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THE PREVALENCE OF SINISTRALITY IN A PSYCHIATRIC POPULATION

By

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled THE PREVALENCE OF SINISTRALITY IN A PSYCHIATRIC POPULATION

submitted by DAVID MUNRO GILL

in partial fulfilment of the requirements for the degree of Master of Education.

Supervisor

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ABSTRACT

This study was designed to investigate a hypothesized interaction between handedness and psychiatric diagnosis. A sample of 432 psychiatric in-patients at the Edmonton General Hospital were assessed for handedness using the Marian Annett Handedness Questionaire. From this group all sinistrals (n = 40) were removed and matched with a sample of dextrals on the basis of age, sex and handedness classification. The entire sample of sinistrals and matched dextrals was submitted to Research Diagnostic Criteria in order to provide a uniform diagnostic standard to facilitate comparison between the two age groups.

It was hypothesized that there would be differences between the patterns of handedness in the psychiatric population and the general public-at-large. Also that differences in diagnostic frequency between the sinistrals dextrals would occur. This was not found to be the case and of the six hypotheses presented in the study only one was confirmed. It was found that in the sinistral sample the ratio of females to males approached 1:1, while in the population as a whole the ratio of females to males was 2:1.

In order to explain the lack of support for the hypotheses it was suggested that in order to find differences between sinistrals and dextrals an "extreme group" methodology would have been necessary. Rather than selection based on handedness, selection based on strict psychiatric diagnosis would have been a more effective way of eliciting differences between the sinistrals and dextrals. One could have then compared specific diagnostic sub-groups against one another and avoided the "wash-out" effect of diagnostic heterogeniety within handedness groups.

It was concluded that the patterns of handedness in a general hospital psychiatric setting are similar to those of the public-at-large. In order to detect differences between sinistrals and dextrals an "extreme group" methodology is necessary. One must also be aware of the base-rate incidence of sinistrality in the general population (approximately 10%), the effect of pathological left-handedness, sex and the method used to classify handedness.

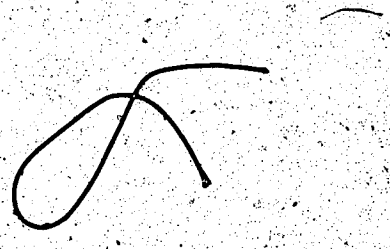

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TABLE OF CONTENTS

CHAPTER PAGE

****

LIST OF TABLES

LIST OF TABLES (continued)

CHAPTER I

INTRODUCTION

The left-handed or "sinistral" minority have been with us throughout history. From the Book of Judges, in the Old Testament, to the most recent research journals, reference is made to the 10% of the population who are "lefties". The causes of left-handedness are still unclear, although some of the more colorful historical theories have at last been discarded.

A basic assumption of this thesis is that left-handedness is not, by itself, indicative of pathology. It is accepted though that good evidence exists to link certain forms of left-handedness with dysfunction (Silva & Satz, 1979). Two further assumptions form a basis for the work to be presented later in this thesis. It is assumed that the assessment of handedness or motor laterality is a crude measure of cerebral lateralization. Also that the brains of sinistrals show a different pattern of lateralization of cognitive functions than dextrals specifically, decreased lateralization of functions, (Hécaen & Alberta, 1978; Hardyck & Petrinovich, 1977). Thus the degree of dextrality or sinistrality is an indirect reflection of lateral specialization.

Recent advances in neuropsychology, neurophysiology and psychiatry have produced a body of evidence to suggest that within the functional psychoses, dysfunction of lateralized mechanisms within and between the hemispheres exists (Yeudall & Fromm-Auch, 1979; Flor-Henry, 1974, 1975 (a), (b)). Several studies have shown unusual patterns of handedness in selected psychiatric populations (Flor-Henry & Yeudall, 1977; Lishman & McMeekan, 1976). It is inferred from this that there may be a connection

between the functional pyschoses, as reflected in dysfunction of lateralized brain systems, and sinistrality with its correlate of increased bicerebrality of function. To investigate this possibility the author collected handedness data among 432 psychiatric in-patients at the Edmonton General Hospital. Two major hypotheses are to be investigated. Firstly, whether or not the distribution of handedness types is the same for a general hospital psychiatric population as for non-hospitalized controls. Secondly, whether or not there are differences in the frequency of diagnostic classification between the dextral and sinistral in-patients.

Outline of the Study

Chapter II reviews the literature on handedness from the perspectives of: etiology of left-handedness, the search for deficits among the left-handed population, sinistrality as it relates to lateralization of brain function, evidence for the interrelationship of handedness and the functional psychoses, and lastly an examination of moderator variables in the assessment of handedness. The third chapter discusses the methodology of the study, the instruments used (Marian Annett Handedness Questionaire, Research Diagnostic Criteria), their rationale, reliability and validity (Annett , 1967, 1970; Spitzer et al, 1975, 1978(a), (b)). From the handedness data accumulated, all sinistrals were abstracted and matched with dextrals on the basis of age, sex and degree of handedness. Chapter IV presents the results of the six hypotheses presented in the previous chapter on the impact of sinistrality on mental illness. The final chapter discusses the research findings and suggests some improvements in methodology and directions for future research on sinistrality.

This study is not an attempt to document the voluminous literature on handedness, nor does it seek a definitive etiology for sinistrality. Its purpose is to examine the incidence and pattern of handedness and its possible relationship to psychiatric diagnosis in a general hospital setting.

CHAPTER II

REVIEW OF RELEVANT LITERATURE

1. Organization of Chapter

Material for this chapter has been divided into six sections. These are, in order of presentation: an introduction, a review of the numerous theories concerning the etiology of handedness, a discussion of the research oriented towards the association of sinistrality with defects, a review of laterality theory and data linking left-handedness to the functional psychoses and finally an examination of moderator variables relevant to the study of handedness. Considerable controversy presently surrounds many of the different avenues of research subsumed under the rubic, "Handedness". It is the writer's intention to highlight these areas and also make clear his own biases, where they differ from those of quoted researchers.

2. Etiological and Historical Aspects of Handedness

In order to answer the deceptively simple question "What causes one to become right-handed or left-handed?", a host of theories have emerged. They include genetics (Levy, 1972; Annett, 1979); anatomical differences (Galaberda, 1978; Records et al., 1977); differing vascular supply (Cameron & Gombos, 1970); perinatal factors and birth order (Bakan, 1977); ocular dominance (McKinney, 1969); social factors (Burt, 1937); psychological theories (Blau, 1946); and historical theories (reviewed in Clark, 1957, and Barsley, 1967). Detailed evaluation of etiological models of handedness is beyond the scope of this thesis; however, a brief summary of the theories is warranted.

A. Genetic Theories

Two main theories have been proposed, that of Annett (1967, 1970, 1973, 1979) and Levy and Nagylaki (1972; Levy, 1972, 1974, 1977(a), 1977(b)). Annett proposed a binomial distribution of right, mixed and left handedness caused by the presence of a "right-shift" factor. This factor results in speech being lateralized to the left hemisphere, which gives greater control over the right side of the body and hence dextrality results. The "right-shift" factor does not cause handedness; in fact, Annett believes that in the absence of this factor handedness and brainedness (i.e. the hemisphere dominant for language functions) will be independent of each other. In such a case cultural factors will take over to induce dextrality. For Annett, handedness is a continuously distributed variable that is a function of the normal distribution skewed in the direction of dextrality through the action of the "right-shift" factor. Annett's model requires unilateral representation of speech, a finding incompatible with studies showing bilateral speech functions in some sinistrals (Branch et al, 1964). The Levy-Nagylaki proposal is a complex two gene, four allele model that argues that handedness is largely a function of genetics. This model does attempt to account for bilateral representation of function but has been criticized by Hudson (1975) as not being compatible with observed data on the distribution of handedness patterns in families.

While no genetic model currently offers a comprehensive explanation of handedness it is difficult to deny some form of genetic influence. As Levy (1976) says, there is

> "...a genetic variance in the human population for a variety of structural and functional asymmetries, among them handedness."

B. Anatomical Differences

While gross morphological differences between the two cerebral hemispheres are absent, current evidence does demonstrate subtle, fundamental anatomical dissimilarities between the two half-brains. Records et al. (1977), reviewing the work of Geschwind & Levitsky (1968) stated that in a sample of 100 brains these authors had found the planum temporales and parietal operculum to be larger in the left, "language" hemisphere in 81% of adult brains and 86% of the neonatal brains studied. This finding has been confirmed by Witelson & Pallie (1973), (cited by Records et al. 1977) and also by Galaburda et al. (1978) who conclude that there is an association between sinistrality and reduced brain asymmetry. While it would be ridiculous to suggest that structural asymmetry within the brain is the cause of handedness the fact that asymmetries do exist is evidence for the theory that the brains of sinistrals and dextrals may show different patterns of neural organization.

