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Handedness in Schizophrenia

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SUMMARY Handedness was assessed in 272 schizophrenics and compared with findings in normal controls. The schizophrenics differed significantly from the normal controls in their handedness patterns, having a higher proportion of fully right-handed subjects. Findings in brain-damaged and elderly schizophrenic patients are also reported. The lack of consistency of reporting of handedness in schizophrenic populations in previous studies is discussed. While it is probable that differences in the methods of study of handedness account for some of the variance, differences in the type of schizophrenic illness seem likely to be of greater importance.

The study of handedness in psychiatric populations is chiefly important for the information it yields about cerebral organization. A relationship between handedness and lateralization of cerebral function has been acknowledged since the 1860's, although a detailed understanding of the link remains elusive. The collection of handedness data is very little trouble to the patients, and demands little of them in terms of cognitive skills or attention span, so it is a particularly useful approach to the study of cerebral dominance in severely disturbed psychiatric populations.

Interest in handedness patterns in schizophrenia is very recent, almost all the studies having appeared since 1972. Their findings are contradictory. Two studies find no difference in handedness between schizophrenic and normal populations (Wahl, 1976; and Oddy and Lobstein, 1972); two suggest an excess of left-handers in the schizophrenic group (Dvirskii, 1976; and Gur, 1977) and two an excess of right-handers amongst schizophrenics (Bolin, 1953; and Fleminger *et al*, 1977a).

Boklage's work (1977) on handedness in schizophrenic twin pairs emphasizes these discrepancies. When dizygotic twin pairs alone were considered no significant difference emerged in handedness between schizophrenic and normal twin populations. Among the monozygotic twin pairs discordant for handedness there was an excess of non-right-handedness largely accounted for by the schizophrenic twins. When consideration was confined to the nuclear or poor prognosis schizophrenics, however, right-handedness was the rule.

In view of these mixed findings it was felt that a further study of handedness in schizophrenia was justified.

Method

The selection of subjects

Two hundred and seventy-two schizophrenics were included in the study. All diagnosed schizophrenics in the non-geriatric wards of the local mental hospital were asked to participate in the study. As this resulted in a population of 232 biased towards older ages than those in existing studies, data were included from a further forty consecutive in-patient schizophrenics participating in another research project. These forty patients had a PSE diagnosis (Wing *et al*, 1974) of schizophrenia, nuclear syndrome. The diagnosis of all the mental hospital patients was confirmed, in terms both of the research criteria of Feighner and his colleagues (1972) and of the British Glossary to The International Classification of Diseases (General Register Office, 1968), after a case note search by one of us (P.J.T.). For forty of the mental hospital patients, there was evidence of organic brain dysfunction, such as IQ of 70 or less or abnormal EEG, as well as of unequivocal symptoms and signs of a schizophrenic psychosis.

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They were included in the study, but as a separate group, providing the evidence for organic disturbance had been recorded before or at the time of the documented onset of the schizophrenic symptoms. The few patients in whom such evidence was recorded only when their schizophrenia was well established and, for example, after several courses of insulin coma treatments or ECT, were not included in any part of the study.

The assessment of handedness

Handedness was assessed using Annett's questionnaire (Annett, 1970), on which subjects are asked to express their handedness preference as right, left or either, on twelve items. On the basis of an association analysis, on data collected from over 2,000 normal subjects, Annett designated six of the items as primary (writing, throwing, holding a racket, holding a match to strike it, hammering and using a tooth-brush) and six secondary (using scissors, guiding a thread through the eye of a needle, hand at the top of a broom and of a shovel, dealing cards and unscrewing the lid of a jar).

A questionnaire was completed by one of us (P.J.T.) during an interview with each patient, which allowed the information given to be checked in a number of ways. The patients were asked to identify their hands as right or left, before their verbal response to each question was recorded. All patients were then asked to write their names and to perform each of the secondary activities. The necessary equipment for doing so was placed in front of them equi distant between their hands. When a discrepancy was found between the report and performance of any activity, performance on all twelve items was checked. Either responses were retained when the patient could demonstrate equal proficiency between hands.

Categories of handedness were defined as right if the right hand was preferred for all activities, left if the left hand was preferred for writing, and mixed if the right hand was preferred for writing but a left or either response was given for one or more of the other items. There were no ambidextrous writers. The handedness patterns for the schizophrenic subjects were compared with those of the 800 normal controls collected by Fleminger *et al*, 1977.

