on earnings are likely to be negative for left-handers. As a marker for some underlying pathology, left-handedness might also predict lower wages. There are several possible sources of advantage however (e.g. higher creativity and greater connective tissue in the brain) and these occur primarily for males only so any negative effect is likely to be smaller or absent for males.

One argument that arises informally but has not been studied may be called the "advantage of being disadvantaged" theory. Assume that both left-handers and right-handers each possess a certain set of abilities. Given that the environment is geared

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[7] See Goldberg *et al* (1994) for example.

towards right-handers, left-handers have an incentive to invest effort in acquiring additional skills, naturally possessed by right-handers, that may foster creative behaviour, see Peterson and Lansky (1977). It follows then they may over-compensate for their handicap. This may be counterintuitive but is consistent with a theory of competency which argues that individuals are motivated to achieve competency as a desire to master their environment, see White (1971) for example. This environmental theory would predict some advantage to being left-handed. Moreover it seems plausible that the advantage would be *greater* for manual workers since, effectively, they would be at more of a disadvantage in the first place.

It has been long established that some brain functions are localized in particular areas. For example language is largely located in the left hemisphere and also that the left side of the body is controlled by the right hemisphere and vice versa. Subsequent work has shown that *to some extent* the left hemisphere is specialized for verbal, analytical, abstract thinking while the right hemisphere specializes for non-verbal (visual/spatial), holistic, intuitive thinking. However the popular idea that individuals have dominant hemispheres so that one hears of "left brained" and "right brained" people, the latter being invariably more creative, artistic or emotional, over-simplifies a more complex relationship between the hemispheres. Since the left side of the body is controlled by the right side of the brain (and *vice versa*), hemisphericity is consistent with the folklore of greater artistic and creative abilities of left-handers.

One feature that is understood however is that language lateralization is lower for left-handers, being located in the left hemisphere for about 70% of individuals compared to about 97% of right-handers. It is also lower in women than in men[8]. This has led to speculation that left-handers brains are wired somewhat differently on average and this variation may sometimes convey an advantage. If one thinks of the brain of consisting of a set of specialized modules then if a particular module, say for speech production, is unusually located beside another module than this could enhance some activity which requires both of them to communicate. Clearly such variation could convey disadvantage in some circumstances. This does not imply that they will typically be advantaged rather that they will be more variation[9].

3. Data

Our analysis is based on the 1958 National Child Development Survey (NCDS). This is a longitudinal study of all persons living in Great Britain who were born between 3rd and 9th of March 1958. The 1958 perinatal mortality survey has been followed by 6 subsequent waves (NCDS 1–6) at age 7, 11, 16, 23, 33 and the most recent, at ages 41-42. NCDS 1-3 comprised of interviews with the child, his parent's, his school and the report of a medical examiner. This data is an exceptionally rich source on child development from birth to early adolescence, child care, medical care, health, physical statistics, home environment, educational progress, parental involvement, cognitive and social growth, family relationships, etc. NCDS 4-6 is based largely on interviews with the

[8] Women in general show less hemispheric asymmetry than men, see Hellige (1990). The evidence suggests that *footedness* rather than handedness better predicts language lateralisation, Elias & Bryden(1998).

[9] This theory of *random cerebral variation* is due to McManus (2003) p229.

cohort member and his partner. They document economic activity, income, training, housing as well as the development of the cohort member's own family.

The analysis is carried out separately for men and women. For males we exclude part-time workers as they would be less than 1% of the sample. For females they are included as they are around 25% of the sample. Only individuals with non-missing observations for all variables used in our study have been included. Descriptive statistics are provided in Tables 1 and 2 for men and women respectively. Although missing values reduces the sample size considerably the means for the entire sample and that used in the empirical work are in most cases quite similar although for example for both men and women those with children are over-represented relative to the entire sample (67% in the sample and 42% overall for the males).

The dependent variable is the natural log of hourly earnings in 1991. The earnings of men and women were derived separately. For the male sample the hourly earnings was derived using usual gross pay, pay period and hours worked per week. Amounts for those who stated they were not economically active were coded to missing, as were observations recording hours worked of outside the range of thirty to eighty hours per week. A trimming of the earnings data at the top and bottom five percentiles took place to eliminate the effects of suspect extreme values.

Three forms of human capital are included in the model: schooling, cognitive ability and experience. The years of schooling variable was calculated from the monthly economic activity information recorded from 1974 to 1981. Respondents reporting school leaving ages of less than sixteen (the legal minimum) were dropped from the sample since the legal minimum was generally very well enforced..