C. Differences in Vascular Supply

This theory suggests that the vascular supply to the two hemispheres is different, with the left carotid artery having a more rapid blood flow than the right (Hyrtl (1871) cited by Hardyck & Petrinovich, 1977). This idea of superior vascularization of the left brain became untenable when it was shown that the circle of Willis functions to provide equal vascularization to both cerebral hemispheres.

D. Perinatal Factors and Birth Order

Bakan (1975, 1977) has proposed that left handedness is a deviation from the norma of dextrality due to pathological factors during pregnancy and birth (especilly the first and fourth birth onwards). Specifically, he postulated that left-handedness results from left hemisphere pyramidal motor dysfunction due to perinatal hypoxia. To support his theory he cites an increased frequency of difficult births among left-handed and ambilateral university students, (40% and 41% respectively) compared to strong right-handers (33%). Rather than genetically determined sinistrality, Bakan believes what is inherited is a familial tendency towards birth stress, with left-handedness being a manifestation of this. The idea that left-handers are "brain damaged" has resulted in considerable controversy and Bakan's model has been severely criticized (Hicks et al., 1978(a), 1978(b), 1979; Schwartz, 1977).

E. Ocular Dominance

Eye preference as a causal explanation for handedness has been suggested but has not found any empirical support (McKinney, 1967). While the idea that in infancy voluntary movements depend on vision is not unreasonable, the high incidence of crossed dominance (e.g. preferred eye left, preferred hand right) invalidates this theory (Clark, 1957).

F. Social Factors

It is unlikely that anyone would deny that social and cultural factors play a part in the determination of hand preference. However, the assertion that handedness is purely a social and cultural phenomenon is extreme. Sir Cyril Burt (1937) espoused this view, for him handedness

was due to education and socialization. It was normal and healthy to be right handed; while being left handed was an aberration at variance with the individuals own best interests.

G. Psychological Theories

Blau (1946) explained handedness from a psychoanalytic point of view. For him handedness was acquired through social conditioning, with dextrality being indicative of normal development. Left-handedness could result from an inherent physical or mental defect, from faulty education, that is parents or teachers not modelling "proper" right-handed behaviors or most importantly from emotional negativism. In the latter case the child chooses to spite his parents or teachers by deliberately using his left hand. This may be an unconscious decision taken as part of an infantile psychoneurosis. Because boys are encouraged by society to be more active and aggressive than girls they are more likely to express rebelliousness by becoming left-handed.

H. Historical Theories

As described by Hécaen and Ajuriaguerra (1964) one mechanism for the origin of hand preference is the development of tools. In pre-Neolithic times it was assumed that people were ambilateral, skilled equally with both hands. With the development of stone knives and scraping tools a tendency for specialization to one hand or the other would arise. With increasing sophistication, people who were not making their own tools would be forced to accept the hand preference of the tool-crafter. Thus, over time patterns of manual preference would arise.

The earliest written references to left-handedness are found in the Book of Judges in the Old Testament around 1400 B.C. (Clark, 1957;

Burt, 1937). The reference is to the Benjamite army of 26,700 men which contained an exclusive batallion of 700 left-handed men:

> "Among these people there were seven hundred chosen men left-handed; everyone could sling stones at a hair's breadth, and not miss."
>
> (Old Testament, Judges 20, v. 15)

This gives a prevalence estimate of sinistrality of 2.6%, low by current standards, but perhaps not when the selection factors are considered.

A popular historical theory of handedness development was the "sword and shield theory" credited to Thomas Carlyle (1795-1881). This theory utilized the process of natural selection, stating that soldiers who fight with a weapon in their right hand and protect their heart with a shield held in their left hand will have a better chance of survival. Left-handers, having a less efficient form of defence will gradually become extinct. As Clark (1957) pointed out, the heart is not entirely on the left side and injuries to other organs such as the liver could also prove fatal. Needless to say this theory is little more than an historical curiosity.

An equally quaint theory of handedness is derived from sunworship, which involves an instinctual turning towards the source of light. The sun rises in the east, and circles rightwards to set in the west. This clockwise, or turning to the right, motion became associated with sanctity and piety while movement leftwards, in the opposite direction, was linked with respect for Satan and evil (Barsley, 1967).

None of the above reviewed theories is sufficient to explain handedness, but their diversity serves to underscore the complexity of the phenomenon. Certainly a mix of genetic, physiological and cultural factors is necessary to explain the ontogeny of handedness. It is evident that a certain percentage of the population is going to be left-

handed, and as the next section will document, they are and will be subject to research and theorizing.

3. Handedness Research: "The Search for Deficits"

Before reviewing the evidence for and against the association of sinistrality with deficit states, some discussion of the incidence of left-handedness in the general population is warranted. Summarizing the results of forty studies from 1871 to 1976 Hardyck & Petrinovich (1977) conclude that the prevalence of sinistrality in the general population is between 8 and 10%. Most recent population estimates are congruent with this figure. Hicks & Kinsbourne (1978) estimate 90% dextrality, while Le Roux (1979) utilizing a sample of 882 white school age children in South Africa offers figures of 11.13% sinistrality in males and 7.69% sinistrality in females. In a much larger sample (n = 7,658) Hardyck et al. (1975, 1976) cite figures of 90.4% dextrality and 9.6% sinistrality. Older studies tend to show a reduced frequency of sinistrality, Clark (1957) estimated sinistrality in males to be 7.84% and in females 3.9%. Hécaen & Ajuriaguerra (1964) gave an adult range of sinistrality between 5 and 10% but reviewed studies that ranged from a low of 1% sinistrality to a high of 30% sinistrality depending on the criteria used to assess handedness.

Turning now to the relationship between handedness and cerebral dominance for speech, it is generally accepted that the vast majority of dextrals are left-brained for speech. This is not so for sinistrals. Levy (1974, 1976) states that 89% of the general population are phenotypic dextrals and of this group 99.67% are left-brained for speech. Of the remaining 11% of the population who are non-dextrals, 56% show

left-hemisphere speech dominance and 44% show right hemisphere speech dominance. Utilizing the intracarotid sodium amytal technique, Branch et al. (1964) produced a more conservative estimate of right-brained speech in their sinistral sample. Of their left-handers 70% showed left-sided speech dominance, 15% right-sided speech dominance and 15% bilateral speech representation. Of note was their finding that in sinistrals who gave a history of early childhood or birth injury to the left hemisphere, two-thirds showed right-brained speech dominance. If no injury was present, two-thirds of the sinistrals were left-brained for speech dominance. Two other studies, Warrington & Pratt (1973) and Fleminger & Bunce (1975) are in agreement with Branch et al., citing figures of 70% and 67% respectively for left-sided speech representation in sinistrals.

To summarize the above, the prevalence of left-handedness in the general population is roughly 8-10% with the vast majority of dextrals (96% or more) and two-thirds of sinistrals showing left-hemisphere dominance for speech functions. To keep this section in perspective the conclusion of Annett (1973) is appropriate:

> "Handedness and speech laterality are not independent but neither is their association complete."

An extensive body of literature has arisen on the topic of sinistrality and its association with a variety of pathologies. Left-handedness has been linked to alcoholism (Bakan, 1973), difficult birth (Bakan, 1975, 1977), mental retardation (Hécaen & Ajuriaguerra, 1964; Satz, 1972, 1973; Silava & Satz, 1979), cognitive defects (Levy, 1969; Nebes, 1971; Miller, 1971; Hicks & Beveridge, 1978(c)), delinquency (Fitzhugh, 1973) and learning disorders (Zangwill, 1962; Blai, 1972; Annett & Turner, 1974).

Two of the most controversial areas in handedness research involve the suggestion that left-handers may have mild cerebral dysfunction, ("brain-damage" to its critics) and that sinistrality is associated with cognitive deficit. As mentioned earlier, Bakan (1975, 1977) has suggested that left-handedness may result from left-hemisphere pyramidal motor dysfunction due to perinatal hypoxia. He implies that all left-handedness is pathological. This theory has been refuted by Schwartz (1977) who used a rigorous method of handedness classification and concluded that there is:

> "...no evidence of an increase in sinistrality resulting from either high-risk pregnancies or pregnancies marked by complications during gestation or delivery."

Further rebuttals have been provided by Hicks et al. (1978(a), 1978 (b), 1979) who have attempted to replicate Bakan's work and have been unable to do so.

The suggestion that sinistrals may have impaired intellectual or cognitive functions received support from the work of Jerre Levy (1969). She found, using a sample of 25 male graduate science students at the California Institute of Technology, that the mean WAIS Verbal I.Q. and Performance I.Q. of the sinistrals was 142 and 117 respectively, while for the dextrals it was 138 (Verbal I.Q.) and 130 (Performance I.Q.). Levy interpreted this finding as evidence for impairment of Gestalt perceptive capacities in the left-handed. Support for this hypothesis came from the work of Miller (1971) and Nebes (1971) who both found evidence for impaired spatial abilities in samples of left-handed individuals.