The statistical analysis

In order to investigate the association between handedness and the three major variables age, sex and diagnostic group, various hierarchical log-linear models with Poisson errors (Everitt, 1977) were considered, using Generalized Linear Interaction Modelling (GLIM) (Baker and Nelder, 1978). The importance of this method is that it makes it possible to determine whether apparent differences in handedness patterns between diagnostic groups are real, or due to the varying proportions in the different age-sex groups and an association of handedness with age and sex. The simplest model to fit allows for the proportions in each age-sex group within each diagnostic group and the overall proportions in each handedness category (Model I, Table II) but does not propose a relationship between handedness and any of the three other variables. If it is shown that this simple model does not fit then the associations between handedness and each of the other three variables must be considered in turn. The final model chosen is the one including the fewest of these associations and such that no model including any other associations would fit the data significantly better.

Results

The majority of the patients were fully cooperative. Two females and eight males, all right-handed writers, had right-left confusion and consistently referred to their right hand as their left hand. In the light of the performance checks made, however, the validity of the findings with respect to the handedness of the patients was thought to be high. Many patients were unable to give any information about their families, and of those who did a substantial minority were clearly fabricating. The results of the enquiry about family history of handedness are therefore not reported.

Table I shows the distribution of handedness preference according to age and sex in the schizophrenics without overt evidence of brain damage ('pure' schizophrenics), the schizophrenics with prior organic brain dysfunction and the normal controls.

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TABLE I

Handedness distribution of schizophrenics and controls

Sex	Age	Handedness	Controls	'Pure' schizophrenics	Schizophrenics with evidence of organic disease
Male	Under 40	Right	72 (40.2)	24 (54.5)	6 (75.0)
		Mixed	89 (49.7)	15 (34.1)	0
		Left	18 (10.1)	5 (11.4)	2 (25.0)
		Total:	179 (100.0)	44 (100.0)	8 (100.0)
	40 to 64	Right	93 (52.2)	35 (62.5)	11 (68.8)
		Mixed	73 (41.0)	19 (33.9)	3 (18.8)
		Left	12 (6.7)	2 (3.6)	2 (12.5)
		Total:	178 (99.9)	56 (100.0)	16 (100.1)
	All under 65	Right	165 (46.2)	59 (59.0)	17 (70.8)
		Mixed	162 (45.4)	34 (34.0)	3 (12.5)
		Left	30 (8.4)	7 (7.0)	4 (16.7)
		Total:	357 (100.0)	100 (100.0)	24 (100.0)
	65 and over	Right	—	21 (65.6)	5 (100.0)
		Mixed	—	11 (34.4)	0
		Left	—	0 (0.0)	0
		Total:		32 (100.0)	5 (100.0)
Female	Under 40	Right	117 (47.0)	17 (63.0)	3 (60.0)
		Mixed	106 (42.6)	7 (25.9)	2 (40.0)
		Left	26 (10.4)	3 (11.1)	0
		Total:	249 (100.0)	27 (100.0)	5 (100.0)
	40 to 64	Right	114 (58.8)	25 (65.8)	3 (75.0)
		Mixed	66 (34.0)	8 (21.1)	1 (25.0)
		Left	14 (7.2)	5 (13.2)	0
		Total:	194 (100.0)	38 (100.1)	4 (100.0)
	All under 65	Right	231 (52.1)	42 (64.6)	6 (66.7)
		Mixed	172 (38.8)	15 (23.1)	3 (33.3)
		Left	40 (9.0)	8 (12.3)	0 (0.0)
		Total:	443 (99.9)	65 (100.0)	9 (100.0)
	65 and over	Right	—	26 (74.3)	1 (50.0)
		Mixed	—	9 (25.7)	1 (50.0)
		Left	—	0 (0.0)	0
		Total:		35 (100.0)	2 (100.0)

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TABLE II

Likelihood ratios for different log-linear models investigating the relationship between handedness and other variables for controls and pure schizophrenics

Hierarchy of model	Constraints (each model includes terms in previous model together with allowance for new association)	Degrees of freedom	Likelihood ratio χ^2	Degree of fit	Reduction in χ^2 between current model and preceding one (degrees of freedom = 2)	Significance of new association
I	Totals for each age-sex category within each diagnostic group. Overall numbers in each handedness category	14	29.79	$P < 0.01$	—	
II	+ association between age and handedness	12	17.07	$P > 0.10$	12.72	$P < 0.005$
III	+ association between diagnostic group and handedness	10	9.38	$P > 0.40$	7.69	$P < 0.025$
IV	+ association between sex and handedness	8	3.52	$P > 0.80$	5.86	$P = 0.053$

Table II shows the fitting of the different log-linear models for the controls and 'pure' schizophrenics under the age of 65. The simplest model showed a significant lack of fit, confirming the importance of an association between handedness and at least one of the three other variables.

