LEFT-HANDEDNESS

LATERALITY CHARACTERISTICS AND THEIR EDUCATIONAL IMPLICATIONS

by

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PREFACE

Lack of knowledge concerning left-handedness springs from the multiplicity of studies and contradictory nature of the findings on the various aspects of laterality, rather than any insufficiency of material on the subject. The absence of any single authoritative work and extensiveness of existing material make necessary for a full appreciation of the problem a study more prolonged than the average interested person is willing or able to make. The present work, presenting as it does both an attempt at critical evaluation of previous investigations and an original study of laterality characteristics in a group of normal children, will it is hoped satisfy a need for a comprehensive report on the subject. The practical problems confronting teachers and parents dealing with left-handed children have been kept in the forefront throughout, in the hope that the information contained herein may make some contribution towards a better understanding of left-handedness and may even lead to a more tolerant attitude towards the 'sinister minority', to which the author herself belongs.

Acknowledgment has been made of all printed sources consulted. The author wishes to state her indebtedness to all those who by their practical assistance, encouragement and invaluable advice have contributed to this study. From the absence of individual reference to those many friends it should not be inferred that the author is any the less conscious that without their assistance the work could never have been completed.

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CHAPTER I.

INTRODUCTION.

It is only when embarking upon an investigation of hand preference that one realises the amount of data available on the subject. Unfortunately, however, no sooner are supposed facts obtained on such matters as the incidence of handedness, its inheritance, eyedness and its connection with handedness, the effect of these on education and so forth, than other research findings are discovered completely at variance with these 'facts'. For this reason it is unwise, if not actually impossible, to state the authoritative finding on each aspect without further qualification and clarification. The only way of dealing adequately with the subject seems to be to make a statement of the main investigations which have been carried out, brief comments on the results and a critical analysis of these. Bias inevitably creeps in - even with regard to selection, but at least this approach reveals to the reader that there are different points of view and contradictory statements, and does not involve the pretence that the stated conclusion is the only one. The following chapters are, therefore, an attempt to present a summary and critical analysis of at least the more important investigations on laterality preference. The aim has been to present sufficient comment on each of the researches mentioned to enable the reader to follow the argument without having to consult each authority /

authority cited. The remarks are, nevertheless, limited by the necessity of doing justice to as many investigators as possible. In spite of that, many of the studies have had to be omitted to keep the work within manageable proportions, the necessity for such omissions being evident to anyone consulting the bibliography.

Bias is inevitable in practically any study, no matter how scientific it may appear, and if not in the actual treatment of the data, then probably in the selection of these aspects to be investigated and the relative importance to be ascribed to the various results. The human factor is present in all studies, even in those of inanimate material, in the fallible person of the investigator. It is present to an even greater extent in studies of human behaviour, where one's own personality and behaviour become inextricably involved, making it a delusion to believe oneself capable of objective, unbiassed judgments on the behaviour of other human beings. Even experimenters are guilty of seeing what they want to see, and that only. Apart from being a psychological study, subject to all the vagaries which that involves because of the very nature of the material, the topic here under consideration inevitably suffers from a very clear-cut, but nevertheless important, bias. All persons, investigators included, are either /

either left- or right-handed; if left-handed, they are well aware of the difficulties involved in having such a preference in a right-handed society, and in belonging to a minority group of not more than one-tenth of the population. While such appreciation makes their interest in the subject understandable, and makes them, in some ways, more suited to carry out such investigations than others not so conscious of the difficulties, their particular concern makes it unlikely that they will embark on a study which will show left-handedness to be an oddity resulting from negativism or faulty training, or to be a degenerate form of behaviour; not that they will consciously distort the results, but that they will tend to avoid such aspects. Interest of right-handers in left-handedness is more difficult to understand, probably more varied in its origin, and certainly less direct. The presence of a bias in one direction or the other is clearly seen in the reports of investigations on handedness, and is evident from even a cursory glance at the various books and articles on the subject, where one can so often tell whether or not the investigator is left-handed long before he admits it, since his whole approach to discussion on the subject seems coloured by the fact. There are obvious disadvantages in the physician suffering from the disease he is studying, but so often the increased understanding resulting is sufficient to outweigh these. It

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is hoped, and is, in fact, pleaded in support of the present investigator, that the increased awareness and more intense appreciation of the effects of being left-handed in a right-handed world are sufficient to counterbalance the bias inevitably resulting from being one of the 'sinister minority'.