Newcombe & Ratcliffe (1973) and Kutas et al. (1975) attempted to replicate the findings of Miller and Nebes but were unable to do so

using a larger population. Newcombe & Ratcliffe (1973) concluded that unselected groups of left-handers in the general population performed as well as dextrals on standardized cognitive tasks. In extensive and comprehensive reviews of the topic of left-handedness and cognitive deficit Hardyck et al. (1976), Hardyck & Petrinovich (1977) were unable to find any association between sinistrality and cognitive deficit. They tested 7,688 school children as well as reviewed 33 studies concerned with deficits linked to left-handedness and concluded:

> "...the hypothesis of no difference in intellectual and cognitive performance between right and left-handed subjects can be accepted as true."

However, the argument is still not totally resolved. While accepting the conclusions of Hardyck et al. (1976), Hicks & Beveridge (1978) suggest that when viewed from the perspective of the theory of fluid and crystallized intelligence perhaps they are true only for crystallized intelligence. To this end they tested 67 university students (37 dextrals, 30 sinistrals) on recognized tasks of fluid and crytallized intelligence. They found the left-handers to be inferior to the right-handers on measures of fluid intelligency ($p < .02$). Thus the door is still open for investigation of differential abilities between sinistrals and dextrals.

One plausible resolution for the inconsistent findings in the literature on handedness and ability has been suggested by Annett & Turner (1974). They hypothesized that researchers utilizing unselected subjects will probably <u>not</u> find differences between dextrals and sinistrals, but when problem groups are studied (e.g. mental retardates, dyslexics) left-handers will be overrepresented. This seems to be

reflected in the literature and leads to the idea that left-handedness may not be quite the same thing in different groups.

Satz (1972, 1973) has proposed a model of pathological left-handedness based on the postulate that early damage to one cerebral hemisphere can cause mild hypofunction of the controlateral hand and, if it is the preferred hand, lead to a switch in hand preference. Thus a genotypic dextral could become a phenotypic sinistral. Obviously the possibility for pathological right-handers exists, but since the frequency of "natural" left-handedness (either genetic or cultural) is less (8-10%) the absolute number of left-handers becoming right-handers would be very small compared to right-handers becoming pathological left-handers (Schonblom, 1977). In a most elegant elaboration of his model Satz showed that if one assumed an equal probability of lesion site and an 8% incidence of "natural" left-handedness, then the ratio of pathological left-handers to pathological right-handers is 11.5:1. Saltz also indicated that researchers in medical settings, where there is higher incidence of brain dysfunction, will also encounter a higher frequency of pathological left-handers. This could result in a spurious relationship being found between left-handedness and disability. The above fits well with the previously mentioned suggestions of Annett & Turner (1974).

Summary 1

The evidence for deficits, in a general sense, among the left-handed population is weak. Selected subgroups may show deficits associated with sinistrality most probably acquired. Left-handedness, in and of itself is not pathological, however when manifest in selected samples

(such as dyslexics, mentally retarded) sinistrality may be a reflection of cerebral dysfunction. A fruitful area of investigation is the pattern of cerebral lateralization shown by sinistrals as compared to dextrals. Rather than implying deficiency it seeks to elucidate the functional organization of perceptual and cognitive abilities within the brain.

4. Sinistrality and Lateralization of Function

Handedness or manual dominance begins to differentiate at the same time as language development occurs, at approximately 18 months (Gesell & Ames, 1947; Subirana, 1969). These two functions are felt to be interdependent to a certain extent (Annett, 1973). Studies of aphasia following unilateral head injury have shown that left-handers and right-handers have different patterns of recovery (Subirana, 1969; Hecaen & Sauget, 1971). While more left-handers become aphasic following left-hemisphere lesions, than right, when groups of dextrals and sinistrals are compared the frequency of aphasia is higher in the sinistrals, given similar injuries. Conversely the prospect of full recovery from aphasia is greater for the left-handed than the right-handed. The reason for this seems to lie in the idea that sinistrals have greater bicerebrality of function than dextrals. Considerable research has been conducted in this area (Hécaen & Ajuriaguerra, 1964; Branch et al., 1964; Subirana, 1969; Hecaen & Sauget, 1971; Levy, 1972, 1974, 1977(a); Annett, 1973; Beaumont, 1974; Riseberg et al., 1975; Donchin et al., 1977; Hicks & Kinsbourne, 1978; Davis & Wada, 1978). From this has emerged a pattern of differing lateralization of function between sinistrals and dextrals. A useful classification of handedness and lateralization of function has been suggested by Hardyck & Petrinovich (1977). The right-handed with no

history of left-handedness are the most strongly lateralized while the left-handed with a family history of left-handedness show bilateral lateralization of functions. Left-handers with no family history of left-handedness are regarded as having the same pattern of cerebral lateralization as right-handers with no family history of sinistrality. Presumably this group would consist largely of acquired or pathological left-handers.

That familial versus acquired left-handedness does affect the degree of lateralization of functions has been documented by Falek (1959), Gilbert (1977) and McKeever & Van Deventer (1977). In the latter two studies it was shown that familial left-handers showed increased bicerebrality of function. There is also evidence to suggest a sex bias in handedness with females showing less complete lateralization of linguistic function than males (Buffery, 1971; Taylor, 1969; Ray et al., 1976; Hannay & Malone, 1976). This indicates the presence of two important moderator variables in handedness, family history of handedness and sex. Thus an individual's pattern of cerebral lateralization will depend on whether one is male or female, one's degree of dextrality or sinistrality, whether or not the sinistrality is inherited or acquired and the incidence of sinistrality in that person's family.

5. Sinistrality and Psychoses

Recent reports in the literature have associated schizophrenia with dominant hemisphere dysfunction (Schweitzer et al., 1978; Taylor et al., 1979), leftward tendencies (Gur, 1977) and left-handedness (Blau, 1977; Wahl, 1976). While affective disorders have been linked to dysfunction of the non-dominant hemisphere (Yozawitz et al., 1979). The idea of the

functional psychoses as being manifestations of abnormal functioning of lateralized systems has been extensively investigated by Pierre Flor-Henry and Lorne T. Yeudall (Flor-Henry et al., 1979(a), 1979(b); Flor-Henry & Yeudall, 1979; Yeudall & Fromm-Auch, 1979).

Essentially these authors postulate that schizophrenia, psychopathy in males and hysteria in females reflects disorganization primarily of dominant fronto-temporal neural mechanisms, while depression and mania involve disturbances of non-dominant fronto-temporal areas. Their theorizing is based on evidence from extensive neuropsychological assessments and power-spectral analysis of the E.E.G. during lateralized cognitive tasks.

Flor-Henry & Yeudall (1979) examined the patterns of handedness of 114 consecutive admissions who satisfied strict diagnostic criteria for schizophrenia, mania, hypomania or depression (unipolar or bipolar). Handedness was assessed using the Marian Annett Handedness Questionaire (described fully in Chapter III) and a normal control group of 772 University of Alberta undergraduates was utilized for comparison purposes. They found an increased frequency of sinistrality in the bipolar affective psychoses (manic depressive and periodic schizoaffective). This was due to an increased frequency of inconsistent sinistrality in this group. Excess sinistrality was not present in the unipolar depressive or schizophrenic psychoses.

Two other studies have found unusual patterns of hand preference in psychiatric patients. Lishman & McMeekan (1976) administered the Annett Questionaire to 65 males and 65 females admitted to the Maudsley Hospital in London. Patients with any history of organic cerebral pathology were not admitted to the study. Psychiatric diagnoses were

based on classifications from the eighth revision of the International Statistical Classification of Diseases, Injuries, and Causes of Death (1965). A significant shift towards left-hand preference was noted, primarily among young, male psychotics. Specifically this was among the manic depressive and schizoaffective subgroups and not the schizophrenics. Also of note were their findings that among the psychotic group sinistrality appeared to be acquired rather than inherited and more prevalent among the males.

A second study by Fleminger et al. (1977(a)), comparing 800 psychiatric patients with 800 controls, did not find excess sinistrality associated with male gender or any significant differences in handedness pattern between the two groups. Three factors are relevant in explaining the discrepant results in the above studies. First, Fleminger and associates used a different method of handedness classification from Flor-Henry & Yeudall and Lishman & McMeekan, although all three used the Annett Handedness Questionaire. Second, Fleminger et al. did not separate out the affective group into schizo-affective, unipolar and bipolar psychoses as did the other two studies. Lastly, the Fleminger et al. study utilized a very general psychiatric population including both in-patients and out-patients while much more rigorous selection procedures were used by Lishman & McMeekan and Flor-Henry & Yeudall.

