CHAPTER 3: HANDEDNESS AND BIRTH STRESS

"For he himself is subject to his birth"

Hamlet, I.3.18

Summary

No evidence was found, either in two retrospective studies, or one large prospective study, for a relation between left-handedness and birth complications.

3:1 Introduction

Bakan (1971) proposed that left-handedness might be a result of "neurological insult associated with pre-natal or delivery factors". At that stage his only substantive evidence was a relation between handedness and birth order, those birth ranks associated with a higher incidence of perinatal mortality (1, 4+) having a higher frequency of left-handedness than the lower-risk birth ranks (2,3). Bakan, Dibb and Reed (1973) attempted a slightly more direct approach to the problem, asking students whether there had been any complications during their own birth. Left-handers reported more birth stress, as also did both left- and right-handers with a sinistral family history as compared with the appropriate control group without a sinistral family history. The incidence of left-handedness was also raised in the children of older mothers (greater than 30 years), another high-risk group for perinatal morbidity and mortality. Bakan, Dibb and Reed proposed that familial tendencies in left-handedness might be a secondary result of a familial tendency to birth stress. Extrapolating further from their hypothesis, they suggested that "the frequency of left-handedness ... might serve as a general index of the prevalence of birth-related neurological insult". They also implied that left-handedness should be more common in lower socio-economic groups, although the opposite to this was later claimed by Bakan (1977).

Bakan (1975) without presenting any further data took his hypothesis even further. Birth stress, and by direct implication left-handedness, "may be related to a variety of genetic or environmental factors, such as maternal physique, parity, nutrition, drug ingestion, smoking, or even pain sensitivity which may influence the amount of anaesthetic used in delivery". Left-handedness was regarded as "an indication of neurological insult associated with pregnancy and birth. It is something to be reduced rather than tolerated ... In fact handedness deviation in a group indicates that the group is at risk for neuropathological conditions. Preventive interaction in such groups could play tremendous dividends, both economically and in the reduction of suffering". Clearly such a theory, if true, is of the greatest importance, both for neuropsychology and for obstetrics.

Bakan's theory has not had smooth running the whole way. Hubbard (1971) was unable to replicate Bakan's birth order effect: neither was Schwartz (1977). Bakan (1977) attempted to account for these discrepancies in terms of socio-economic differences between samples. He also presented another sample of data which showed the birth order effect at the 0.05 level. Further evidence cited by him in favour of his hypothesis was that Leviton and Kilty (1976) had found a 'dose-related effect', especially high incidences of left-handedness being found in birth ranks of 6 and higher. Despite this apparent sophistication the authors omitted to give the sample size within each birth rank, and also gave no statistical tests; a reconstruction of the data suggests that there is no statistical significance, their sample being far too small to find effects of the size postulated (Chi-square = 9.58, 6 df, NS).

Hicks, Pellegrini and Evans (1978) also failed to find a birth order effect, and Hicks, Evans and Pellegrini (1978) pointed out that a compilation of all the studies in the literature still failed to show a significant birth-order effect of the type postulated by Bakan. My own analysis of surveys I and II came to the same conclusion (data not given here).

The only published replication of the study by Bakan, Dibb and Reed (1973) is that of Schwartz (1977) who failed to find any significant effect. My own data from surveys I and II are shown briefly in Table 1.

Details of Surveys I and II may be found in Chapter 2:2. In summary, Survey I consisted of a questionnaire returned by 936 undergraduates in which they were asked to report any known history of complications during birth, and also to complete a 28-item handedness questionnaire, handedness being defined as in Chapter 2. Survey II consisted of a larger questionnaire, distributed on the eve of the graduation ceremony, to all graduates. The students, and also their parents, were asked to complete items relating to handedness, and the whole family was asked to report birth complications in the propositus and the siblings of the propositus. A total of 512 adequately completed questionnaires was received, and these replies contained information on a total of 1245 propositi and siblings. Information on birth complications in Survey II might be expected to be slightly more reliable (and also more frequent) than that in Survey I, since the mother in particular would have a more detailed recollection of the events of the birth. Nevertheless given the work of Chamberlain and Johnstone (1975) which demonstrated the fallibility of mothers' memory for events of the previous parturition (only a few years previous), the present data should not be relied upon to any great extent.

Table 3:1a shows that in neither survey is there any evidence for a relationship between handedness and birth complications. Table 3:1b shows that, contrary to the findings of Bakan, Dibb and Reed (1973), there is no relationship, either in right or left-handers, between a history of birth complications and a family history of sinistrality. In both surveys, family history of propositi and siblings is defined in terms of the handedness of all the <u>remaining</u> family members, a single report of left-handedness being sufficient to define a positive family history.

There has been little other evidence to support the birth stress hypothesis (although this has not prevented it from being widely quoted as established truth). Bakan (1977) has pointed out that in a small prospective study, Barnes (1975) found that the time to regular breathing after delivery correlated closely with subsequent handedness measured at the age of three. Barnes however puts a totally different interpretation upon this fact, suggesting "that left-handers are more likely to have a stressful birth, rather than the stressful birth causing the left-handedness". Whether or not the hypothesis of Barnes deserves serious consideration will depend upon the same evidence which would test Bakan's hypothesis, for unless an effect is demonstrated both hypotheses must surely fail.