The first part of this study, devoted as it is to an analysis of the existing material on left-handedness, reveals the erroneous nature of the widespread belief that few investigations have been undertaken on the subject of hand preference. A survey of the more important theories which have been propounded in explanation of hand preference will be followed in Chapter III by a discussion on the operation of hereditary factors in the transmission of left-handedness. The connection between hand dominance and the development of speech is an important aspect of the problem and will, therefore, be discussed at some length, with special emphasis on the studies on the relationship of left-handedness and stuttering. Difficulties encountered in any attempt to measure laterality preferences will then be discussed, together with some suggestions concerning the relative merits of the more widely used tests of the characteristics. The last few chapters of the first part of this study are concerned with investigations on the connection between left-handedness and writing problems, including mirror-writing, and between laterality /

laterality preferences and reading difficulties.

An investigation of the laterality characteristics found in a normal group of school children, unselected with regard to hand preference, is described in the second part of this work. The type and strength of hand, foot, ear, and eye preferences found in this group have been studied, together with the educational implications of such preferences. It was hoped that such a study might act as a corrective to the numerous studies of abnormal children showing left-handedness. Here, in contrast, the left-handed subjects have been tested together with their right-handed fellows in the same class, and a comparison made of their relative positions compared with the right-handed subjects. The selection of such a group has made it possible to compare the results of the left-hand writers with those who, though they use the right hand for writing, are left-handed in other respects. Without testing whole classes it is difficult to obtain a representative group of those who have had their handedness changed, or who have changed of their own volition. This difficulty was brought out when, in the course of the present study, an attempt was made to ascertain, not only the number of subjects tested whose handedness had been changed, but also the total number in the schools in which the testing took place. The discrepancies between the numbers in different classes and schools were such that they could only have been caused by incomplete or inaccurate /

inaccurate reporting. Since the method used in the actual study enabled the range of hand preference found in a normal group to be studied intensively, it was hoped that this would overcome the difficulty mentioned above, though it would, of necessity, result in an investigation on a very much less extensive scale.

This is by no means the first study of the educational implications of left-handedness. It is, however, the first investigation which has taken into consideration the various types of hand preference found in a normal population, and is, further, intensive in character where others have been extensive. This is its justification, together with the fact that, since the classical studies of the subject, the whole social attitude to left-handedness has been undergoing a gradual change from one of censure combined with fear and distrust to something more akin to faint disapproval. The effect on the incidence of left-handedness of these changing conditions seems, therefore, worth studying. Together with the increased incidence in apparent left-handedness, resulting from the more tolerant attitude towards it, has appeared an increased interest, amounting, in some instances, to concern, particularly on the part of parents whose children are left-handed. Little assurance seems to be gained by visits to teachers or to doctors, the natural recipients of such troubles. /

troubles. Letters in the daily papers in the last year or two, and queries on the radio, are an indication of this growing interest and concern about left-handedness. Many of the answers given, however, are misinformed, or contain long disproved views on the subject, and are, frequently, merely perpetrating the negative attitude to left-handedness which has been common to most societies.

Even if it did nothing else, this study might reassure some parents by showing them that at least a few left-handers have learned to read and write without any particular emotional upset. Incredible though it may seem, a not inconsiderable number of parents have doubts about this possibility, and are bewildered and perturbed when they find that a child of theirs shows left-handed tendencies, their very concern forming a breeding ground for instability and emotional disturbance. Many instances are known to the writer where, for example, the father says: 'Change him over', and the mother says: 'Don't'; or where the teacher says: 'Change', and the parents say: 'No', or frequently the reverse. A child has sufficient emotional issues to face in the course of his career without making one of his preference for right or left hand. Children have been taken from one school and sent to another on this very issue. Where the parent or teacher is himself left-handed, or has some relative or intimate friend who is left-handed, his attitude seems more inclined to be /

be one of toleration; whereas, when it is his first encounter with the phenomenon, he is more inclined to blame it on mere stubbornness, and insist that it be changed.