Overall, it appears that there are grounds for suspecting that differences exist in the cerebral organization of dextrals and sinistrals. Further, if laterality theory is correct and the functional psychoses can be viewed as perturbations of lateralized brain systems, then it is not unreasonable to suspect that an interaction between handedness (motor laterality) and mental illness exists. Before going on to discuss the

methodology to examine this proposition, some of the variables to be aware of in the assessment of handedness will be presented.

6. Variables in the Assessment of Handedness

Essential to the reasoning behind this thesis is the idea that handedness relates to brain function, and that, although a crude measure, assessment of handedness tells one something about the organization of the brain. A very recent study by Johnston, Galin & Herron (1979) compared different measures of handedness with E.E.G. alpha asymmetry and dichotic measures of lateral specialization. They found that the Annett Hand Preference Quesionaire predicted three times more unique variance than performance measures of speed, strength and dexterity. The authors also report that handedness should be treated as a continuous variable rather than as a dichotomous or trichotomous variable (right, mixed, left). This implies that the finer the degree of handedness classification the better the analysis (Peters & Durding, 1978). As discussed earlier both sex and hereditary factors are relevant to the analysis and assessment of handedness (Satz, 1972, 1973; Buffery, 1971). Assessment in terms and preference versus performance will be discussed more fully in Chapter III.

Assuming that handedness is being analyzed as a continuous variable, the number of groups and criteria used to categorize handedness types is important. Hicks & Kinsbourne (1978) summarize the problems inherent in developing performance methodologies to assess handedness. These include: task complexity, task novelty, fatigue, practice effects, precision and type of motor response required and the fact that counter-balancing the order of task presentation across hand assumes a symmetrical transfer of practice effects. For a further discussion of the effects of differing

criteria chosen as indexes of handedness and laterality see Birkett (1977) and Colburn (1978).

Summary 2

This chapter has overviewed a selection of the considerable literature on handedness. Different theories of handedness were presented and it was concluded that handedness cannot be accounted for by any single model. About 8-10% of the population is sinistral, but left-handedness is not a uni-factoral construct. Family history of sinistrality, sex or perinatal insult can modify the expression of handedness in an individual.

The search for cognitive deficits in left-handers has been fraught with methodological difficulties, not the least of which has been the assessment of handedness itself. In the general population no differences exist between sinistrals and dextrals, but within pathological subgroups left-handers tend to be overrepresented.

Fundamental differences in cerebral organization between dextrals and sinistrals are suggested by studies on aphasia and cerebral dominance as assessed by intra-carotid sodium amytal. Left-handers are regarded as showing less lateralization or more bicerebrality of brain function.

In terms of sinistrality and mental illness, results are suggestive of a relationship between the motor system controlling hand preference and those involved in the expression of disorders of mood or thought. A higher incidence of sinistrality in the functional psychoses might be a reflection of disturbance of lateralized brain mechanisms. The purposes of this study are therefore to investigate the prevalence of sinistrality within a general hospital setting and determine whether an association exists between handedness and psychiatric diagnosis.

In order to assess handedness, this study utilized the Marian Annett Handedness Questionaire. There is still active discussion as to whether performance or preference data are more valid and reliable measures of handedness. Evidence is presented in Chapter III to support the use of the Annett Questionaire.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

The Sample

The data for analysis in this study were generated from handedness questionaires administered to 432 admissions to the Edmonton General Hospital Department of Psychiatry, between January first and December thirty-first, 1979. The questionaire utilized was the Marian Annett Handedness Questionaire (Annett, 1970, see Appendix I) and it was administered, by nursing staff, as part of the routine admission procedures.

The author provided instruction to the nursing staff on the administration of the questionaire but was personally responsible for scoring all protocols. Patients too disturbed to complete the questionaire on admission were given the handedness inventory at a later date during their stay in hospital. Questionaires filled out by the patients themselves were not acceptable for this study. Patients who were readmitted within the time frame of the study completed the questionaire a second time and these data were examined for reliability over time.

Procedure

Handedness questionaires were scored according to the criteria of Annett (1970) and Flor-Henry & Yeudall (1977), (see Appendix II for a detailed description of the scoring method). From the total number of protocols (n = 432) all sinistrals were extracted (n = 40) and were matched to a group of dextrals on the basis of age, sex, and category of handedness (see Appendix III for the computer matching program used). All but three sinistrals were successfully matched. The hospital records for

this sample (n = 77) were requisitioned by the investigator, after approval was given by the Chairman of the Department of Psychiatry, and the Research Diagnostic Criteria of Spitzer, Endicott & Robins (1978) was applied to them. A summary of the diagnostic classifications of all admissions to the Department of Psychiatry at the Edmonton General Hospital in 1979 was utilized for comparison with the sample of sinistrals and matched dextrals.

Instruments

Following is a discussion of the test instruments used in this study. Attention will be paid to their development, reliability, validity and a rationale given for their inclusion.

Measurement of Manual Superiority/The Marian Annett Handedness Questionaire

Assessment of handedness is generally defined in one of two ways, by means of preference or performance. Other approaches used in the past have included self-classification or classification based on the hand used for writing (Levy, 1969; Bakan, 1973). Neither have proved satisfactory in view of the heterogeniety of the samples generated (Hécaen & Ajuriaguerra, 1964). In order to more completely understand the phenomenon of handedness a continuum of preference or performance is conceptually more useful than a dichotomous classification scheme (Annett, 1970).

Manual superiority of hand performance is assessed by having the subject carry out standardized tasks with either hand and recording the time taken and errors made. These may be novel or overlearned tasks and

vary in their degree of complexity. From this an index of handedness may be calculated by comparing the performance of the two hands (Provins & Cunliffe, 1972(a)). While accepted as a valid measure of handedness, performance testing is time consuming and confounded by practice effects, the subject's familiarity with the task, as well as the subject's age, sex and possibly cultural background (Oldfield, 1971).

Assessment of handedness by preference measures has been shown to be a reliable and straightforward method as will be documented below. Several different handedness questionaires are available (Oldfield, 1971; Humphrey, 1951; Raczkowski, Kalat & Nebes, 1974; Annett, 1970; Briggs & Nebes, 1975; Crovitz & Zener, 1962; Harris, 1958; Provine & Cunliffe, 1972(a), 1972(b). These inventories concern themselves with establishing which hand the subject most commonly employs to perform a series of unimanual activities. Tasks most frequently included are hand preferred for: writing, throwing, hammering, drawing, using a toothbrush, striking a match, holding a tennis racquet, cutting with scissors, dealing cards, pouring a pitcher, and opening a box or lid. While not exhaustive, the above demonstrates the variety of tasks commonly found in handedness questionaires and also that the tasks are usually over-learned activities.

In terms of the reliability and validity of this approach to the measurement of manual superiority several studies are relevant. Factor analytic studies carried out by White & Ashton (1976) on Oldfield's Edinburgh Handedness Inventory and by Bryden (1977) on both the Crovitz-Zener and Oldfield inventories showed a simple factor structure with a primary handedness factor emerging in both cases. White & Ashton (1976) based their data on a sample of 406 Introductory Psychology students

while Bryden (1977) used an even larger sample of 620 men and 487 women, also Introductory Psychology students. He found a mean inter-test correlation on overlapping items (i.e. items common to both the Oldfield and Crovitz-Zener inventories) of 0.85. Of note is that Factor 1, the primary handedness factor, contains four out of six of the same items as Annett (1970) identified by Association Analysis as comprising her primary handedness factor (writing, throwing a ball, holding a tennis racquet, using a toothbrush).

Specific testing of the reliability and validity of the items contained in handedness questionaires have been carried out by Taczkowski et al. (1974) and Provins & Cunliffe (1972(a)). Raczkowski and his colleagues had college students (n = 47) complete a handedness questionaire (modified from Hull, 1936 and Oldfield, 1971), perform the tasks listed in the questionaire and complete the questionaire a second time. Examination of their figures comparing percentage agreement between questionaire items and performance of those items, as well as test-retest on the same questionaire shows high reliability and validity for items found on the Marian Annett questionaire. The range of agreement is from a low of 89% to a high of 100% overall, and on five of Annett's six primary factors from 93% to 100%; the exception being striking a match which showed 89% agreement. From this it is concluded that independent verification has shown that Annett's primary factors are valid (writing, throwing a ball, holding a tennis racquet, using a toothbrush, using scissors, striking a match). Items on the Annett questionaire are items possessing high validity and reliability (Raczkowski et al., 1974) and are associated with a pure handedness factor (White & Ashton, 1976; Bryden, 1977).