Bakan appears to have missed one small piece of evidence which lends some support to his theory. Turkewitz, Moreau and Birch (1968) found that head turning in response to tactile stimulation was less asymmetric in a group of babies with low Apgar scores, than in babies with high Apgar scores.

Bakan (1978) has cited experimental evidence by Brann and Myers (1975) that experimental asphyxia in neonatal rhesus monkeys effects only the left hemisphere if the hemispheres are affected asymmetrically; whilst superficially impressive, the study in fact refers to a total of only 3 monkeys, and is thus less than convincing in statistical terms.

As both Bakan (1977) and Hicks, Pellegrini and Evans (1978) recognise, the only way of resolving these questions is by a prospective study. In this Chapter I will report the results of such a study, about 12,000 children being followed from birth to at least the age of 11 years. The children comprise a nationally representative sample from all social classes. Ironically this data has been in existence for some years, and was available even before the start of the present controversy over birth-stress and left-handedness. Other aspects of handedness in the NCDS data have previously been considered by Calnan and Richardson (1976, a, b).

3:2 Method

The data for the present study were those collected by the National Child Development Study (NCDS), and now available to bona fide researchers via the Social Science Research Council's Archive of computer-readable data at the University of Essex. The NCDS study was originally the 1958 Perinatal Mortality Survey (PMS), which was sponsored by the National Birthday Trust Fund. It looked at a wide range of obstetric factors relating to all children born in England, Wales and Scotland during the period 3rd to 9th March 1958. Obstetric and other data were collected by the mid-wife or doctor present at the birth, and are undoubtedly of a very high quality and accuracy. Extensive analyses of these data have already been published (Butler and Bonham, 1963; Butler and Alberman 1969).

In 1964 the NCDS was set up in order to trace as many as possible of the children studied during the 1958 PMS. This study (NCDS I) looked at the children at about the age of 7, and obtained interviews with parents and teachers, gave each child several ability tests, and also had each child examined by a doctor. Naturally, it was not possible to obtain adequate answers on all items for all children, and some children were not subjected to a whole section of the survey (e.g. the medical examination). Nevertheless the response rate was extremely high. Many results have already been reported from that study (National Child Development Study, 1966, 1972).

The 1958 cohort was studied again in 1969, when they were aged about 11, in a second study (NCDS II), which was essentially similar in content to that of NCDS I. A third study (NCDS III) was also carried out when the children were 16 years of age, but these data have not been used in the present study, being not yet available for public re-analysis.

For the present study, information was requested on some 500 variables on each of a total of 18,285 children. This information was supplied on magnetic tapes which were analysed using the SPSS programme package (Nie et al, 1975), on the IBM 370/165 computer at the University of Cambridge.

In view of the potential importance of the NCDS data for research on handedness, since the comprehensive nature of its information allows a whole range of studies, it is worthwhile in the present paper devoting a little space to an analysis of the formal structure of the handedness information. This analysis can be regarded as being complementary in some sense to the study of the structure of handedness reported in Chapter 2, and provides further evidence that a simple classification of handedness into two categories, left and right, is adequate for most purposes.

3:3 The structure of handedness in the NCDS

The NCDS contains five variables explicitly concerned with hand preference. It also contains several items on differential skill of the two hands, and also questions on foot laterality and eye dominance; the first of these items has been considered further in Chapter 2.

Table 3:2 summarises the five items concerned with hand preference. Table 3:3 gives for completeness, the number of children (out of a total of 11029 for whom valid information was available on all five hand preference items) in each of the possible 108 response categories. Note that 25 (23.1%) of each of the categories of Table 3:3 are actually empty, despite the large sample size. Table 3:4 shows an inter-correlation matrix for the five hand-preference items. All correlations are high, positive, and highly significant. Factor analysis of this 5 x 5 matrix gives eigen-values of 4.08, 0.36, 0.29, 0.17 and 0.07, the first factor alone accounting for 81.7% of the total variance. Clearly this first factor is the only significant factor. There is thus only a single dimension of handedness in the NCDS data. The question then arises as to the best way of dividing this continuum into categories, if at all. Factor scores were calculated for each subject on the single dimension derived from the factor analysis, and these factor scores were standardised so that the maximum and minimum possible scores were +100 and -100 (as in Chapter 2). Figure 3:1 shows the frequency distribution of individuals with particular factor scores. Note that the ordinate of this figure is logarithmic, and thus the 'dip' in the centre is far steeper and deeper than it appears. From Figure 3:1 it is clear that there are only two major categories present, right handers having positive scores and left-handers having negative scores. Using a criterion of zero on the standardised factor scores, the present population contains 11.25% left-handers. Whilst computationally correct, the criterion described is somewhat inconvenient. Table 3:5 shows the relation of handedness, as classified above, to each of the five variables of which the scale was initially constructed. The relation with item 1275, the writing hand of the child at the age of 11, is extremely close, only one child being mis-classified if this variable is used instead of the above criterion derived from the factor analysis. In this and all future studies therefore, 'handedness' will refer to the response recorded in item 1275. It is noteworthy that this conclusion is consistent with the arguments put forward in Chapter 2 that the single best criterion of handedness is the writing hand.

3:4 Handedness and birth stress

The NCDS data contains a large amount of information on the pre-natal and peri-natal condition of each child, the information being collected at the time of birth, and therefore having a high degree of accuracy. In all the following tables, children have been considered only if they are singletons without congenital defects.