The measure of ability is based on three separate tests, a mathematics test taken at ages 7 (taken from the Problem Arithmetic Test – Pringle *et al*, 1966) and tests of verbal and non-verbal ability taken at age 11 (from General Ability Test, Douglas 1964). We use the first Principle Component of the three. Unlike other NCDS studies (e.g. Dearden, 1997), we include a measure of work experience which was calculated by examining the detailed employment history of the cohort member since leaving school. Although this is a study of a single cohort, work experience may differ due time spent in education, sickness and unemployment. The effects of experience were incorporated into the model in the usual quadratic form.

Aside from the level of schooling a number of variables are taken from waves prior to 1991. Information on the type of school attended by the respondent is included. A number of other variables are taken from the 1991 wave including union membership status, size of employer and marital status.

There are several laterality variables contained in the dataset. Laterality has many different dimensions and degrees. The variable used in this study is the parent's opinion of the child's laterality at age 7. In introducing laterality into the model one has to note that the measurement of it is not simple. Ideally one constructs a *laterality profile* or *inventory* that measures the extent to which one is left or right dominant. This will depend not just on hand use but also on eye and foot use (people have a dominant foot and a dominant eye) and will vary in the number and nature of functions with which they use their hands. A "weak left-hander" might use their left hand for writing but otherwise use their right hand for most other tasks. The data contains measurements of foot and eye dominance and some other measurements of lateral ability (e.g. the speed at which they could pick up matches with either hand). These other forms of laterality are less well studied.

There is an argument for using an early record of laterality as they are more likely to be influenced by environmental pressures (such as school or family) as they get older. On the other hand at a very early age a child may not have fully revealed their true handedness. So a disproportionately high number of children at age 7 are recorded (see

Table 1) as being mixed handed[10]. One could simply take this at face value. However over time one finds that mixed-handers "disappear" i.e. they become left or, mostly, right-handers. We make the assumption that the indication at age 7 of mixed handedness is largely measurement error. We considered two ways of dealing with this: either one could impute the handedness of the mixed-handers from data taken at age 11 or we could simply omit them. These two approaches give very similar results but in this paper we present results mostly using the second strategy. So our laterality variable indicates whether they were left handed at age 7, the omitted category being right handed.

4. Results

The model we estimate is the standard Mincer model in which the logarithm of hourly earnings is a linear function of years of schooling, a quadratic term in work experience (based on monthly records of labour market activity) and a number of additional controls such as cognitive ability as well as the variable of particular interest, a measure of handedness. The extensive literature on human capital models has considered a large number of variations on this basic model to deal with such issues as the possible endogeneity of schooling, non-linearities in returns and heterogeneous returns. To deal with these would take us a long way from the focus of this paper so we sidestep them: Blundell, Dearden and Sianesi (2005) address these and other issues using the same data as this paper.

The basic results for males are in Table 3. The first regression includes left-handedness only as a covariate. The results suggest that left-handed males earn 4% more per hour than right-handers. The second column adds variables that are normally in

[10] Being mixed-handed is distinct from being ambidextrous (equally good with both hands) which is extremely rare.

earnings equations, a quadratic in work experience and human capital. In addition controls for region and firm size are included. We allow for non-linearity in schooling by including, in addition to years of schooling, a dummy variable for whether they stayed in education beyond the minimum school leaving age of 16. The marginal return to a year's education is 3.5%. This is lower than many published OLS estimates for the UK. It is difficult to compare with other estimates using the NCDS since most of these have very different specifications and, in particular, most look at the returns to particular levels of education rather than years of schooling. The average return to schooling here is higher since staying in education one year beyond the minimum age of 16 generates a return of nearly 8%. Given that the average level of education in this group is quite low (64% leave at age 16 and the average years of schooling is 11) the implied average return (close to 8%) is not very different from estimates which impose equality of marginal and average returns, for example Dearden (1999), who estimates returns to males of around 6%.

The returns to experience follow the usual shape but the coefficients are not individually (or jointly) statistically significant. This is not entirely surprising since all the respondents were born in the same week so the variation is low. The return to one standard deviation of cognitive ability is nearly 7%.