There was a significant association between age and handedness for the controls and the 'pure' schizophrenics of 64 and under combined ($P < 0.005$ Table II, Model II). The association did not differ significantly between these groups. It was due to a shift towards full dextrality in the over 40 age groups. This study thus again establishes age as a significant factor in the handedness of adults. A significant relationship of a similar kind had already been shown for the control group, and also a general psychiatric population, in a previous study (Fleminger *et al*, 1977). Data collected on a group of 32 male and 35 female schizophrenics aged 65 and over show a continuation of the trend towards increasing dextrality with age ($\chi^2 = 8.04$ d.f. $= 2$, $P < 0.025$).

The handedness pattern of the 'pure' schizophrenics was significantly different from the normal controls ($P < 0.025$. Table II, Model III). The schizophrenic group contained more fully right-handed individuals than the control group, which in turn contained a relative excess of mixed-handed subjects. There was no significant difference between diagnostic groups in the proportion of left-handed subjects.

The significance of the association between handedness and age and handedness and diagnostic group was unaffected by the order of fitting, suggesting that the two associations are independent. Having allowed for these associations, and not before, there was also a significant association between handedness and and sex ($P = 0.053$ Table II, Model IV). This was due to fewer of the females showing mixed handedness patterns.

The log-linear model allowing for the association between handedness and each of the variables of age, diagnosis and sex fitted extremely well.

The handedness patterns of the schizophrenics in all age groups with some evidence of underlying organic dysfunction were compared with those schizophrenics with no such evidence. Amongst the females there was no significant difference in handedness patterns between the 'pure' and the 'organic' schizophrenics. Amongst the males, the numbers are rather small in the organic group, and there are no left-handed patients aged 65 and over, therefore a log-linear model with Goodman's (1970) modification was fitted. A significant association between handedness and diagnostic group was found ($P < 0.025$). The model fitted well ($P > 0.5$) and there were no other significant associations with handedness. This finding was due to the comparative lack of mixed-handedness amongst those with organic disturbance. In other words, rather contrary to expectations, it was found that the tendency towards full dextrality amongst schizophrenics was even greater if overt organic disorder could be identified.

Discussion

These findings apparently contradict the results of two other major studies of handedness in schizophrenics (Gur, 1977; and Dvirskii, 1976). In varying degrees they support the results of other workers in the field. All the other studies are agreed in failing to find an excess of left handedness amongst schizophrenics, while Bolin (1953) appears to demonstrate the same tendency to full dextrality among his schizophrenic population. The results of Fleminger *et al* (1977) are the only ones that could be compared statistically with those presented here. A log-linear model was used in a similar manner to compare the former with the 'pure' schizophrenics aged under 65 from this study. No significant difference in handedness patterns was found between them.

Although a study of this kind appears simple for the researcher and minimally demanding for the subjects, data collection, analysis and interpretation are subject to many potential biases and errors. Differences in methodology between studies are pronounced and seem likely to account for some of the differences in the results.

Attitudes to handedness affect both researchers and subjects. Dvirskii's study (1976) is by far the most impressive in terms of numbers of subjects, but his bias in searching for left-

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handedness amongst schizophrenics is considerable. On the method of assessing handedness he says "attention was paid to the preferential use of left hand" and reported no data on any other form of handedness. This approach may have been relevant to his discovery of the significantly higher frequency of left-handedness in schizophrenics. A number of the schizophrenics in our sample volunteered their own version of this bias. Invariably proving to be right-handed at the time of interview, many claimed increased use of the left hand, variously attributing this to the illness itself, to being in hospital or, in one case, to the doctor not seeing him regularly.