Table 3:6 shows the relation between left-handedness and the occurrence of each of 28 dichotomous items which might be predicted to increase, or to be associated with birth stress. Results are given for all births (i.e. singletons without congenital defects), male births alone, and female births alone. In the NCDS data there is a significantly higher incidence of left-handedness in male children (12.81%) than in female children (9.64%), and therefore data combined by sex might sometimes give spuriously significant results, particularly if a complication were itself of different incidence in the two sexes. The combined male and female data are given, both for completeness, and also to assist interpretation of data from relatively rare conditions. Chi-squared values and p values in Table 3:6 are two-tailed values, Yates' correction being applied in all cases.

The great majority of the differences in Table 3:6 fail to reach significance, thus arguing against a relation between handedness and birth trauma. However, it might be argued that many of the variables shown in Table 3:6 actually show a small correlation with handedness and that this correlation is in the expected direction, and thus the combined impact of all of these minor correlations might be to produce a correlation overall which is significant. To assess this possibility the exact probability values for each 2 x 2 matrix were found, and these two-tailed probabilities converted to one-tailed probabilities (by taking into account the direction of the result found), and these one-tailed probabilities then combined, using the method of Kendall (1951). Even when this has been carried out for the results shown in Table 3:6 the data still show no significant relation between left-handedness and birth stress, either for males (Chi-squared = 53.31, 56 df, p = 0.577), or for females (Chi-squared = 71.12, 56 df, p = 0.083) or for males and females combined (Chi-squared = 124.45, 112 df, p = 0.2005). Note that in the present data it is in the females in whom the greater effect is found, contrary to the findings of Bakan, who suggests that males are more likely to show such a link between handedness and birth stress.

Looking at the probability values in the first part of Table 3:6 (i.e. for males and females combined) it is apparent that for three items ('Caesarian Section', 'Neonatal convulsions or cyanosis', and 'Other abnormalities of presentation') that the p values reach a conventional significance level of 0.05. If one examines the probabilities for these items for males and females separately, then for the first two items, none of the probabilities within sex are significant, whilst for the third item, only the value for females is significant. Combining the male and female chi-squared results gives Chi-squared values of 5.22, 3.25, and 5.61 respectively, none of which are significant with 2 degrees of freedom. In summary, the three 'significant' results in Table 3:6 cannot be accepted as evidence for a real effect.

Table 3:7 shows similar results to Table 3:6 but is instead for those variables for which more than two possible response categories are available. Chi-squared values for homogeneity are given for all variables. For those variables which are ordinal in their classification a Kolmogorov-Smirnov two-sample test was also carried out to check for differences in overall distribution between the left-handed and the right-handed children.

The significance values of Table 3:7 may also be combined by addition of Chi-squared values. This has been carried out for the first 14 items (i.e. 'social class' to 'smoking', inclusive) and gives values of Chi-squared = 57.03, df 61, for males and Chi-squared = 52.55, 61 df for females, neither value being statistically different from chance expectations, as neither is the combination of the male and female values (Chi-squared = 109.25, 122 df, NS).

Table 3:8 shows the breakdown of those variables which were cardinal and for which there were a sufficiently large number of possible responses to allow the use of statistics designed for continuous distributions. F-tests of significance have been carried out for all these items; in addition the Kolmogorov-Smirnov two-sample test is also reported in view of the possibility of small degrees of non-normality being confounded by the large sample size to produce spuriously significant or non-significant results.

Several composite indices of the data presented in

Tables 3:6, 3:7 and 3;8 have also been produced. Goldstein (1969) has used the variables age, parity, social class, height, smoking and pre-eclampsia to predict the perinatal mortality rate. All are independent predictors of differing strengths, and after their combined use (with appropriate weighting), a non-significant degree of variance is left unaccounted. Table 3:8 shows my own reconstruction of this variable (called the perinatal mortality predictor scale, PMPS), in left and right-handers. There is no significant difference between the two groups, when a non-parametric test is used (the distribution being strongly non-normal; skewness = 1.22, kurtosis =).

Three other indices have also been constructed, these being simple counts of adverse events occurring during a particular period. The ante-natal risk factor count (ARFC) was a simple count of the following variables:-

- maternal haemoglobin of less than 9 gms/100mls
- placenta praevia with bleeding
- abruptio placentæ with bleeding
- any vaginal bleeding before 28 weeks
- any other vaginal bleeding after 28 weeks
- maternal diabetes
- maternal heart disease
- maternal TB (active)
- hydramnios

Note that none of these items overlap with the items in the PMPS.

The Intra-partum risk factor count (IRFC) was a simple count of the number of events from the following list:-

- Caesarean section
- use of forceps during delivery
- breech presentation
- occipito-posterior presentation
- other abnormality of presentation (face, shoulders, etc.)
-
- umbilical cord prolapse
- meconium staining of amniotic fluid
- fetal distress as indicated by abnormality of fetal heart rate
- other signs of fetal distress

The neonatal risk factor count (NRFC) was a simple count of all adverse events recorded after delivery of the child, i.e.