The effect of left-handedness is now somewhat higher, close to 5%. The third column adds an additional set of controls: for marital status, union membership, parenthood, indicators of school type and a measure of cognitive ability. The coefficient on left-handedness is essentially unchanged although the returns to education fall because of the inclusion of ability

Table 4 explores the robustness of these results further by considering several other specifications. In column 1, we include measures of two additional forms of laterality: eye and foot dominance. In general, the incidence of right-footedness is lower than right-handedness, (about 70%, 90% respectively). The measurement of eye dominance is more complicated. One criterion is sensory dominance, which records which eye's (monocular) vision one's binocular vision is closer to. In this data, the respondents were handed a tube and asked to look down it; the eye they use being designated as dominant, and this is sighting dominance. However they are more likely to use their dominant hand to hold the tube so this can generate a bias[11]. There is a positive correlation between most forms of laterality (left-footers more likely to be left-handed than right footers and so on). For example, from Table 1 one can see that 94% of right-handers are also right footed but only 45% of left-handers are. In general eye dominance is much less well understood and the correlation with both hand and foot dominance is much smaller.

The results indicate that these other forms of laterality have no effect on earnings and the handedness result remains. In the second column, we use an alternative measure of left-handedness where those mixed-handers at age seven (who had been omitted otherwise) were imputed with their handedness measured at age 11. This procedure increases the sample slightly. The argument for doing this is that a lot of the mixed-handedness recorded early in life is not genuine and their true handedness is revealed as they age. The counter-argument is that they are more open to environmental pressures later in life. It is difficult to distinguish between these two hypotheses and we have no firm view on this. In any event this has only a marginal effect on the results. We also

[11] These two are generally correlated. A third alternative, acuity dominance, is based on differences in visual acuity and is generally not correlated with the first two, see Bourassa *et al*. (1996).

considered the possibility that there may be an impact from being "cross-lateral" e.g. left-handed and right-footed but we found no evidence of such interactions[12].

The environmental hazard discussed in section two would suggest the disadvantage of being left-handed is more prominent in blue-collar occupations where manual skills are more important. The final two columns present estimates of the earnings equations for white and blue-collar workers separately. Contrary to one's intuition, the positive impact of left-handedness is *greater* amongst blue-collar workers and the hypothesis that the coefficients are the same can be rejected.

Workers' occupations are likely to be endogenous and in particular they may select into on the basis of their handedness if the hazard theory was correct with left-handers avoiding more manual occupations. In an earlier version of this paper (Denny & O'Sullivan 2004), we present estimates of the white and blue collar using an endogenous switching model using the method of Lee (1978). The results were not very different from the OLS ones presented here. However the identification assumptions were problematic. In the probit determining whether workers select into blue- or white-collar occupations left-handedness was not statistically significant (a coefficient of 0.74 and a t statistic of 0.54) so there is no evidence that workers sort according to their laterality[13].

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[12] There is an influential theory associated with amongst others, Delacato (1966) that cross-laterality is associated with abnormal intellectual development and disorders such as dyslexia 'though the evidence in support of it is weak, see McManus and Mascie-Taylor (1983).

[13] The other covariates are school type, education, marital status, parental status, union membership, number of siblings, father's education, cognitive ability and regional dummies. Cosenza and Mingoti (1993) find that, controlling for sex, that handedness has no effect on career choice.

One can summarize the male results as follows: if left-handers were at a disadvantage because of the right handed environment they live in, one would expect them to be paid less, *ceteris paribus*, to select into non-manual occupations and to experience a greater penalty in manual/blue-collar occupations. One can reject all three hypotheses. The results can in principle be explained by several possible advantages to left-handers discussed earlier though it is not possible to distinguish between them at present.

Table 5 contains results for females with the same specifications as in Table 3. In the simplest specification one finds the reverse result to that of males: left-handers are paid *less*, over 8% in the first model. Adding additional controls reduce this by about half but the number is still well determined[14]. It is not obvious why the male and female results should be so strikingly different. However it could be argued that since our priors are so weak in the absence of any previous research and with limited theoretical priors there should not be a strong presumption that the effect should be the same. It is not unusual for a given variable to have opposite effects for men and women, for example the presence of children in earnings equations (as in this paper) or labour supply functions. In many of these cases one can readily think of an explanation but these are largely *ad hoc*. A more pertinent comparison is recent work on the effect of sexual orientation on earnings (Berkhout and Plug (2004), Berg and Lien (2001)), which shows that homosexuality is associated with lower earnings in males and higher earnings in females. It is unclear why this is so. Similarly, Bowles *et al* (2001) report that for high status jobs,

[14] To increase the sample size, we include part-time female workers and hence a binary indicator for this is included in the model. The number of part-time male workers is negligible, about 1% of workers.

males are rewarded for aggression and penalized for withdrawal whereas the reverse is true for females.