The present concern about left-handedness, and desire for some understanding of its various aspects, shown by parents and others dealing with children, indicates the need for a spread of information on the subject. The existence of such feelings has been most forcibly brought to the notice of the present writer who, during the course of this study, has received a number of letters both from parents of left-handed children and from persons who are left-handed themselves, stating their pleasure that a comprehensive study of the subject has at last been undertaken, and, pleading, to quote one: 'that more facts should be published to let people know that we are not a queer and awkward lot'. The inaccessibility of existing material is not the only difficulty; another is its inadequacy at the present time, due, in part, to the fact that it was written under conditions which have ceased to exist. The desire for, and lack of, such information would seem to reveal the need for some study such as the present one, presenting as it does both an attempt at critical evaluation of existing material and a new approach to the subject, which will, it is hoped, be of some interest to those dealing with left-handers, and, not least, to left-handers themselves.

PART I

A CRITICAL EVALUATION OF PREVIOUS INVESTIGATIONS ON LATERALITY CHARACTERISTICS.

CHAPTER II

THEORIES ON THE CAUSE OF HAND PREFERENCE.

THE PROBLEM

The basis for the use of the term 'hand preference' is the fact that each person, though possessing two hands, finds that many operations carried out by man, even in primitive society, involve the use of one only. It is evident that in the interests of efficiency a person is not likely to continue to use one or other hand at random, but to choose one and train it to become proficient in unimanual activities. The puzzling point about this choice of one hand is that it would be expected that mankind would either be equally divided between left and right preference suggesting a chance selection, or would be right- or left-handed without exception, and that neither of these alternatives is confirmed by observation of everyday activities. The great majority does use the right hand, and in deference to the needs and desires of this majority, society is built on the assumption that the right hand will be selected. This is evident in the construction of tools, both household and industrial; dextrality being also assumed in the instruction in manual skills and games. There exists, however, a not insignificant minority, about one in ten of the population, which displays left-handedness in all its actions /

actions in spite of its accompanying disadvantages. This obviously provides a tempting field for investigators, many of whom have studied this anomaly in order to explain its occurrence. Such attempts have led to studies of the nature of hand preference and its consistency, to a consideration of the existence of a possible hereditary mechanism, and to studies of the intelligence and temperament of left-handers in order to find some explanation as to why they should evince a preference for the left hand in spite of all expectations to the contrary.

Similar problems arise regarding eyedness and the preferential use of one foot. The study of eyedness has really developed out of investigations of handedness, since dominance of one eye is not so evident to the casual observer, nor does it, superficially at least, appear to present such problems. There are few important actions commonly performed in which one eye only is used, our vision being predominantly binocular, and the fact that actually in binocular vision one eye is dominant is not apparent on casual observation. The percentages for right- and left-eyedness are not comparable with those for handedness, right-eyedness being about twice as common as left-eyedness.

The preferential use of one foot is more evident in leisure activities involving such actions as hopping and kicking, where a /

a similar trend to that in handedness is evident, the larger proportion being right-footed and a smaller number left-footed, though the preference is not so consistent as in handedness.

Why does there exist this small percentage of sinistrals?

EARLY INVESTIGATIONS

Numerous indeed are the theories which have been propounded to elucidate the mystery of the existence of this sinister group. The existence of a small group of left-handers has been noted by observers from earliest times, references to this being present in the literature of most countries, as, for example, in the Old Testament (Judges XX, verses 15-16), where mention is made of a group of left-handers in the tribe of Benjamin who could sling stones with unusual accuracy. This reference has, in fact, led some people to suggest that present left-handers are descended from this tribe. Actually the percentage which that group of left-handers represented out of the total tribe is little different from the percentage of left-handers found in the nineteenth-century investigations. There is no suggestion that the whole tribe was left-handed; the very fact that the left-handedness of these particular individuals was stressed indicates its unique nature.