- rhesus incompatability
- hyperbilirubinaemia
- neonatal convulsions or cyanosis
- neonatal hypothermia
- respiratory distress
- pyloric stenosis

- other miscellaneous neonatal conditions

A composite risk factor count (CRFC) was also constructed by using all the variables already described for the ARFC, IRFC and NRFC, and also adding to this list dichotomised versions of the variables used in the PMPS, as well as several others which might be thought pertinent to the question of birth stress and handedness. The extra variables were:-

- mother's weight greater than 10 stones 13 pounds
- mother's height less than 62 inches
- gestation period less than 36 weeks or greater than 42 weeks
- parity zero or greater than 2
- history of previous spontaneous abortions or ectopic pregnancies
- history of previous premature live births
- history of previous still-births or neonatal deaths
- history of previous toxaemia
- history of previous ante-partum haemmorhage
- history of previous Caesarean section
- first stage of labour longer than 24 hours
- second stage of labour longer than 2 hours
- membrane rupture longer than 48 hours
- mother's age greater than 29 years
- mother smoked after 4th month of pregnancy
- surgical induction of labour carried out
- oxytocin usage during labour

- moderate or severe toxaemia
  (as defined by Butler and Bonham, 1963).

The number of items on each of the scores ARFC, IRFC, NRFC and CRFC was 9, 9, 7 and 43 respectively. Clearly it is not possible to attain these maximum scores since some of the items are mutually exclusive. Results for the ARFC, IRFC and NRFC have already been presented in Table 3:7; none show significant relations with handedness. Table 3:9 shows the distribution of scores for males, females, and both sexes combined, on the composite risk factor score. For none of the groups is there a significant difference between right- and left-handers; this is also reflected in the absence of a difference in means of right- and left-handers.

3:5 Conclusions

In this Chapter I have reported results from two moderately large retrospective studies, and one very large prospective study of the relation between birth complications and subsequent left-handedness. None of the studies produced any substantial evidence for a relation between birth stress and left-handedness.

There seems little doubt that birth stress is unlikely to play any role in the development of left-handedness in the majority of the population. It may be concluded safely that the incidence of left-handedness need be of no concern to obstetricians anxious to monitor the efficiency of their services.

Table 3:1a shows separately for Surveys I and II, the relation between handedness and a history of birth stress (or birth complications). In the table + indicates a history of birth complications, and - their absence.

Survey I

Birth complications	Handedness Right	Left	N	% Left
-	721	108	829	13.0
+	95	12	107	11.2

$X^2 = 0.14$, 1 df, $p = 0.708$

Survey II

Birth complications	Right	Left	N	% Left
-	803	129	932	13.8
+	262	51	313	16.3

$X^2 = 1.14$, 1 df, $p = 0.285$

TABLE 3:1.b Shows, separately for Surveys I and II and for right and left-handers, the relation between reported birth stress (or complications), and a family history (FH) of sinistrality.

RIGHT-HANDERS

		SURVEY I				SURVEY II			
		FH-	FH+	N	% +	FH-	FH+	N	% +
Birth stress	-	463	55	518	10.6	349	131	480	27.3
	+	252	37	289	12.8	454	131	585	22.4

Survey I: $X^2 = 0.67$, 1 df, $p = 0.411$

Survey II: $X^2 = 3.41$, 1 df, $p = 0.061$

LEFT-HANDERS

		SURVEY I				SURVEY II			
		FH-	FH+	N	% +	FH-	FH+	N	% +
Birth stress	-	25	2	27	7.4	30	17	47	36.2
	+	83	10	93	10.8	99	34	133	25.6

Survey I: $X^2 = 0.02$, 1 df, $p = 0.884$

Survey II: $X^2 = 1.93$, 1 df, $p = 0.161$

TABLE 3:2 Gives details of the five items in the NCDS data set which are concerned with hand preference

NCDS item number	Age at assessment	Survey	Person assessing child	Method of assessment	Item description in data manual	Possible responses
291	7	NCDS I	Mother (structured interview)	From memory	"Laterality (hand) - mother"s report"	-Right-handed -Left-handed -Mixed right and left
373	7	NCDS I	Doctor	Direct examination	"Task: Throw a crumpled paper ball Draw a cross	-Only right hand used -Only left hand used -Both right and left hand
1274	11	NCDS II	Mother (interview)	From memory	"Ask mother if the child is:-	-Left-handed -Right-handed -Mixed right and left
1275	11	NCDS II	Mother (interview)	From memory	"Which hand does your child write with?"	-Left hand -Right hand
1582	11	NCDS II	Doctor	Direct examination	"Ask child to throw ball to you. Did he/she use;-	-Right hand -Left hand

TABLE 3.3 Shows the numbers of children, out of a total of 11029 for whom adequate information was available on all five hand preference items, who gave each particular combination of responses.

Item 1274	Item 291	Right / Right	Right / Left	Mixed / Right	Mixed / Left	Left / Right	Left / Left	item 1582
		← item 373 / ← item 1275						
Right	Right	7849	1	852	0	31	0	Right
Right	Right	62	0	19	0	3	0	Left
Right	Mixed	338	1	63	1	0	0	Right
Right	Mixed	2	0	8	2	3	1	Left
Right	Left	31	0	12	0	2	0	Right
Right	Left	1	0	1	1	4	3	Left
Mixed	Right	223	3	27	4	2	1	Right
Mixed	Right	10	2	13	0	2	1	Left
Mixed	Mixed	131	6	31	16	1	2	Right
Mixed	Mixed	5	1	22	6	0	14	Left
Mixed	Left	0	4	5	27	1	8	Right
Mixed	Left	1	1	1	7	3	30	Left
Left	Right	13	7	3	7	0	0	Right
Left	Right	0	1	1	7	2	7	Left
Left	Mixed	3	7	2	25	0	9	Right
Left	Mixed	1	2	2	14	0	41	Left
Left	Left	1	21	0	136	0	68	Right
Left	Left	0	16	0	142	0	589	Left

Column headings: upper line = item 373, lower line = item 1275.