What evidence there is on between sex and handedness (the evidence on colossal size, the evidence on divergent thinking and cognitive novelty, discussed in section 2) points to advantages for left-handed males only which is consistent with the results. There is a considerable body of evidence which points to male/female differences being associated with asymmetry in general[15]. So it is perhaps less surprising from a purely biological point of view that results differ by sex.

Table 6 contains further results for females to explore whether those in Table 5 are robust. We first consider alternative forms of laterality by including measures of foot and eye dominance in addition to handedness. Unlike males, these have some explanatory value. What is surprising is that the effects are not qualitatively the same, specifically that footedness has a positive effect that is almost statistically significant. The second column eliminates the least well determined of the three, handedness, and the third includes the only remaining statistically significant variable, eye dominance. The penalty associated with left-eye dominance in column 3 is of a similar magnitude, around 5%, to that found for hand dominance in Table 5. If we estimate the model for women (column 3 of table 5) for white-collar and blue-collar workers, the coefficients and t ratios for being left-handed are -0.048 (2.00) and –0.044 (1.18) respectively. So, like males, being left-handed is better (or not so bad) if you are a blue-collar worker.

[15] See Kimura (1999), chapter 12 or Baron-Cohen (2004). There is some evidence of behavioural differences for other primates: Westergaard *et al* (2004) find that for female rhesus macaques (*Macaca mulatta*) right-handers are more submissive, the reverse of what is true for males.

5. Conclusions

This paper looks one particular feature of the brain that has been widely studied and has widespread cultural and scientific significance. It might be argued that the inclusion of laterality in an earnings equation is *ad hoc* since it lacks a strong theoretical foundation. If so, similar arguments apply to the inclusion of controls like employer size, school type, marital status or number of children, variables which are increasingly becoming common. Laterality by itself is a more profound phenomenon, being evident in every human (and many non-human) society and has existed for well over a million years.

Examining its relationship with economic success we find large effects that differ between the sexes. One explanation for the existence of such effects is the "environmental hazard theory". In this, left-handers are paid less as they struggle with a right-handed world. It would also predict the penalty is greater for manual than non-manual workers and that hence that left-handers would sort into non-manual jobs. For males, all three predictions are rejected by the data. Left-handers are paid more, other things being equal; the premium is greater for manual workers and there is no evidence of occupational sorting by laterality. This suggests that the complaints of (male) left-handers of their tribulations in life, if correct, appear to be compensated for generously and the folklore of talented left-handers may have some substance.

Curiously, for females, there is a significant penalty for being left-handed with the penalty being lower for manual workers (consistent with the male results). However many of the advantages that might be expect to exist from being left-handed arise primarily or exclusively in males so qualitatively this is what would one expect.

Research on the nexus between the brain and economic outcomes is in its infancy and has largely focused on a narrow set of behaviours that can be studied using brain imaging technology such as strategic behaviour. However it seems highly likely that neuroscience will, in the future, provide more data to better understand labour market and other market outcomes.

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Table 1: Descriptive statistics: Men by handedness.

	All NCDS			Sample	
	Right:	Left:	Mixed:	Right:	Left:
Log hourly wages 1991:	1.96	1.98	1.90	1.96	2.00
	0.29	*0.30*	*0.32*	*0.29*	*0.29*
Years of schooling	1207	1205	1199	1206	1184
	1.88	*1.77*	*1.94*	*1.86*	*1.59*
Experience in years:	16.15	16.14	16.27	16.15	16.22
	1.45	*1.59*	*1.35*	*1.46*	*1.57*
Ability:	0.00	-0.13	-0.10	0.01	-0.04
	1.00	*1.06*	*1.01*	*1.00*	*0.97*
Left Eye-dominant (no mixed)	0.28	0.58	0.40	0.28	0.55
	0.45	*0.50*	*0.49*	*0.45*	*050*
Left Footed (no mixed)	0.06	0.55	0.20	0.06	0.57
	0.25	*0.49*	*0.40*	*0.23*	*050*
Married:	0.65	0.63	0.66	0.68	0.66
	0.48	*0.48*	*0.48*	*0.46*	*0.47*
Has children:	0.68	0.66	0.63	0.67	0.66
	0.49	*0.49*	*0.49*	*0.47*	*0.47*
Trade union member:	0.35	0.38	0.34	0.51	0.53
	0.47	*0.48*	*0.46*	*0.50*	*0.50*
Stayed in education post-16:	0.34	0.34	0.31	0.36	0.31
	0.47	*0.48*	*0.47*	*0.48*	*0.47*
Type of school:					
Selective:	0.65	0.68	0.67	0.67	0.68
	0.48	*0.48*	*0.49*	*0.47*	*0.47*
Maintained:	0.32	0.31	0.29	0.31	0.32
	0.47	*0.47*	*0.47*	*0.46*	*0.47*
Independent:	0.03	0.02	0.03	0.02	0.01
	0.17	*0.18*	*0.20*	*0.14*	*0.08*
N:	6008	870	598	2150	327