Though not of scientific importance, it is certainly of interest to note the type of context in which 'left' or 'left-handedness' is mentioned. 'Sinister' and 'gauche' are so /

so frequently used with unpleasant associations that one is inclined to forget that they both mean 'left'; while 'dexterity' in the sense of skill is so inevitably associated with right-handedness that there is an underlying feeling that a left-hander will not merely be different but that he will also be awkward or 'gauche'. The evidence that something out of the ordinary, unusual or inexplicable is regarded with suspicion, and even fear, is to be seen throughout the history of man, and the attitude of many to left-handedness is no exception. Left-handedness seems to be associated in the minds of many with something unlucky. In some districts, for example, it was regarded as an ill-omen to encounter a left-handed person when setting off on a journey. Most districts have among their dialect words some term of derision to describe left-handers - 'southpaw', 'cack-handed' and 'corrie-fister' being but a few examples of this. The word 'corrie-fister', the Scots expression, is supposed to have originated from the surname 'Kerr', which an ancient Scottish tradition traces to a Dalriadic king Kynach-Ker who was left-handed.[1]

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1. D. Wilson, The Right Hand: Left-handedness. London: Nature Series, The Macmillan Company., 1891.

It was only in the nineteenth century that serious attempts were made to explain left-handedness. The earliest theories /

theories were rather directed towards accounting for the right hand preference of the majority, and tended to dismiss left-handedness as the result of an accident, faulty training or some abnormality in bodily structure. Explaining a right-hand preference is not difficult but, unfortunately, the theories which explain only this are inadequate when applied to left-handedness. It is impossible here to do justice to all the theories which have been propounded in explanation of the phenomenon of hand preference, and mention will accordingly be made only of the historically more important.

I. PRIMITIVE WARFARE THEORY

An intriguing explanation of right-handedness is the Primitive Warfare Theory, whose upholders suggested that in primitive warfare man held his stick or sword in his right hand, in order to leave the left free to protect his heart. Thomas Carlyle, the nineteenth-century philosopher, is supposed to have been the originator of this theory when his enforced use of his left hand in later life was necessitated by disease in the right arm. This led him to consider the reason for the right-hand preference of most men, and to suggest that some peculiar advantage resulted from protection of the heart by a shield held in the left hand, resulting in the perpetuation of right-handedness partly by transmission of the characteristic and partly by a process of natural selection whereby /

whereby left-handers became gradually extinct, since this represented a less efficient form of defence.

This theory leaves more questions unanswered than it answers, and is of little more than historical interest, criticisms of it being obvious. In the first place, the heart is not entirely on the left side; while injuries to liver, for example, would prove equally fatal to primitive man; and, finally, the theory does not explain the sinister minority of left-handers who, so far as we know, still have their hearts in the 'right' place.

II. THE MECHANICAL AND CENTRE OF GRAVITY THEORIES

These two theories are also attempts to explain handedness on an anatomical basis. The Mechanical Theory was expounded by Buchanan, a Professor in the University of Glasgow, who claimed that immediately a child begins to use the limbs together he becomes aware of a mechanical advantage possessed by the right side. Right hand usage does, according to him, lead to a greater development of the muscles on the right side, but initially this results from a mechanical cause inherent in the constitution of the human frame. He explained the advantage claimed for the right side as resulting in part from the position of the centre of gravity of the body. In his first /

first paper in 1862[1] Buchanan dismissed left-handedness as being of no consequence, and did not attempt to make his theory account for its existence; but in his second paper, in 1877[2], he realised this omission and also modified his views

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1. A.Buchanan, 'Mechanical Theory of the Predominance of the Right Hand over the Left', Proceedings of the Philosophical Society of Glasgow, vol.V, 1862, pp. 142-167.
2. A.Buchanan, 'On the Position of the Centre of Gravity in Man, as Determining the Mechanical Relations of the Two Sides of the Body Towards Each Other', Proceedings of the Philosophical Society of Glasgow, vol.X, No.2, 1877, pp. 390-413.

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considerably. He emphasised further the importance of the position of the centre of gravity, and went on to suggest that in most people it lies in such a position that it enables them to balance more effectively on the left foot, which means that they thus become right-footed and thereafter, and as a necessary consequence, become right-handed. He suggested that left-handedness could be explained by a displacement of the centre of gravity in the opposite direction, while ambidexterity would result when it was so placed that it did not favour either foot. He did not continue and explain how this would occur, nor prove that these differences did actually exist in left-handed and ambidextrous persons.