A somewhat different approach to the assessment of validity and reliability of handedness questionaires has been used by Provins & Cunliffe (1972(a)). These authors tested 20 male subjects (10 dextral, 10 sinistral as assessed by a handedness questionaire containing all 6 of Annett's primary factors) on a complex battery of motor tasks. Comparison of the questionaire evaluation of handedness with the assessment based on performance tests utilizing a Spearman rank correlation gave a ρ value of 0.70 ($p < .01$) which the authors interpret as "a reasonably good agreement" between the subjective and objective measures of handedness.

The investigations of Benton et al. (1962), Provins (1967), and Satz et al. (1967) have shown that self-classification of handedness and quantitative assessment of handedness do not always agree, especially among left-handers. Thus it is important that the items comprising a hand preference questionaire are also reflective of hand performance abilities.

As part of the standardization of her questionaire, Annett (1970, 1976) examined the relationship between hand performance and hand preference. Before further analysis of this topic a discussion of the overall development of the Annett inventory is relevant.

Annett's (1970) standardization sample consisted of psychology students at the University of Hull (n = 460), non-psychology undergraduates at the University of Hull (n = 1,232) and the new recruits entering the armed forces (n = 630). Computer analysis of the handedness questionaires was performed to determine the following information.

1. The frequency of the relevant responses to each question.
2. The contingencies of responses in all possible pairs.
3. The matrix of correlation coefficients (Φ) between pairs of responses.
4. The number of individuals in each subdivision of the analysis.
5. The maximum χ^2 between any pair of questions, identifying the pair.
6. The question or attribute on which the sample was to be divided.

(Annett, 1970)

From this Annett elicited her primary and secondary handedness factors. Primary factors include: hand used for writing, throwing a ball, using a racquet, striking a match, using a hammer, and using a toothbrush. Secondary factors are: hand used for cutting with scissors, threading a needle, sweeping with a long-handled broom, shovelling with a long-handled shovel, and dealing playing cards. The analysis also demon[illegible] handedness is best conceptualized as a continuum, stretc[illegible] consisted dextrality through to consistent sinistrality, rather [illegible] a dichotomous variable, left or right. In her analysis Annett i[illegible]ified 23 types of handedness, but for most purposes, the author's i[illegible]uded, a simpler six-fold classification is sufficient. As mentioned [illegible]rlier a detailed scoring system is outlined in Appendix II. In the pr[illegible]ent study handedness is classified according to one of six categories: consistent dextral (C.D.), inconsistent dextral (I.D.), mixed dextral (M.D.), mixed sinistral (M.S.), inconsistent sinistral (I.S.), or consistent sinistral (C.S.).

In order to determine the relationship between manual preference and manual skill (performance) Annett (1970) studied 118 undergraduates in Honors Psychology at the University of Hull as well as 165 twelve year

old children. These subjects completed the Annett Inventory and also were tested on a manual speed task. The measurement used was the mean difference between time taken to complete the task using the left and right hands. She found that subjects sorted for handedness were classified the same way in terms of manual speed. Essentially, strong dextrals showed greater right hand speed while strong sinistrals performed more rapidly with their left hand. This co-ordination of hand performance with hand preference is a cogent assertion of the validity of Annett's questionaire. Six years later (Annett, 1976), Annett replicated this finding on a sample of 804 subjects at the Lanchester Polytechnic in Coventry. Once again the continuum of hand preference co-ordinated with the continuum of manual skill. In fact, the two distributions, generated six years apart, were identical in seven out of eight categories.

The above discussion has been intended to demonstrate that hand preference questionaires may be regarded as valid and reliable measures of manual superiority. The Marian Annett Handedness Questionaire has been selected on the basis of its sound empirical base, clearly defined factorial structure and demonstrated relationship to hand performance measures.

Research Diagnostic Criteria (RDC)

In order to minimize the problem of criterion variance in psychiatric diagnosis the Research Diagnostic Criteria sets out explicit operational definitions for 25 categories of functional disorders (Spitzer et al., 1978(b)). Developed from the pioneering diagnostic work of John P. Feighner and his associates (Feighner et al., 1972), the RDC form a coherent

diagnostic framework that may be used with patients or retrospectively, with chart data (Spitzer et al., 1975). Relevant dimensions in the RDC include clear clinical description, consistency over time, familial incidence, level of severity, prediction of outcome/response to treatment, duration and frequency of episodes.

In order to determine the reliability of RDC, three separate reliability studies were carried out by Spitzer and his co-workers (Spitzer et al., 1978(b)). The first study (A) involved the assessment of 68 newly admitted patients to the New York State Psychiatric Institute. The second study (B) was carried out by pairs of raters at four separate hospitals as part of a pilot study on the Psychobiology of Depressive Disorders and consisted of 150 newly admitted psychiatric patients. The third study (C) involved a test-retest procedure where two independent raters evaluated the same patients at different times. The same facilities were used as in (B), with 60 new admissions. In studies (A) and (B) two raters were present, one conducted the interview and one observed but both rated the patient independently. The κ statistics of these three studies are reproduced in Table 1.

The κ statistic is the proportion of agreement corrected for chance agreement as a function of the base rate of a particular psychiatric diagnosis (Spitzer et al., 1967). As can be seen from Table 1, the reliability of the RDC is generally high.

In terms of its applicability to chart data Spitzer et al. (1975) applied RDC to 120 psychiatric records and found diagnosis based on RDC of higher reliability than that based on DSM II (the Diagnostic and Statistical Manual of Mental Disorders, 2nd edition) or independent psychiatric assessment.

Table 1.

Kappa Coefficients of Agreement for Major Diagnostic Categories using the Research Diagnostic Criteria

	Study A (N=68)	Study B (N=150)	Test-Retest (N=60)
Present Episode Only:			
Schizophrenia	.80	N/A	.65
Schizo-affective disorder manic type	N/A	N/A	.79
Manic disorder	.82	.98	.82
Schizo-affective disorder depressed type	.86	.85	.73
Major depressive disorder	.88	.90	.90
Minor depressive disorder	N/A	.81	N/A
Alcoholism	.86	.97	1.00
Drug Abuse	.76	.95	.92
Lifetime Diagnosis:			
Schizophrenia	.75	.91	.73
Schizo-affective disorder depressed type	.94	.87	.70
Manic disorder	.89	.93	.77
Hypomanic disorder	.85	N/A	.56
Major depressive disorder	.97	.91	.71
Minor depressive disorder	N/A	.68	N/A
Alcoholism	.88	.98	.95
Drug Abuse	.89	1.00	.73
Obsessive-compulsive disorder	N/A	1.00	N/A
Briquet's disorder	.79	.95	N/A
Labile personality	N/A	N/A	.70
Bipolar I	.93	.95	.40
Bipolar II	.79	.85	N/A
Recurrent unipolar	.81	.83	.80
Intermittent depressive disorder	N/A	.85	.57

(Spitzer et al, 1978)

While the RDC is not the only nosological framework available it has the advantage of having been empirically tested for reliability and validity. Further, the explicitly stated operational definitions it contains provide a uniform criteria to impose order on the heterogeneous data found in psychiatric case records.

Analysis of Data

Statistical analysis of the data generated by this study is by the Chi Square statistic. This is because the data consists of frequency counts (Robson, 1975). The Contingency Coefficient is calculated for all significant ($p < .05$) Chi Squares to indicate the degree of relationship in the Chi Square statistic (Ferguson, 1976). The two major hypotheses are outlined below followed by the minor hypotheses tested in the study.

Hypothesis 1

It is hypothesized that the incidence, or frequency distribution of handedness of patients in the Edmonton General Hospital psychiatric wards is not the same as for the general (i.e. non-hospitalized) population.

To test this hypothesis two analyses will be carried out. Comparison of "goodness of fit" between Annett's (1970) standardization sample (the reference population) and the handedness of psychiatric patients at the Edmonton General Hospital between January 1 and December 31, 1979 ($n = 432$). This will determine whether the psychiatric sample is a "representative sample" of the general population. The same analysis will also be carried out by comparing the handedness classification of 772 University of Alberta undergraduates (Flor-Henry & Yeudall, 1977) with the Edmonton General Hospital psychiatric sample.

Hypothesis 2

It is hypothesized that the differential frequency of diagnostic classification is not the same for the dextrals as for the sinistrals within the Edmonton General Hospital psychiatric population.

To test this hypothesis, firstly a comparison of the frequency of specific diagnostic classifications of the total General Hospital psychiatric population (n = 569) versus the selected sample of matched sinistrals and dextrals (n = 77) will be made. This will be followed by specific comparisons of total population versus sinistrals and total populations versus matched dextrals. This will allow determination of whether the total sample shows the same pattern of diagnostic frequency as the reference population (i.e. admissions to the Department of Psychiatry in 1979). Further if differences are present it will show if they are due to the dextral, or as predicted, sinistral sub-group.

Hypothesis 2.1

It is hypothesized that within the Edmonton General Hospital population of psychiatric admissions an excess of sinistrality will be associated with the male gender.