Many workers have demonstrated the importance of including performance measures in handedness surveys of any kind but the reports of Benton *et al* (1962) and Satz *et al* (1967) effectively emphasize the particular necessity for this precaution when excess left-handedness is an issue. They demonstrated that the probability of mis-classification is much higher for the self-reports of left-handedness than for right-handedness, almost invariably in the direction of over-reporting. Of further importance for this study is Wahl's finding that schizophrenics showed more confusion about hand preference than other subjects. Ironically, the criticism of relying on subjects' reports of preference alone could be applied to the Fleminger *et al* (1977) study which showed a higher proportion of right-handers among schizophrenics. Gur, in 1977, who reported increased left-handedness amongst schizophrenics, also relied on self-report data for this part of the study, although she did complete a performance report validity check on a subgroup of the schizophrenics.

Methods of grouping and analysing handedness data have been shown to be important determinants of results (Fleminger *et al*, 1978). Many workers depend on a simple classification of subjects into right, mixed or left-handed groups but not all agree on the criteria for allocation. The study of Fleminger *et al* (1978) compared the Handedness Survey of Psychiatric Patients (Fleminger *et al*, 1977) with that of Lishman and McMeekan (1976) both of which used this simple classification. When data from the Fleminger study were reclassified such that allocation to handedness groups was made in precisely the same way as in the Lishman study some of the apparent differences in handedness patterns between the diagnostic groups disappeared. Another problem is that although there is a core of activities studied which is common to all the work, namely writing and throwing, the number of activities examined ranges from 2 to 23, and although reliability studies have in most instances been performed on the items, no study applies any form of weighting to balance the effects of the less-reliable items. This problem appears to be greatest in the studies using the largest number of items, for example, that of Gur (1977). This study presents a further potential source of discrepancy in findings in that Gur used a completely different approach in classifying her data; she gave scores from 1 to 3 according to the degree of hand-preference and determined the tendency to left-sidedness in schizophrenics by the sum of these scores. The method of classification in the present study and that of Fleminger *et al* (1977) would, if anything, bias towards excess reporting of left-handedness, since a place in the left-handed group depends only on left-handed writing, and bias against the finding of right-handedness, since a place in the right-handed group depends on undoubted right-handedness on all items checked. Nevertheless the schizophrenic groups contained a significantly higher proportion of right handers and left-handedness was shown to occur with similar frequency among schizophrenics and normals.

While differences in collection and analysis of handedness data explain some of the discrepancy between studies, variation in the populations under study may account for more. Most workers collect their own controls as well as their own sample of experimental subjects. In their review of left-handedness Hardyck and Petrinovich (1977) cite studies to demonstrate a wide variation in estimates of the occurrence of left-handedness in the general population—from a low of 1 per cent to a high of 30 per cent. In studies where performance measures have been taken as supporting criteria for the definition of handedness the occurrence of left-handedness is stable at 9 or 10 per cent. This

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compares closely with the occurrence of left-handedness in the control group used in this study. Bolin (1953) does not employ a 'normal control' group in his study. When the percentages of left-handed and ambidextral individuals in his schizophrenic group are added together they still fall far below this figure and it is on this basis that it is suggested he demonstrates an excess of right-handedness among his schizophrenics. Dvirskii, who reports significantly more left-handedness among his schizophrenics than among his normal controls reports percentages of left-handed schizophrenics which for the men only just reach this figure of 9–10 per cent and for the women are substantially lower. The significance of the excessive left-handedness among his schizophrenics depends on the exceptionally low prevalence of left-handedness in his control group. This does not necessarily diminish the importance of his findings but does emphasize further the possibility that differences in the handedness pattern of schizophrenics between studies are apparent rather than real. Other, perhaps less striking differences between populations may nevertheless be important. Age has already been said to be an important factor in handedness (Fleminger *et al*, 1977) and this study reinforces that finding. The upper age limit for both the studies by Gur (1977) and Dvirskii (1976) was 55, ten years below that for the studies by Fleminger *et al* (1977) and Oddy and Lobstein (1972). As the mean age of the subjects of Bolin (1953) was 50, it seems likely that he too was working with an older population.