Standard deviations in italics.

Table 2: Descriptive statistics: Women by handedness.

	All NCDS			Sample	
	Right:	Left:	Mixed:	Right:	Left:
Log hourly wages 1991:	1.62	1.56	1.64	1.61	1.53
	0.37	*0.38*	*0.34*	*0.36*	*0.36*
Years of schooling:	12.5	12.2	1308	1206	1187
	2.07	*2.18*	*2.36*	*1.75*	*1.59*
Experience in years:	15.47	15.76	15.49	15.23	15.20
	1.95	*2.09*	*1.69*	*2.60*	*2.79*
Ability:	0.65	-0.04	-0.13	0.01	-0.07
	0.98	*0.95*	*0.99*	*1.00*	*0.95*
Part-time worker	0.32	0.32	0.34	0.42	0.48
	0.47	*0.47*	*0.45*	*0.49*	*0.50*
Left Eye-dominant (no mixed)	0.30	0.52	0.30	0.31	0.62
	0.45	*0.50*	*0.47*	*0.46*	*0.49*
Left Footed (no mixed)	0.04	0.50	0.15	0.04	0.51
	0.20	*0.50*	*0.37*	*0.20*	*0.50*
Married:	0.65	0.67	0.64	0.61	0.66
	0.48	*0.48*	*0.48*	*0.49*	*0.48*
Has children:	0.74	0.78	0.75	0.65	0.71
	0.50	*0.50*	*0.50*	*0.48*	*0.45*
Trade union member:	0.25	0.24	0.25	0.41	0.33
	0.42	*0.41*	*0.43*	*0.49*	*0.47*
Stayed in education post-16:	0.41	0.35	0.39	0.40	0.35
	0.49	*0.48*	*0.49*	*0.49*	*0.48*
Type of school:					
Selective:	0.66	0.67	0.66	0.65	0.72
	0.48	*0.47*	*0.48*	*0.48*	*0.45*
Maintained:	0.32	0.29	0.33	0.33	0.27
	0.47	*0.46*	*0.48*	*0.47*	*0.45*
Independent:	0.02	0.04	0.01	0.02	0.01
	0.16	*0.16*	*0.11*	*0.15*	*0.10*
N:	6019	632	414	1934	200

Standard deviations in italics.

Table 3: Estimation results for full time men:

	(1) Log Hourly Wages	(2)* Log Hourly Wages	(3)* Log Hourly Wages
Laterality age 7 – left handedness:	0.04	0.048	0.049
	2.38	3.03	3.16
Years of education:	-	0.035	0.029
	-	6.94	5.69
Stayed in education post-16:	-	0.078	0.048
	-	3.99	2.44
Experience:	-	0.032	0.026
	-	0.74	0.62
Experience squared:	-	-0.001	-0.001
	-	0.64	0.53
Married:	-	-	0.059
	-	-	4.83
Has children:	-	-	0.038
	-	-	3.1
Trade Union member:	-	-	0.001
	-	-	0.09
School type – maintained:	-	-	0.003
	-	-	0.26
School type – independent:	-	-	-0.016
	-	-	0.36
Ability:	-	-	0.068
	-	-	12.02
N	2477	2477	2477
R Squared adjusted	.0022	.1654	.2248

Heteroscedastic robust t ratios below coefficients.
*Regional and employer size dummies omitted.