In this case Chi Square is being used as a "test of independence" and a statistically significant value for Chi Square would imply that a relationship exists between sex and handedness.

Hypothesis 2.2

It is hypothesized that the sex ratio in the Edmonton General Hospital psychiatric population will differ from that of the sample of sinistrals and matched dextrals selected for analysis.

A Chi Square on a 2 x 2 contingency table is sufficient in this case to show whether the sample of sinistrals and matched dextrals have the same sex ratio as the total psychiatric population. Further, the same analysis is performed on the sinistral subgroup, but not on the dextral subgroup as they have been matched by sex, to the sinistrals.

Hypothesis 2.3

It is hypothesized that there is an association between age and handedness, that is to say that these variables are not independent.

As in Hypothesis 2.1, a Chi Square "test of independence" will be used. Should Chi Square prove to be significant a relationship between age and handedness would be inferred.

Hypothesis 2.4

It is hypothesized that the frequency of familial sinistrality will be significantly different in the sinistral group from that in the rest of the psychiatric population.

Analysis with a 2 x 2 contingency table will show if a significant relationship exists between left-handedness and a familial history of left-handedness.

For the purposes of this study only those individuals with sinistral parents or grandparents were considered as having a positive family history for left-handedness. Should the relationship prove negative the question of an increase in "acquired" sinistrality within psychiatric groups is raised.

Summary Statistics

These include the mean age and standard deviation for the sample, by sex and a summary of the handedness patterns of the readmitted patients (n = 49).

CHAPTER IV

RESULTS

Descriptive Statistics

Of a total of 646 admissions (males 217, females 429) to the Department of Psychiatry (between January 1 and December 31, 1979) 432 patients completed the Marian Annett Handedness Questionaire (males 154, females 278). A sixfold handedness classification yielded the following percentage breakdown: Consistent Dextral (60.1%), Inconsistent Dextral (25.5%), Mixed Dextral (5.1%), Mixed Sinistral (3.7%), Inconsistent Sinistral (2.1%), Consistent Sinistral (3.5%), For a comparison of the percentage distribution of handedness by sex in the psychiatric population see Table 2. Tables 3 and 4 respectively give the diagnostic frequency of five major categories in both the total psychiatric population (n = 646) and in the samples of sinistrals and matched dextrals. In order to compare the relative frequency of handedness classification between the psychiatric population and two non-hospital populations (see Table 5). The mean age and standard deviations of the sample of sinistrals and matched dextrals are given in Table 6.

Concerning readmission to the Edmonton General Hospital during the one-year time frame of the study, results are as follows:

1. Total Readmissions: n = 49, 11% of sample.
2. Number of patients with handedness shifts: 8/49.
3. Number of patients with constant handedness: 41/49.
4. Summary of changes:
   (a) Inconsistent to Consistent Dextral: 5
   (b) Consistent to Inconsistent Dextral: 2
   (c) Consistent to Mixed Dextral : 1

Table 2.

Percentage Distribution of Handedness in Psychiatric Population by Sex (N=432)

	Consistent Dextral	Inconsistent Dextral	Mixed Dextral	Mixed Sinistral	Inconsistent Sinistral	Consistent Sinistral
Males (N=154)	53.9	27.9	6.5	3.9	2.6	5.2
Females (N=278)	63.7	24.1	4.7	3.2	1.8	2.5

Table 3.

Comparison of Diagnostic Frequency of Total Psychiatric Population with Sample of Sinistrals and Matched Dextrals

Diagnostic Frequency	Population Frequency (N=646)	Sample Frequency (N=77)
Affective Disorder	365 (56.5%)	43 (56%)
Schizophrenia	39 (6.1%)	8 (10.4%)
Personality/Neurosis	176 (27.2%)	16 (20.8%)
Organic Brain Syndrome	25 (3.9%)	8 (10.4%)
Other Psychiatric Disorder	41 (6.3%)	2 (2.6%)

Table 4.

Comparison of Diagnostic Frequency of Sinistral Sample with Matched Dextrals

Diagnostic Category	Dextrals (N=37)*	Sinistrals (N=40)
Affective Disorder	20 (26.2%)	23 (30%)
Schizophrenia	4 (5.2%)	4 (5.2%)
Personality/Neurosis	9 (11.7%)	7 (9.1%)
Organic Brain Syndrome	2 (2.6%)	6 (7.8%)
Other Psychiatric Disorder	2 (2.6%)	0 (0%)

*From the dextral sample three males who were mixed dextrals and over 70 years of age could not be found to complete the matching, hence the smaller number of dextrals.

Table 5.

Comparison of Percentage Distribution of Handedness in two General Populations: (Annett 1970), (Flor-Henry and Yeudall 1977) with a General Hospital Psychiatric Population

Study	C.D.	I.D.	M.D.	M.S.	I.S.	C.S.*
Annett (N=3,128)	65.5	21.1	4.0	2.7	4.0	2.5
Flor-Henry and Yeudall (N=772)	61.5	26.8	2.9	3.1	4.1	1.4
Current Study	60.1	25.5	5.1	3.7	2.1	3.5

*C.D. is Consistent Dextral, I.D. is Inconsistent Dextral, M.D. is Mixed Dextral, M.S. is Mixed Sinistral, I.S. is Inconsistent Sinistral, C.S. is Consistent Sinistral.

Table 6.

Summary of Means and Standard Deviations of Selected Sample of Sinistrals and Matched Dextrals (N=77) for Age in Years by Sex

	Sinistrals (N=40)	Dextrals (N=37)
Total Sample	33.3 (16.1)	29.6 (11.1)
Males	37.7 (19.9)	29.6 (11.8)
Females	29.2 (10.4)	29.6 (10.7)

Table 7.

Chi Square Comparison of Classification of Handedness According to Annett (1970) and the E.G.H. Psychiatric Population (1979)

	C.D.	I.D.	M.D.	M.S.	I.S.	C.S.	Total
Annett 1970 (N=3,128)	2,050	661	126	86	79	126	3,128
E.G.H. 1979 (N=432)	260	110	22	16	9	15	432
Total	2,310	771	148	102	88	141	3,560

$\chi^2 = 7.76$, d.f. = 5, not significant

From the above it can be seen that only 8/49 readmissions showed any change in handedness and that in 7/8 cases this involved a switch on only one secondary factor. Only one patient changed on a primary factor. All shifts occurred in the dextral group, none in the sinistral. Indirectly this supports arguments in favor of the reliability of the Marian Annett Handedness Questionaire.

Results of Hypotheses

Hypothesis 1

It is hypothesized that the incidence, or frequency distribution, of handedness of patients in the Edmonton General Hospital psychiatric wards is not the same as for the general (i.e. non-hospitalized) population.

Comparison of the distribution of handedness between the hospital population and Annett's (1970) population yields a Chi Square of 7.76 (d.f. = 5) which is not significant (see Table 7). A similar analysis between the psychiatric population and Flor-Henry & Yeudall's (1977) university group yields a Chi Square of 5.02 (d.f. = 5) which is not significant (see Table 8). From the above it is concluded that Hypothesis 1 is not accepted, the psychiatric population shows the same incidence of handedness as does the general population.

Hypothesis 2

It is hypothesized that the differential frequency of diagnostic classification is not the same for the sinistrals as for the dextrals within the Edmonton General Hospital psychiatric population.

Table 8.

Chi Square Comparison of Classification of Handedness According to Flor-Henry and Yeudall (1977) and E.G.H. Psychiatric Population (1979)

	C.D.	I.D.	M.D.	M.S.	I.S.	C.S.	Total
Flor-Henry and Yeudall (N=772)	475	207	23	24	11	32	772
E.G.H. 1979 (N=432)	260	110	22	16	9	15	432
Total	735	317	45	40	20	47	1,204

$\chi^2 = 5.02$, d.f. = 5 not significant

Table 9.

Chi Square Comparison of Total Sample Diagnostic Pattern Versus Total Hospital Population Diagnostic Pattern

	Aff.	Sx.	P.P.N.	O.B.S.*	Other	Total
Sample No.	43	8	16	8	2	77
Population No.	322	31	160	17	39	569
Total	365	39	176	25	41	646

$\chi^2 = 15.62$, d.f. = 4, $p < .01$
Contingency coefficient C = .153

*Aff. is Affective, Sx. is Schizophrenia, P.P.N. is Personality/ Psychoneurosis, O.B.S. is Organic Brain Syndrome

Three comparisons are relevant here: total psychiatric population versus total sample, total psychiatric population versus sinistral sample, and total psychiatric population versus dextral sample. These results are presented in Tables 9, 10 and 11, respectively. Chi Square values are for the first comparison 15.62, d.f. = 4, $p < .01$ with a Contingency Coefficient of 0.153. For the second comparison Chi Square is 19.65, d.f. = 4, $p < .001$ with a Contingency Coefficient of 0.17. The third comparison yields a Chi Square of 2.04, d.f. = 4, which is not statistically significant.