By far the most obvious potential source of variation within populations is in diagnosis of schizophrenia. The term 'schizophrenia' is widely held to cover a spectrum of disorders rather than a single discrete entity. Most of the studies leave a sense of uncertainty about the clinical characteristics of their schizophrenic population, while conveying the impression that considerable effort has been made to ensure that the label 'schizophrenia' is appropriate. Boklage (1977) leaves no doubt that at least among monozygotic twins, type of schizophrenia is a very important variable. He examined the distribution of laterality patterns among the schizophrenic twins when their illness had been classified along two overlapping but distinct dimensions—nuclearity and severity. A diagnosis of nuclear schizophrenia implies that the clinical picture of the disorder is undisputably schizophrenia, with at least one first rank symptom in evidence. The nuclear syndrome was very significantly more commonly associated with dextrality. Severity of illness was defined by a number of measures including length of time in hospital and mean global ratings of psychopathology. The most severe form of the illness was significantly associated with right-handedness. The less nuclear type of schizophrenia and the illnesses with better prognosis were concentrated in the non-dextral twin pairs. Within this group 68 per cent of the non-right handed twins were diagnosed schizophrenic against 54 per cent of the right-handed twins showing a tendency towards the association of excessive sinistrality with this sub-type of the disorder. The group of schizophrenics investigated in the present study compares best with the nuclear group of Boklage's study; forty were designated as having schizophrenia, nuclear syndrome, on the PSE. Their level of psychopathology was high and most had been ill for substantially longer than the six months minimum period laid down by the study. Of the rest, none had been ill for less than two years and most had been continuously hospitalized for more than five years. Among the other studies there is little comment on sub-type of schizophrenia and no special selection of cases to study. Dvirskii (1976) differentiated between 'continuous' and 'episodic' and 'recurrent' forms and found the significant excess of left-handedness to be among those with the continuous type of schizophrenia. It is possible that this continuous type of Dvirskii equates with the nuclear type of Boklage, in which case, again, findings contradict each other, but there is insufficient information on which to base this view.

Several studies have linked left hemisphere dysfunction with schizophrenia (for example, Flor-Henry, 1969 and 1976; Gruzelier and Venables, 1973). Many studies have linked left-handedness with various types of presumed cerebral impairment (Wilson and Dolan, 1931;

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Levy, 1969; Miller, 1971) and early cerebral insults at or soon after birth are held to be responsible for both the cognitive deficit and the left-handedness (Satz, 1972). The left-handedness as well as the cognitive deficit is designated pathological in these cases. Those who have found an excess of left-handedness in schizophrenic populations have argued similarly for a common left hemisphere aetiology for the disease and the unusual handedness. Schizophrenia, however, manifests after many years of normality. If cerebral dysfunction is to be taken as a basis of the mental state, a lesion acquired years after birth might therefore better account for the emergence of the disorder, while left hemisphere damage resulting in pathological left-handedness would be most likely to be at or around birth. The differences required in the timing of the left hemisphere pathology weaken a hypothesis postulating an association between pathological left-handedness and schizophrenia. In relatively few cases psychosis indistinguishable from schizophrenia appears to be superimposed on other long-standing deficits. The idea that a single, common pathology in the left hemisphere in this group might account for all mental disturbance and a shift to left-handedness, as another outward sign of their cerebral disorganization, is attractive in its simplicity and logically more acceptable. In so far as the brain-damaged schizophrenics in this study are representative of this category of patient, they form the group most likely to show an association between pathological left handedness and schizophrenic symptoms. Our overtly brain-damaged group, however, showed an even greater tendency towards full right-handedness than the other schizophrenics. There is then no support from this study either for any special association between left-handedness and schizophrenia or for the more specific suggestion that pathological left handedness occurs with some frequency in association with schizophrenic illnesses.

An alternative hypothesis best accounts for all the information available. The degree to which one hemisphere dominates another for various states or skills differs between individuals and makes them more or less vulnerable to disease or injury affecting that hemisphere. Full right-handedness reliably correlates with strong left hemisphere dominance for language skills and, possibly, consciousness (Zangwill, 1967; Rasmussen and Milner, 1975). Lesser degrees of right-handedness and left-handedness correlate much less well with specific patterns of cerebral organization but are likely to be associated with more bilateral, albeit still unequal, representation of language function. Boklage (1977) proposes a model, drawing a parallel between schizophrenia and aphasia and their relation to cerebral damage. If this is adopted, one might postulate that left-handed individuals would be more likely to develop either condition but less likely to suffer with a severe or lasting form of it than the right-handed individual. This appears to hold true for aphasia (Zangwill, 1960) and, given the evidence available so far, would be worth further exploration in schizophrenic populations. Boklage's data suggest that, at least among monozygotic twins, non-right handedness and better prognosis schizophrenias are significantly associated. This study confirms that a group of severely and chronically ill schizophrenics are significantly more likely to be fully right-handed than the general population.

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