Table 3:4 shows the inter-correlation matrix for the five hand preference items described in Table 3:2.

	1275	1274	291	1582	373
1275	-	0.917	0.861	0.744	0.766
1274	0.917		0.840	0.726	0.728
291	0.861	0.840	-	0.692	0.713
1582	0.744	0.726	0.692	-	0.701
373	0.766	0.728	0.713	0.701	-

Table 3:5 shows the relationship between the single variable derived from factor analysis ('Hand': see Chapter 3:3 for description) and the five simple variables from which it is derived.

		Hand	
		Right	Left
Item 291			
	Right	9113	40
	Mixed	612	145
	Left	63	1056
		Right	Left
Item 373			
	Right	8672	72
	Both	1062	385
	Left	54	774
		Right	Left
Item 1274			
	Right	9282	9
	Mixed	478	133
	Left	28	1099
		Right	Left
Item 1275			
	Right	9787	0
	Left	1	1241
		Right	Left
Item 1582			
	Right	9622	356
	Left	166	885

TABLE 3:6 Shows, for those variables which can be regarded as dichotomous, the proportion of those children with and without the condition, who are left-handed. Chi-squared values use Yate's correction for continuity, and probability values are two-tailed.

		Males Only						Females Only					
Condition	NCDS code number	condition absent N	condition absent %L	condition present N	condition present %L	Chi^2	p (two tailed)	condition absent N	condition absent %L	condition present N	condition present %L	Chi^2	p (two tailed)
hesus negative blood group	518	5050	12.8	941	13.6	0.352	0.552	4778	9.5	940	9.5	0.000	0.991
bruptio placentae	522	6815	12.7	8	12.5	0.263	0.607	6483	9.5	8	12.5	0.097	0.755
leeding per vaginam rior to 28 weeks	522	6627	12.7	196	12.8	0.007	0.929	6273	9.4	218	11.9	1.299	0.254
lacenta praevia	522	6805	12.7	18	27.8	2.458	0.117	6454	9.5	37	13.5	0.313	0.575
ther bleeding in pregnancy	522	6696	12.7	127	15.0	0.403	0.525	6354	9.4	137	10.9	0.200	0.654
aesarean Section	534	6637	12.6	186	16.1	1.713	0.190	6344	9.4	147	14.3	3.505	0.061
orceps	534	6494	12.7	329	12.8	0.002	0.958	6253	9.5	238	10.1	0.045	0.830
reech presentation	534	6741	12.7	82	14.6	0.129	0.718	6370	9.5	121	9.1	0.000	0.991
cciput-Posterior resentation	534	6678	12.7	145	11.7	0.054	0.815	6335	9.5	156	9.0	0.006	0.938
ther abnormality of presentation (face, shoulders, etc.)	534	6803	12.7	20	15.0	0.001	0.978	6468	9.4	23	26.1	5.610	0.018
mbilical cord prolapse	535	6488	12.8	8	12.5	0.251	0.615	6164	9.5	9	11.1	0.160	0.688
conium staining of niotic fluid	535	6388	12.8	108	13.9	0.035	0.850	6087	9.4	86	12.8	0.769	0.360
al heart distress	535	6306	12.8	190	12.6	0.001	0.976	6048	9.4	125	11.2	0.267	0.605
her signs of fetal stress	535	6134	12.8	362	13.3	0.031	0.861	5870	9.4	303	11.2	0.947	0.330
esus incompatability	1831	6800	12.7	23	13.0	0.070	0.791	6451	9.4	40	15.0	0.857	0.354
onatal hyper-bilirubinnia	1831	6814	12.7	9	22.2	0.127	0.721	6482	9.5	9	0.0	0.161	0.687
Neonatal convulsions or	1831	[illegible]	12.7	41	19.5	1.160	0.281	[illegible]					

--- esentation	534	6678	12.7	145	11.7	0.054	0.815	6335	9.5	156	9.0	0.006	0.938
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Neonatal convulsions or cyanosis	1831	6782	12.7	41	19.5	1.160	0.281	6473	9.4	18	22.2	2.091	0.148
Neonatal hypothermia	1831	6816	12.7	7	14.3	0.195	0.658	6487	9.5	4	25.0	0.042	0.836
Respiratory Distress	1831	6813	12.7	10	0.0	0.536	0.464	6482	9.5	9	11.1	0.161	0.687
Pyloric stenosis	1831	6803	12.7	20	5.0	0.490	0.483	6480	9.5	11	0.0	0.312	0.567
Other miscellaneous neonatal problems	1831	6782	12.8	41	4.9	1.624	0.202	6454	9.5	37	13.5	0.313	0.577
Maternal diabetes	1837	6817	12.7	6	16.7	0.103	0.747	6484	9.5	7	14.3	0.044	0.833
Maternal heart disease	1837	6769	12.7	54	11.1	0.022	0.822	6440	9.5	51	3.9	1.253	0.262
Hydramnios	1837	6807	12.7	16	12.5	0.123	0.725	6475	9.5	16	12.5	0.000	0.989
Maternal tuberculosis	1837	6812	12.7	11	9.1	0.008	0.926	6470	9.5	21	14.3	0.145	0.703
History of previous toxaemia	509	6076	12.7	418	14.8	1.420	0.233	5802	9.5	368	9.5	0.003	0.951
History of previous ante-partum haemmorhage	509	6346	12.8	148	12.8	0.014	0.904	6038	9.4	132	11.4	0.363	0.546
History of previous Caesarean Section	509	6413	12.8	81	13.6	0.001	0.970	6103	9.5	67	6.0	0.597	0.439