Inadequate though the theory is as an explanation of hand preference, the work of Buchanan is worth consideration, since it /

it represents the views of a nineteenth-century physiologist on the subject. Though part of his theory was the result of experimentation, Buchanan was not guiltless of stating generalisations from one or two instances he happened to observe. This tendency makes it difficult to separate the valid from the invalid. From a comparative point of view it is important to take account of these early studies, bearing in mind that much of the discussion contained in them is, nevertheless, mere speculation with no experimental basis, or is based on everyday experience, a notoriously inaccurate method of obtaining information.

III. EYE DOMINANCE

The suggestion made by Buchanan that footedness explains handedness was followed by a suggestion by Parson that eye dominance is the cause and handedness the effect. This theory was based on the fact that in infancy nearly all voluntary movement depends on vision, and it is according to Parson also the greatest stimulus throughout life. He stated, further, that:

> Man has also developed certain dominant single faculties such as speech and memory which cannot be classed as belonging to either side of the body exclusively, but rather to the organism as a whole. In a general way it can be said that we find the neural areas which innervate these highly complex single faculties grouped in the same hemispheres that contain the centres controlling handedness and eyedness. This affords the most direct and speedy /

speedy co-ordination of sight impressions with intellect, will and action[1].

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1. B.S.Parson, Lefthandedness - A New Interpretation, p.24. New York: The Macmillan Co., 1924.

In suggesting the connection mentioned above, Parson was anticipating some of the more recent neurological findings on the connection between handedness and brain dominance, but few would agree with him that there is a close connection between handedness and eyedness, far less that eyedness actually explains handedness. His theory certainly does not encounter the difficulty found by others in explaining left-handedness, since for him it results from left-eyedness. This is obviously no more satisfactory, since he cannot explain why some are left-eyed and some right-eyed. Two important objections render Parson's theory untenable. First, crossed dominance is extremely common, there being about half as many people who have their dominant hand and eye on opposite sides as there are people with them in accord. Some of these exceptions could be explained away as resulting from an enforced change of handedness, as Parson attempted to do, but that would account only for those who are left-eyed and right-handed, while one frequently finds left-handed persons who are right-eyed. Second, it has been found that left-handedness is as high among the congenitally blind as it is in the normal population.

Although /

Although it is probably not true, as Parson suggested, that all actions are hampered unless the dominant hand and eye are on the same side of the body, there may be certain actions which are facilitated by this, actions where hand-eye co-ordination is of particular importance. This is merely mentioned to suggest that though it is generally agreed that handedness does not arise as an effect of eyedness yet it is possible that some of Parson's views about hand and eye dominance may be of importance.

IV. CHANCE FACTORS

In most theories in this group the assumption has been made that right-handedness is normal and that only the small group of left-handers requires explanation. Left-handedness has, then, been explained as resulting from carelessness on the part of the mother or nurse in the way the infant was carried, or from bad training in childhood. Such theories, or, rather, explanations of left-handedness, are accepted by many who completely overlook the fact that left-handedness in many instances actually persists in spite of all attempts to train, or enforce, right-handedness, and that it is unlikely, therefore, to be explained by accidental factors.

One cannot omit entirely consideration of such suggested explanations of left-handedness, but since they are far from adequate /

adequate theories, mention of their existence will suffice.

V. EDUCATION

The basis for this type of theory differs from the former explanations in that they are based on the assumption of right-handedness as normal and of left-handedness as abnormal, or, at least, an exception; whereas advocates of education as the explanation claim that naturally only a few people are either strongly right- or left-handed, and that for the majority right-handedness is largely the result of education. This was the view of Wilson[1], who, being left-handed himself,

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1. op. cit.

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was not willing to dismiss the characteristic so lightly as others had done. Unfortunately such a theory does not explain why the swing has always started to the right in all societies. It may be true, nevertheless, that only a small number of right-handers are strongly biassed in that direction, and that the preference of the remainder does result from the fact that it is the accepted usage; in other words, many of these might equally well have become left-handed had that been desirable. It seems that one must accept Humphry's nice distinction /

distinction that the superiority of the right hand is acquired through frequent use, but,'though the superiority is acquired, the tendency to acquire the superiority is natural'[1].