This data indicates that the frequency distribution of psychiatric diagnosis in the total sample and in the sinistral sample, differs from that of the total population. For the dextral sample it is similar to the total population. While the differences are statistically significant at the (.01) and (.001) levels respectively, the Contingency Coefficients which measure the degree of association within contingency tables are very low (1.153) and (.17). The significant findings in Tables 9 and 10 reflect a higher than expected incidence of Organic Brain Syndromes in the sinistral sample. Their removal reduces Chi Square to non-significance. However, the fact that such a high number of Organic Brain Syndromes were found is an interesting and useful finding in and of itself. Given the above stipulation it is considered that Hypothesis 2 is not supported.

Hypothesis 2.1

It is hypothesized that within the Edmonton General Hospital population of psychiatric admissions an excess of sinistrality will be associated with the male gender.

Table 10.

Chi Square Comparison of Sinistral Sample Diagnostic Pattern Versus Total Hospital Diagnostic Pattern

	Aff.	Sx.	P.P.N.	O.B.S.*	Other	Total
Sample No.	23	4	7	6	0	40
Population No.	342	35	169	19	41	606
Total	365	39	176	25	41	646

$\chi^2 = 19.65$, d.f. = 4, $p < .001$

Contingency coefficient C = .17

Table 11.

Chi Square Comparison of Dextral Sample Diagnostic Pattern Versus Total Hospital Diagnostic Pattern

	Aff.	Sx.	P.P.N.	O.B.S.*	Other	Total
Sample No.	20	4	9	2	2	37
Population No.	345	35	167	23	39	609
Total	365	39	176	25	41	646

$\chi^2 = 2.04$, d.f. = 4, not significant

*Aff. is Affective, Sx. is Schizophrenia, P.P.N. is Personality Psychoneurosis, O.B.S. is Organic Brain Syndrome

A Chi Square value of 5.25, d.f. = 5 (N.S.) indicated that no relationship between sex and handedness is present (see Table 12). Hypothesis 2.1 is therefore regarded as not supported.

Hypothesis 2.2

It is hypothesized that the sex ratio in the Edmonton General Hospital psychiatric population will differ from that of the sample selected for analysis.

Both comparisons, total population versus total sample and total population versus sinistral sample, give significant results, Chi Square of 5.33, d.f. = 1, $p < .05$, with a Contingency Coefficient of (.09) and Chi Square 4.37, d.f. = 1, $p < .05$, with a Contingency Coefficient of (.08) (see Tables 13 and 14). However, the first comparison is biased because it contains both sinistrals and dextrals matched for sex. The second comparison is more interesting in that it selects on sinistrality alone. Inspection of the raw figures of Table 15 shows that for the total psychiatric population the ratio of females to males is roughly 2:1 while in the sinistral sample it approaches 1:1. This suggests an excess of males in the left-handed psychiatric population, although it is recognized that the sinistrals are only 10% of the total psychiatric sample tested for handedness. Hypothesis 2.2 is therefore regarded as supported.

Hypothesis 2.3

It is hypothesized that there is an association between age and handedness, that is to say that these variables are not independent.

Results are presented in Table 15 which shows a Chi Square value

Table 12.

Chi Square Comparison of Sex
Versus Category of Handedness

	C.D.	I.D.	M.D.	M.S.	I.S.	C.S.	Total
Males	83	43	9	7	4	8	154
Females	177	67	13	9	5	7	278
Total	260	110	22	16	9	15	432

$\chi^2 = 5.25$, d.f. = 5, not significant

Table 13.

Chi Square Comparison of the Sex Ratio of
the Total Psychiatric Population Versus the
Sample of Sinistrals and Matched Dextrals

	Female	Male	Total
Total Population	387	182	569
Sample	42	35	77
	429	217	646

$\chi^2 = 5.33$, d.f. = 1, $p < .05$

Contingency coefficient C = .09

Table 14.

Chi Square Comparison of the Sex Ratio of the Total Psychiatric Population Versus the Sample of Sinistrals

	Female	Male	Total
Total Population	408	198	606
Sample	21	19	40
	429	217	646

$\chi^2 = 4.37$, d.f. = 1, $p < .05$

Contingency coefficient C = .08

Table 15.

Chi Square Comparison of Age Versus Handedness Classification in the Total Psychiatric Population

Handedness Code	Age Ranges in 10 year Bands							
	<20	20-29	30-39	40-49	50-59	60-69	70+	Total
Consistent Dextral	20	63	52	43	44	28	10	260
Inconsistent Dextral	8	25	24	17	22	11	3	110
Mixed Dextral	2	9	5	2	3	1	0	22
Mixed Sinistral	1	3	3	4	2	0	3	16
Inconsistent Sinistral	3	6	0	0	0	0	0	9
Consistent Sinistral	2	5	7	0	0	1	0	15
Total	36	111	91	66	71	41	16	432

$\chi^2 = 48.2$, d.f. = 30, $p < .02$

Contingency coefficient C = .32

of 48.2, d.f. = 30, $p < .02$, with a Contingency Coefficient of (.32). This indicates that age and handedness are not independent. The relationship rests mainly on the difference between the Observed and Theoretical frequencies of three mixed sinistral males aged over seventy. Their removal reduces Chi Square to a non-significant level. Because of this, Hypothesis 2.3 is considered not supported.

Hypothesis 2.4

It is hypothesized that the frequency of familial sinistrality will be significantly different in the sinistral group from that in the rest of the psychiatric population.

A Chi Square value of 2.75, d.f. = 1, is not significant (see Table 16). This indicates independence between left-handedness and a positive family history of sinistrality. By implication one may wonder about the role of "acquired" left-handedness in psychopathological populations. In this study however, the incidence of left-handedness closely approximated that of the general population (see Tables 7 and 8). Hypothesis 2.4 is therefore considered not supported.

Summary of Results

Results of the analyses presented in this chapter confirmed only one out of six hypotheses. The sinistral group were found to have the same frequency distribution of handedness as the general population and also the same pattern of diagnostic classification. Within the psychiatric population assessed for handedness no relationship between sex and handedness was found, nor was an association between age and handedness discovered for the total psychiatric population. The final negative

Table 16.

Chi Square Comparison of Frequency of Family History of Sinistrality in Sinistral Group Versus the Total Psychiatric Population

	Family Positive for Sinistrality	Family Negative for Sinistrality	
Population	38	354	392
Sample	7	33	40
	45	387	432

$\chi^2 = 2.75$, d.f. = 1, not significant

finding was of an absence of relationship between sinistrality and a higher incidence of familial left-handedness, when comparing the sinistral sample with the total psychiatric population.

Confirmed was Hypothesis 2.2, that the sex ratio within the sinistral sample would not be the same as the sex ratio for the total psychiatric population.

CHAPTER V

DISCUSSION

Discussion of Research Findings

Although only one of the six hypotheses presented in Chapters III and IV was accepted, the study is not regarded as a failure. Hypothesis 1 found that the pattern of handedness distribution was the same as a sample of university students (Flor-Henry & Yeudall, 1977) and the same as Annett's (1970) standardization sample. From this one may conclude that handedness patterns within a general hospital psychiatric population and the public-at-large are similar. From Hypothesis 2 it is evident that within a large, unselected general hospital psychiatric population sinistrals and dextrals do not differ diagnostically. In this setting whether one is left- or right-handed should not influence one's diagnosis. Similarly, as is shown in Hypothesis 2.1, one's sex should not predispose one to left-handedness or to a specific psychiatric diagnosis, at least in a general hospital.

A pattern of increasing dextrality with age was not found, as has been suggested by Hécaen and Ajuriaguerra (1964) and Fleminger et al. (1977(b)). Recomputing the data in Table 15 after collapsing the six categories of handedness into three categories (right, mixed, left) gives a Chi Square value of 27.87, d.f. = 12, $p < .01$ with a Contingency Coefficient of (.24). While this suggests that handedness and age are not independent the low Contingency Coefficient indicates that the strength of association between the two variables is very weak. This may reflect the more rigorous classification of handedness used in the present study. Fleminger et al. (1977(b)) classified left-handedness based on hand used for writing.

No more familial sinistrals were found in the sample selected for left-handedness than were present in the total psychiatric population. Of 40 left-handers only 7 showed a family history of left-handedness. This opens the possibility that "acquired" left-handedness may be a factor in pathological populations. The work of Satz (1972, 1973) supports this idea, in a restricted population.