Table 3:7 Shows, for those variables which have three or more categories, the proportion of each class which are left-handed. Chi-squared values are given for all items= Kolmogorov-Smirnov two-sample tests are reported for items which can be regarded as ordinal in structure.

			males		
Condition	NCDS code number	group	N	%L	Chi^2 test
Social class	492	I	272	12.9	$Chi^2 = 2.07$
		II	824	11.5	4 df
		III	3737	13.0	$p = 0.721$
		IV	755	13.6	
		V	607	13.7	
Parity	504	0	2336	12.4	$Chi^2 = 5.38$
		1	2105	13.2	6 df
		3	1002	13.9	$p = 0.496$
		4	241	10.0	
		5	127	16.5	
		6+	175	12.6	
Previous abortions, or ectopic pregnancies	505	0	5740	12.9	$Chi^2 = 3.06$
		1	616	13.0	2 df
		2	103	7.8	$p = 0.215$
		3+	36	8.3	
Previous premature live births	506	0	5938	12.7	$Chi^2 = 0.09$
		1	415	13.3	2 df
		2	76	11.8	pp = 0.951
		3+	24	16.6	
Previous still births	508	0	6147	12.9	$Chi^2 = 1.40$
		1	311	11.3	2 df
		2+	36	8.3	$p = 0.496$
Mother's minimum haemoglobin level (gms/100mls)	519	10.5+	3595	12.3	$Chi^2 = 0.76$
		9.0–10.4	495	13.3	2 df
		<9.0	113	10.6	$p = 0.683$
Length of first stage of labour (hours)	527	<3	600	14.8	$Chi^2 = 7.93$
		3–6	1458	12.7	6 df
		6–12	2128	12.6	$p = 0.242$
		12–24	1498	12.4	
		24–48	472	10.8	
		48–72	72	18.1	
		>72	22	22.7	
Length of second stage of labour (minutes)	528	<30	2977	13.9	$Chi^2 = 12.93$
		30–60	1720	11.6	8 df
		60–90	736	11.8	$p = 0.114$
		90–120	338	10.4	
		120–150	189	12.7	
		150–180	75	13.3	

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			females			
	Chi^2 test	Kolmogorov-Smirnov test	N	%L	Chi^2 test	Kolmogorov-Smirnov test
	Chi^2 = 2.07	K-S z = 0.437	248	9.7	Chi^2 = 2.61	K-S z = 0.439
	4 df	NS	789	8.0	4 df	NS
	p = 0.721		3544	9.7	p = 0.623	
			744	8.9		
			536	9.1		
	Chi^2 = 5.38	K-S z = 0.356	2289	8.8	Chi^2 = 4.08	K-S z = 0.610
	6 f	NS	1886	9.8	6 df	NS
	p = 0.496		973	8.5	p = 0.644	
			480	7.9		
			238	10.9		
			153	7.8		
			154	10.4		
	Chi^2 = 3.06	K-S z = 0.215	5450	9.5	Chi^2 = 0.18	K-S z = 0.104
	2 df	NS	582	9.3	2 df	NS
3	p = 0.215		110	8.2	p = 0.912	
3			31	9.6		
7	Chi^2 =0.09	S z = 0.083	5629	9.3	Chi^2 = 2.25	K-S z = 0.323
3	2 df	NS	406	9.9	2 df	NS
8	pp = 0.951		69	11.6	p = 0.323	
6			25	22.2		
9	Chi^2 = 1.40	K-S z = 0.242	5842	9.5	Chi^2 = 5.57	K-S z = 0.150
3	2 df	NS	300	8.3	2 df	NS
3	p = 0.496		27	22.2	p = 0.061	
3	Chi^2 = 0.76	K-S z = 0.683	3402	9.5	Chi^2 = 3.55	K-S z = 0.266
3	2 df	NS	467	10.5	2 df	NS
6	p = 0.683		94	4.3	p = 0.169	
8	Chi^2 = 7.93	K-S z = 0.474	565	8.3	Chi^2 = 7.7	K-S z = 0.733
7	6 df	NS	1325	10.3	6 df	NS
6	p = 0.242		2095	8.4	p = 0.255	
4			1439	10.1		
8			433	10.6		
1			48	10.4		
7			17	17.6		
9	Chi^2 = 12.93	K-S z = 1.376	2982	9.7	Chi^2 = 4.51	K-S z = 0.445
6	8 df	p = 0.045	1601	9.2	8 df	NS
8	p = 0.114		669	8.2	p = 0.989	
4			266	9.4		
7			159	10.7		
3			70	7.1		
			31	16.1		
			15	6.7		