1. G.M.Humphry, The Human Foot and the Human Hand, p.202. Cambridge, England: Macmillan Co., 1861.

VI. LEFT-HANDEDNESS AS A FORM OF NEGATIVISM

This theory is based on the assumption that right-handedness is the normal well-adjusted type of reaction, while left-handedness is a revolt and completely at variance with the best interests of the individual as a socially adjusted person, since society is based on the assumption of right-handedness. Allowing no physiological basis for left-handedness, and dismissing any suggestion that some hereditary mechanism may be at work in its transmission, it offers a psychological or a psycho-pathological explanation. Two types of left-handedness were distinguished by Burt[2], who considered that though some cases might be explained as above, others might result from a strong constitutional bias; unlike Blau[3] who maintained that all left-handedness can be so

2. C.Burt, The Backward Child, chapter X. London: University of London Press Ltd., 1937.
3. A.Blau, The Master Hand, New York: The American Orthopsychiatric Association Inc., 1946.

explained, /

explained, as a neurotic symptom or form of negativism. He claimed that there is no innate basis for laterality and that it is developed by training and education, and becomes a habitual response as a result of social conditioning. Sinistrality he explained as being the result of a deviation in the learning process because of: (a) an inherent deficiency, physical or mental, (b) faulty education, or (c) emotional negativism. In support of this he pointed out that it only occurs in a minority, 'but has relatively greater incidence among males, mental defectives, delinquents, and many psychiatric abnormals'[1]. It seems unwarranted, however,

1. op. cit. p.93

to deduce from abnormals, as Blau has done, the characteristics of normal left-handers. It seems fairer to consider the possibility, as did Brain[2], that left-handedness in such abnormal cases may be of quite another type from normal

2. R.Brain, 'Speech and Handedness'; The Lancet, vol.CCXLIX, No.2. 1945, pp. 837-841.

sinistrality. Failure to develop right dominance should not be confused with left dominance though some tests may, nevertheless, lead to such confusion because they class as left-handed /

left-handed all who are not right-handed.

VII. CEREBRAL DOMINANCE AND LEFT-HANDEDNESS

Some of the early investigators suggested a connection between the relationship of the two sides of the brain and the dominance of one hand. At first the belief was held that some anatomical or physiological difference in structure or functioning between the left and right hemispheres resulted in one hemisphere being dominant, and this led, in its turn, to left- or right-handedness, depending on which hemisphere was, for example, the larger, had the better blood supply or had some other characteristic. These views implied or assumed that there was some absolute difference which led inevitably to dominance of one side of the brain, a view which is doubted by many neurologists now. It is actually difficult to tell whether an arm becomes longer and more powerful as a result of the use to which it has been put or whether the difference in strength explains the fact that it was selected; while it is even more difficult to decide similar questions with regard to the differences in brain structure. It was actually suggested by Wilson[1] that the dominant side of the brain is heavier than

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1. op. cit.

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the non-dominant, and, in an attempt to prove that, he awaited with some anxiety the death of a person of known left-handedness. Upon examination of this man's brain he found, as he had hoped, that the right side was heavier than the left. Physiologists would now question any such simple explanation. More recent investigations on the subject appear to be much less definite and positive in their pronouncements, and there seems to be a cautiousness in attributing left-handedness to any one factor, either anatomical or physiological.

There are two distinct questions which require to be answered in order to provide a complete explanation of the causation of left-handedness:- what is the cause of the right-handedness of the majority, and how is hand dominance acquired by each individual? The type of answer one gives to the first question determines, to a great extent, one's views on the second. If, for example, left- or right-handedness is believed to arise from some difference in physiological structure, then one will consider that genetic factors play an important part in its transmission from one generation to the next. If, however, the view is taken that left-handedness results from negativism, or accidental factors, pre- or post-natal, then no further consideration will /

will be required as, on that basis, both questions would be explained, right-handedness being then normal and left-handedness accounted for in each individual in whom it occurs as the result of some factor in his individual development.

The next few chapters will be devoted to a study of the most recent views on the causation of left-handedness, the effect of left-handedness, and a consideration of the place of hereditary factors in its transmission.

CHAPTER III.

THE INHERITANCE OF LEFT-HANDEDNESS.