Table 4: Estimation results for full time men:

	(1)* Log Hourly Wages	(2)* Log Hourly Wages	(3)* Log Hourly Wages – White collar	(4)* Log Hourly Wages – Blue collar
Laterality age 7 – left handed	0.051	-	0.046	0.063
	2.68	-	2.12	2.81
Laterality age 7 – left handed (mixed recoded):	-	0.04	-	-
	-	2.76	-	-
Laterality age 11 – left eye dominant	-0.004	-	-	-
	0.37	-	-	-
Laterality age 11 – left footed	0.00	-	-	-
	0.02	-	-	-
Years of education:	0.029	0.027	0.02	0.05
	5.69	5.48	3.53	2.47
Stayed in education post-16:	0.048	0.047	0.049	-0.059
	2.42	2.43	2.21	1.38
Experience:	0.026	0.012	-0.011	0.051
	0.62	0.29	0.27	0.71
Experience squared:	-0.001	0	0.001	-0.002
	0.53	0.21	0.42	0.59
Married:	0.059	0.056	0.049	0.053
	4.82	4.57	3.09	3
Has children:	0.038	0.044	0.055	0.019
	3.09	3.64	3.72	0.97
Trade Union member:	0.001	-0.005	0.008	0.034
	0.09	0.5	0.59	1.91
School type – maintained:	0.003	0.007	0.016	0.001
	0.25	0.62	1.04	0.07
School type – independent:	-0.016	0.027	0.079	-0.212
	0.35	0.6	2.07	2.54
Ability:	0.068	0.071	0.056	0.045
	11.97	12.88	6.27	5.63
N:	2477	2671	1358	1055
R Squared adjusted	.2242	.2145	.1618	.1858

Heteroscedastic robust t ratios below coefficients.
*Regional and employer size dummies omitted.
In column 2, those recorded as mixed handed at 7 are recoded according to their reported handedness at age 11.

Table 5: Estimation results for working women:

	(1) Log Hourly Wages	(2)* Log Hourly Wages	(3)* Log Hourly Wages
Laterality age 7 – left handed	-0.085	-0.052	-0.04
	3.14	2.42	2.05
Years of education:		0.059	0.04
		10.5	7.19
Stayed in education post-16:		0.051	0.047
		2.54	2.44
Experience :		0.052	0.031
		3.49	2.34
Experience squared:		-0.002	-0.001
		2.87	1.94
Part time worker:		-0.21	-0.158
		15.45	10.71
Married:			0.042
			3.24
Has children:			-0.078
			5.01
Trade Union member:			0.176
			13.61
School type – maintained:			0.042
			3.29
School type – independent:			-0.011
			0.26
Ability:			0.068
			10.34
N:	2134	2134	2134
R Squared adjusted:	.0046	.3525	.4404

Heteroscedastic robust t ratios below coefficients.
*Regional and employer size dummies omitted.

Table 6: Estimation results for women:

	(1)* Log Hourly Wages	(2)* Log Hourly Wages	(3)* Log Hourly Wages	(4)* Log Hourly Wages
Laterality age 7 – left handed:	-0.029			
	1.33			
Laterality age 7 – left handed (mixed recoded):				-0.044
				2.32
Laterality age 11 – left eye dominant:	-0.039	-0.054	-0.049	
	1.76	2.67	2.42	
Laterality age 11 – left footed:	0.023	0.021		
	1.88	1.7		
Years of education:	0.04	0.04	0.04	0.04
	7.24	7.24	7.17	7.38
Stayed in education post-16:	0.048	0.048	0.048	0.047
	2.5	2.52	2.49	2.54
Experience :	0.031	0.031	0.032	0.031
	2.33	2.35	2.38	2.35
Experience squared:	-0.001	-0.001	-0.001	-0.001
	1.93	1.95	1.98	1.92
Part time worker:	-0.159	-0.16	-0.16	-0.156
	10.8	10.83	10.8	10.88
Married:	0.043	0.043	0.043	0.042
	3.32	3.32	3.3	3.36
Has children:	-0.077	-0.077	-0.078	-0.073
	4.96	4.98	5.02	4.85
Trade Union member:	0.177	0.177	0.177	0.173
	13.63	13.71	13.69	13.7
School type – maintained:	0.044	0.044	0.043	0.05
	3.41	3.45	3.33	3.98
School type – independent:	-0.003	-0.001	-0.004	-0.017
	0.08	0.02	0.1	0.42
Ability:	0.068	0.068	0.068	0.070
	10.37	10.36	10.32	11.19
N:	2134	2134	2134	2244
R Squared adjusted:	.4414	.4412	.4408	.4407

Heteroscedastic robust t ratios below coefficients.

*Regional and employer size dummies omitted.

In column 2, those recorded as mixed handed at 7 are recoded according to their reported handedness at age 11.