rupture (hours)		<3	3860	13.4	Chi^2 = 14.26
		3-6	603	10.6	8 df
		6-12	565	11.3	p = 0.075
		12-24	462	10.0	
		24-48	303	10.9	
		48-72	105	16.2	
		72-120	73	12.3	
		120-168	23	21.7	
		>168	21	23.8	
Inhalational anaesthesia	536	Not available	223	11.7	Chi^2 = 5.08
		Gas & Air	3548	12.9	8 df
		Trilene	1461	12.0	p = 0.748
		Gas,Air & Trilene	136	14.0	
		Gas & Oxygen	14	7.1	
		Not indicated	537	15.1	
		Contra-indicated	169	11.8	
		No time	160	15.0	
		Refused	227	11.9	
Surginal induction	531	None	6054	12.7	Chi^2 = 0.820
		Low	276	13.0	4 df
		High	150	14.7	p = 0.935
		Yes, type NK	207	11.6	
		OBE, oestrogen or strip	136	13.2	
Oxytocin induction	531	None	6483	12.7	Chi^2 = 0.30
		Yes	307	13.4	2 df
		Only in labour	33	15.2	p = 0.858
Toxaemia	548	None	4833	13.1	Chi^2 = 3.02
		Mild	1154	11.4	4 df
		Moderate	280	12.1	p = 0.554
		Severe	259	12.0	
		Proteinuria (?cause)	297	12.1	
Smoking after 4th month of pregnancy	639	None	4285	12.7	Chi^2 = 1.27
		Medium	983	13.9	3 df
		Heavy	754	12.3	p = 0.734
		Variable	395	12.9	
Number of antenatal problems (ARFC)		0	3785	12.4	Chi^2 = 1.19
		1	385	11.7	2 df
		2	33	19.4	p = 0.550
		3	2	0.0	
Number of intra-partum problems (IRFC)		0	5023	12.8	Chi^2 = 1.17
		1	654	11.9	5 df
		2	630	13.8	p = 0.947
		3	138	13.8	
		4	44	13.6	
		5	7	14.3	
Number of neo-natal		0	[illegible]	[illegible]	[illegible]

K-S z = 1.137 NS	484	9.9	8 df	NS
	471	8.7	p = 0.903	
	428	8.9		
	281	10.0		
	93	11.8		
	66	12.0		
	12	0.0		
	18	5.6		
	231	8.2	Chi^2 = 5.09	
	3357	8.9	8 df	
	1389	10.0	p = 0.747	
	152	11.2		
	14	7.1		
	497	10.9		
	152	10.5		
	166	11.4		
	205	10.2		
	5785	9.6	Chi^2 = 3.04	
	262	8.0	4 df	
	132	9.8	p = 0.550	
	202	6.4		
	110	10.0		
	6186	9.6	Chi^2 = 0.97	
	291	7.9	2 df	
	14	7.1	p = 0.615	
K-S z = 0.759 NS	4711	9.5	Chi^2 = 7.84	K-S z = 0.282 NS
	1079	8.8	4 df	
	254	9.4	p = 0.0973	
	222	14.4		
	225	7.6		
K-S z = 0.245 NS	4082	9.2	Chi^2 = 1.25	K-S z = 0.344 NS
	955	10.4	3 df	
	711	9.1	p = 0.739	
	351	9.7		
K-S z = 0.090 NS	3509	9.4	Chi^2 = 1.48	K-S z = 0.16 NS
	403	10.7	2 df	
	48	6.3	p = 0.477	
	3	0.0		
K-S z = 0.296 NS	4823	9.4	Chi^2 = 1.69	K-S z = 0.24 NS
	659	9.1	5 df	
	560	10.5	p = 0.889	
	90	8.9		
	35	11.4		
	6	0.0		
K-S z = 0.079 NS	6371	9.4	Chi^2 = 2.12	K-S z = 0.1 NS
	112	13.4	2 df	
	8	12.5	p = 0.344	

TABLE 3:8 Shows for those variables which are continuous in their distribution, the mean, standard deviation, and sample number for left- and right-handers. F-values are given for a one-way analysis of variance, and in view of possible non-normalities being confounded by the large sample size, a Kolmogorov-Smirnov two-sample test is also reported.

		Males (Mean / sd / N)		
Variable	number	right handers	left handers	F-test
Husband's age	494	30.53 6.49 5484	30.14 6.21 811	F(1,6293)=2.55 p = 0.110
Mother's age	553	27.47 5.70 5661	27.16 5.34 832	F(1,6491)=2.11 p = 0.146
Mother's height (inches)	510	63.39 2.50 5440	63.43 2.52 806	F(1,6244)=0.16 p = 0.687
Mother's weight (stones)	496	8.87 1.50 5529	8.84 1.46 811	F(1,6338)=0.291 p = 0.589
Gestation period (days)	497	280.9 11.81 5123	280.4 11.99 744	F(1,5865)=1.15 p = 0.639
Birth weight (ounces)	646	120.8 18.42 5467	119.5 22.45 794	F(1,6259)=3.57 p = 0.058
Perinatal mortality predictor scale (PMPS		-476.4 208.6 5385	-478.1 196.0 798	F(1,6181)=0.047 p = 0.828