In the nineteenth century, studies of handedness usually tended to be philosophical treatises on the cause and nature of right-handedness. Gradually it became apparent, however, that the stumbling-block in the way of acceptance of these early theories was the existence of left-handedness; in other words, such theories as the Centre of Gravity, Mechanical and Primitive Warfare Theories might have explained right-handedness in man, had all men been, in fact, right-handed. The fruitlessness of these attempts to explain the nature and cause of handedness preference led to a change of emphasis. At the beginning of this century psychologists abandoned, to some extent, their armchair methods and concentrated their energies on the measurement of handedness, a change which resulted in the accumulation of a large volume of material on single tests, batteries of tests and questionnaires on hand dominance. The early investigators had been inclined to emphasise the accidental or acquired nature of right-handedness. As a result of the actual testing there developed an awareness that left-handedness was something more than an oddity in some people which could be dismissed in the way still common with the layman /

layman, or attributed to inefficient training. It was felt that though right-handedness might, in some instances, be no more than the result of training, the same explanation would not suffice for left-handedness which rather persisted in spite of training. This realisation emphasised the need for a comprehensive explanation of the consistent minority of left-handers, a need which brought the geneticists into the field about the turn of the century.

To estimate the importance of these studies of the inheritance of handedness, it is essential to place them in their historical setting, since only then can one ascertain how much information on the problems of testing handedness can be assumed in each. Some of the theories were evolved at a time when little study had been made on how to measure native handedness. In some instances even the difficulties which would be encountered in any such attempt were apparently unrealised by the investigator, who selected, quite arbitrarily, some criterion of handedness preference and assumed that his was the only or the ideal method, or that other methods would have given similar results, neither of which assumptions was justified. Advances in the measurement of handedness and in the science of genetics in the past fifty years have rendered the early studies of the inheritance of handedness of little more than historical interest. Only if the early naive attitude with regard to the measurement of handedness is present in /

in the more recent studies does it become a matter for some concern. As a preliminary to discussing the various studies of the inheritance of handedness, it may be well to mention briefly the actual facts to be explained and the difficulties likely to be experienced in any attempt to do so.

I. THE FACTS TO BE EXPLAINED

Any theory of the inheritance of handedness has to take some account of the fact that one hand is preferred by most humans for all manual tasks and that, while for most people the preferred hand is the right, a small minority exhibit a preference for the left, a preference which persists in spite of the predominance of right-handed objects and in spite of a deliberate pressure by the right-handed majority in society towards conformity. Though some investigators have suggested the possibility, no convincing proof has yet been advanced that there has ever existed any society where left-handedness was the rule and right-handedness the exception. Studies of prehistoric relics and of historical records reveal both that right-handedness has always been preferred by the majority and that a sinister minority has also always existed. The fact that preference for one hand is not evident immediately at birth does not, as some have claimed, rule out the possibility that hereditary factors determine its nature. There appear to be /

be more left-handed males than females. An impression was created by Buchanan[1] that the reverse was true, but the wording

1. A.Buchanan, 'On the Position of the Centre of Gravity in Man, as Determining the Mechanical Relations of the Two Sides of the Body Towards Each Other', Proceedings of the Philosophical Society of Glasgow, vol.X, No.2, 1877, pp.390-413.

of his paper reveals that he was only making an observation from his everyday experience, an observation which neither he nor others has substantiated. There may be no hereditary basis for the preponderance of left-handed males found in the studies but their existence should at least be considered and explained by an adequate theory. Such a preponderance among males raises the interesting question of whether this is the original distribution or whether it results from social pressure. In short: Are more males than females born with a tendency to left-handedness, or is it that girls are more willing to bow to convention, while boys are more inclined to be independent, or stubborn?