At the level of generalization, the negative findings of this study imply that for an unselected psychiatric sample abnormal patterns of handedness do not exist. As Annett & Turner (1974) suggested, in order to detect unusual patterns of handedness an "extreme group" methodology is necessary. This is essentially the methodology Flor-Henry & Yeudall (1977) employed. In their study, they selected, using strict diagnostic criteria 60 Affective disorders (maics, hypomanics, bipolar and unipolar depressives) and 54 Schizophrenics. Then they assessed for handedness and compared the patterns to a reference group of normals (772 undergraduate students at the University of Alberta). By contrast, the present study selected on the basis of handedness, then diagnosed and compared the diagnostic patterns of the sinistrals and matched dextrals. The effect of this was that diagnosis was an unspecified variable and so the sample of sinistrals and matched dextrals was diagnostically heterogeneous, that is to say a random sample of the diagnostic pattern of the total psychiatric population. The effect of this may well have been to "wash-out" any handedness-by-diagnosis effects contained within the data.

A second major confounding variable is the problem of base-rates, that is the actual incidence of a particular phenomenon in a population.

With handedness, a ratio of 9:1 in favor of dextrals to sinistrals is accepted. In the present study the use of a matching paradigm made it 1:1. A more powerful methodology would have been not to match the sinistrals with an equal number of dextrals but to have maintained the same handedness ratio as is in the normal population.

The hypothesis that found support indicated that the sex ratio was not the same within the sinistral sample as within the total psychiatric population. As can be seen from Table 14, the ratio in the population is roughly 2:1 females to males, while in the sample it approximates one to one. Chi Square is significant but the low Contingency Coefficient indicates that the strength of association in the contingency table is very weak (Duggan & Dean, 1968). However, within the sinistral sample selected for handedness and not for sex, there are more males than one would expect from inspection of the total population. Within the total psychiatric population maleness does not appear to be associated with sinistrality but within the sinistral sample the incidence of maleness is higher than the population ratio would predict.

Integration of Research Findings

In order to carry out the study reported in this thesis more effectively several modifications could be made. The painfully acquired wisdom of hindsight indicated that rather than selecting for handedness, selection based on diagnosis would be preferable. This would allow a much more specific study of handedness patterns because of the use of homogeneous sub-populations. The "wash-out" effect resulting from diagnostic heterogeneity would be avoided. The affective category could be

subdefined using RDC as could the schizophrenias. The personality and pschoneurotic subgroups both being non-psychotic disorders probably would not show handedness effects as these would be limited to the acutely disturbed (Lishman & McMeekan, 1976; Fleminger et al., 1977(a)).

A separate study on the patterns of handedness of Organic Brain Syndromes would be valuable, especially if it could be shown that the incidence of pathological left-handedness as compared to familial sinistrality (Satz, 1972, 1973) was higher in this group. The RDC does not include Organic Brain Syndromes but classifications based on etiology (i.e. alcohol, slow virus, head injury) or neurodiagnostic procedures (i.e. CAT scan, cerebral blood flow, E.E.G.) could be made. One would not expect that the various sub-populations of Organic Brain Syndromes would have the same patterns of handedness. Most likely individuals with exogenously caused brain syndromes (i.e. head injury) would show the same pattern of handedness as the normal population.

The criteria used to assess sinistrality are crucial to the results of studies on handedness and pathology (Annett, 1976). There is reason to question the comparability of different performance indices of laterality (Colburnm 1978; Hicks & Kinsbourne, 1978). Handedness questionaires seem to have a basis in lateralized specialization of cognitive mode, as assessed by E.E.G. (Johnstone et al., 1979). But E.E.G. waveforms, while accepted as reflective of differential hemispheric activation are still an indirect measure of cortical processes (Donchin et al., 1977).

As if the above variables are not enough to contend with, sex also appears to be a variable in handedness research. Males and females

perform differently on lateralized cognitive tasks (Buffery, 1971; Ray et al., 1976; Hannay & Malone, 1976). Males appear to show a higher degree of lateralization of function than females.

To summarize, when one is conducting handedness research with psychiatric patients the following variables are relevant. Method of handedness assessment (performance tasks or hand preference questionaire), diagnostic category (preferably assessed by a standardized diagnostic instrument), whether sinistrality is familial or acquired and the base-rate of sinistrality in the general population. Research in this areas is complex in view of the many variables affecting the non-unitary construct we call handedness. As our awareness of these factors increases research studies will be able to isolate the sub-groups who show an increased incidence of sinistrality. By itself sinistrality is not evidence of pathology; however, the evidence in the literature does indicate that the lateralization of cerebral functions in dextrals and sinistrals are not the same.

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APPENDIX I

Annett's (1970) Handedness Questionaire

Which hand do you use:

1) To write a letter legibly?

2) To throw a ball at a target?

3) To hold a racquet in tennis, squash or badminton?

4) To hold a match while striking it?

5) To cut with scissors?

6) To guide a thread through the eye of a needle? (or to guide the needle on to the thread)

7) At the top of a broom while sweeping?

8) At the top of a shovel while moving sand?

9) To deal playing cards?

10) To hammer a nail into wood?

11) To hold a toothbrush while cleaning your teeth?

12) To unscrew the lid of a jar?

Primary factors are items: 1, 2, 3, 4, 10, 11.

Secondary factors are items: 5, 6, 7, 8, 9.

Item 12 did not factor-out as either primary or secondary.

The questionaire used in this study also asks whether any family members are left-handed.

APPENDIX II

Criterion for scoring the Marian Annett Handedness Questionaire.

See Appendix I for attached sample questionaire.

1. Division into dichotomous variables can be achieved by defining sinistrality and dextrality based on hand preference for writing. (Annett 1970)

2. Divisions into six categories: Consistent Sinistral (C.S.), Inconsistent Sinistral (I.S.), Mixed Sinistral (M.S.), Mixed Dextral (M.D.), Inconsistent Dextral (I.D.), and Consistent Dextral (C.D.).

   C.S. : answers left on items 1-11.

   I.S. : answers left on items 1, 2, 3, 4, 10, 11 and right to one or more of items 5, 6, 7, 8, 9.

   M.S. : answers right to one or more of items 2, 3, 4, 10, 11 but left to item 1.

   M.D. : answers left to one or more of items 2, 3, 4, 10, 11 but right to item 1.

   I.D. : answers right to items 1, 2, 3, 4, 10, 11 and left to one or more of items 5, 6, 7, 8, 9.

   C.D. : answers right on items 1-11.

3. Division into three categories: Strong Dextral (S.D.), Strong Sinistral (S.S.), and Mixed (M).

   S.D. : answers right to items 1, 2, 3, 4, 10, 11.

   S.S. : answers left to items 1, 2, 3, 4, 10, 11.

   M. : answers with admixture of preferences on items 1, 2, 3, 4, 10, 11.

APPENDIX III

DAVE GILL PROGRAMS

1. TO MATCH DEXTRALS TO SINUSTRALS

```
      INTEGER DATA(511,4)
      READ(5,11) NS
   11 FORMAT(I5)
      READ(5,1)((DATA(I,J),J=1,4),I=1,NS)
    1 FORMAT(I3,I2,I3,I2)
   -ID NUMBER, ANNETTE CODE, AGE, SEX (0=F,1=M)
      NINC=0
      DO 2 J=1,NS
      IF(DATA(J,2).LT.4)GO TO 2
      IF(DATA(J,2).EQ.4)MAN=3
      IF(DATA(J,2).EQ.5)MAN=2
      IF(DATA(J,2).EQ.6)MAN=1
      MSEX=DATA(J,4)
   28 CONTINUE
      DO 3 K=1,NS
      MAL=DATA(J,3)-NINC
      MAU=DATA(J,3)+NINC
      IF(DATA(K,2).NE.MAN)GO TO 3
      IF(DATA(K,4).NE.MSEX)GO TO 3
      IF(DATA(K,3).GE.MAL.AND.DATA(K,3).LE.MAU)GO TO 6
      GO TO 3
    6 CONTINUE
      WRITE(6,42)(DATA(J,L),L=1,4),(DATA(K,N),N=1,4)
   42 FORMAT(' ','SUBJECT NO.',I5,3X,'SINUSTRAL WITH CODE',I4,3X,'AGE',
     CI4,3X,'SEX',I4/
     C10X,'IS MATCHED TO SUBJECT NO.',I5,3X,'DEXTRAL WITH CODE',
     CI4,3X,'AGE',I4,3X,'SEX',I4//)
      NINC=0
      DO 876 JJ=1,4
      DATA(K,JJ)=0
   76 CONTINUE
      GO TO 2
    3 CONTINUE
      IF(NINC.GT.20)GO TO 78
      NINC=NINC+1
      GO TO 28
   78 WRITE(6,79)DATA(J,1),DATA(J,2)
   79 FORMAT(' ','SUBJECT NO.',I5,3X,'SINUSTRAL WITH CODE',I4,3X,
     C'IS UNMATCHED'//)
      NINC=0
    2 CONTINUE
      RETURN
      END
```