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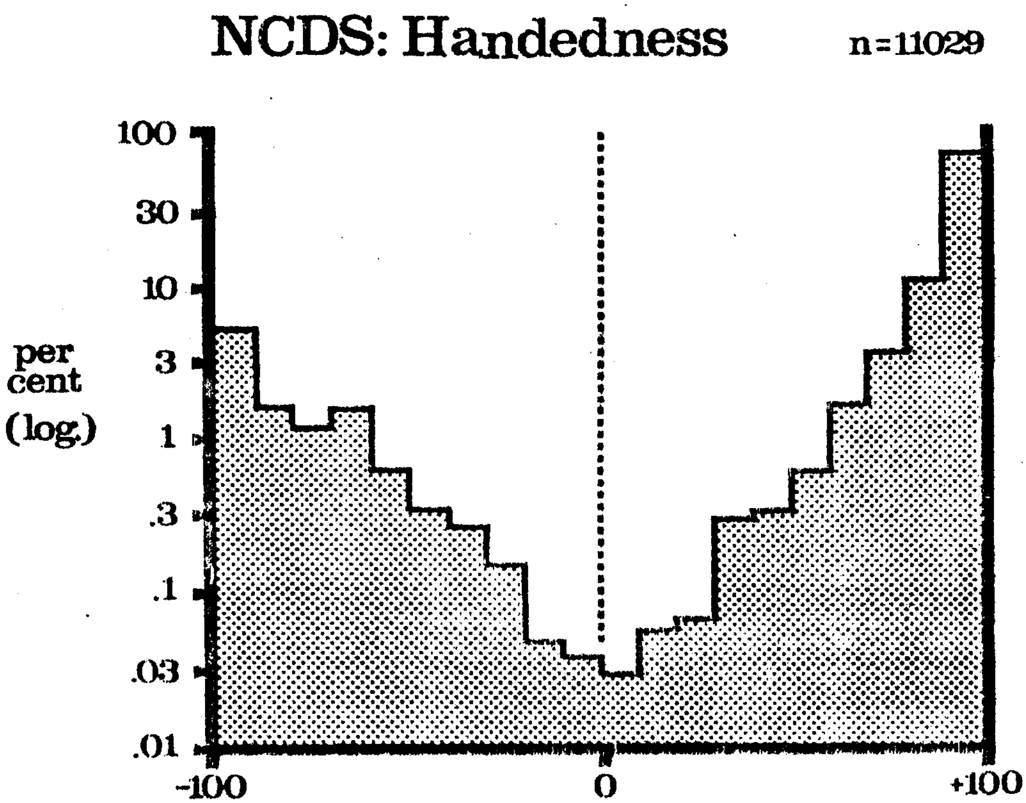
Kolmogorov Smirnov test	Females: right handers (Mean / sd / N)	Females: left handers (Mean / sd / N)	F-test	Kolmogorov Smirnov test
K-S z = 0.903 NS	30.63 6.32 5381	30.75 6.78 555	F(1,5934)=0.186 p = 0.665	K-S z = 0.578 NS
K-S z = 0.822 NS	27.50 5.67 5587	27.41 6.01 33	F(1,6168) =0.143 p = 0.705	K-S z = 0.894 NS
K-S z = 0.293 NS	63.42 2.50 5385	63.40 2.47 556	F(1,5939)=0.039 p = 0.843	K-S z = 0.363 NS
K-S z = 0.032 NS	8.85 1.48 5460	8.84 1.57 572	F(1,6030)=0.020 p = 0.88	K-S z = 0.606 NS
K-S z = 0.743 NS	281.6 11.92 4999	281.2 12.39 515	F(1,5512)=0.625 p = 0.793	K-S z = 0.649 NS
K-S z = 1.433 p = 0.033	115.9 17.45 5418	115.1 18.22 572	F(1,5988)=1.283 p = 0.699	K-S z = 0.699 NS
K-S z = 0.740 NS	-479.8 203.4 5308	-463.3 225.9 545	F(1,5851)=3.205 p = 0.073	K-S z = 0.977 NS

Table 3.9 Shows, for males and females ~~combined~~ the number of adverse events reported during pregnancy and the neonatal period by handedness. The results of Chi-squared test for homogeneity, and of a Kolmogorov-Smirnov two-sample test are reported, non-parametric tests being used in view of the clear non-normality of the data.

	males		females	
n(adverse events)	N	%L	N	%L
0	764	13.6	733	7.9
1	1272	13.1	1256	9.7
2	1235	11.5	1156	9.5
3	956	13.1	852	10.6
4	678	11.5	633	9.3
5	413	14.5	385	8.6
6	258	9.3	230	9.1
7	144	15.3	143	10.5
8	86	19.8	73	4.1
9	45	17.8	39	17.9
10	24	8.3	27	18.5
11	10	0.0	5	0.0
12	4	0.0	1	0.0
13	1	0.0	1	0.0

	males	females
Mean (right)	2.622	2.567
Mean (left)	2.624	2.640
SD (right)	2.068	2.052
SD (left)	2.112	2.073
Chi^2	12.98	15.62
df	13	13
p	0.449	0.269
K-S z	0.518 NS	0.448 NS

Figure 3.1 Shows the distribution of the first factor of handedness (standardised to a range of +100 to -100) of 11028 children from the National Child Development Study. Note the logarithmic scale of the ordinate.



NCDS: Handedness
n=11029
100
30
10
3
1
.3
.1
.03
.01
per cent (log.)
-100
0
+100