II. DIFFICULTIES IN EXPLAINING THE FACTS

Many difficulties confront the geneticist who takes as his study the inheritance of handedness in addition to all the problems which face any student of human inheritance. The main difficulty is that, no matter what test of handedness he uses, /

uses, he will not find all the cases of left-handedness. No society permits the normal functioning of the left hand; on the contrary, all exert some pressure towards conformity, that is, towards right-handedness. If the writing hand were one's criterion, in 1860 about two per cent would have been classed as left-handed, whereas it might now be seven per cent or less, depending on the country under consideration. Even were some other criterion used it would still be influenced by the extent to which writing with the left hand was permitted. Different activities are influenced to a varying degree by compulsion to use the right hand for writing, but one cannot doubt that all are influenced to some extent. Thus emerges the important point, that one cannot measure left-handedness as such; left-handedness, as we term it, is merely a functional concept. It is impossible to measure native left-handedness since society's attitude distorts it at an early age, and the actual amount uncovered depends on the test employed. Even the use of a battery of tests does not necessarily produce a more reliable measure of handedness since this may result, because of left-preference in some relatively unimportant task, in imputing left-handedness or the desire for such to people who might never have used the left hand for any important activity even had society permitted it. Thus one may fall into another trap if one is too avid in seizing on all instances of left-preference and classing them as left-handed. This is a problem encountered /

encountered by all who attempt to investigate left-handedness and is not peculiar to the geneticist whose difficulties in this connection are, however, further increased by the fact mentioned earlier, that percentages of apparent hand preference vary from generation to generation. Many instances in the parental generation in fact comparable to those in the offspring will not be revealed, even using the same criterion of handedness for both generations. The same initial dominance may be led into totally different channels by the different attitude of society at an early stage, while temperamental factors will also have an effect which will vary with society's attitude, being more significant when the attitude against left-handedness is most severe. The problem for the geneticist is to obtain adequate, satisfactory and comparable data for two or three generations, since without that his studies are impossible. Some have attempted to use the same measure of handedness for each generation using, for example, a questionnaire or the writing-hand, while others have employed a battery of tests or a single test with the filial generation and a standard questionnaire or series of questions with the parental generation. It should nevertheless be borne in mind that a negative reply to an enquiry about left-handedness in a family is not proof of its absence, but may indicate nothing more than lack of information. If in each generation more and more prospective or native left-handers /

left-handers are permitted to use the left hand, which appears likely, this will simplify the task of the geneticist who will not then require to rely on admittedly fallible human memories to ascertain whether a certain person desired at the age of five to use the left hand but was prevented by the school authorities from doing so. Unfortunately, since the pressure towards right-handedness varies markedly from community to community, district to district, and even family to family, even within any one generation, one cannot estimate strength of preference from the number of activities for which the left hand is used, or rather, one cannot compare the relative strength of the handedness of two individuals on such a criterion. This would only be valid if the conditions were identical, which they never are.

These difficulties explain to a great extent the limitations and deficiencies of the studies which have so far been attempted on the inheritance of handedness. It is to be hoped that improved methods of testing, of gathering data and dealing with them, combined with the more tolerant attitude in society by allowing a freer development to left-handedness, may facilitate a comprehensive study adequate to explain all the facts of the inheritance of handedness.

III. STUDIES OF THE INHERITANCE OF HANDEDNESS

The earliest studies were those of Jordan in 1911 and 1914 and /

and of Ramaley in 1913. Ramaley claimed that Jordan's first study was of little value as it was prior to the modern genetic type of study, and consisted of selected pedigrees. Ramaley's study of 610 parents and 1,130 children[1], and Jordan's later study in 1914, of 79 families[2], led them both to the conclusion

1. F.Ramaley, 'Inheritance of Left-handedness', American Naturalist, vol.XLVII, 1913, p.730.
2. H.E.Jordan, 'Hereditary Left-handedness, with a note on Twinning', Journal of Genetics, No.4, 1914, pp.67-81.

that left-handedness is inherited and follows the laws of mendelian hereditary. Ramaley claimed that it is a mendelian recessive probably existing in about one-sixth of the population. The crucial point in this connection is that, were this true, then a left-left mating should produce all left-handed children and, as Chamberlain[3] pointed out, Ramaley cited only two families in which both parents were left-handed, and in one of

3. H.D.Chamberlain, 'The Inheritance of Left-handedness', Journal of Heredity, vol.XIX, 1928, pp.557-559.

these not all the children were left-handed. Chamberlain used, as his measure, not a questionnaire as used by Jordan, (Ramaley did not state his criterion), but the writing-hand, which resulted in a smaller percentage of left-handers. He agreed with the two earlier investigators in finding that left-handedness was inherited as shown by the fact that its incidence was considerably greater in those families where one or other of the parents /

parents was left-handed than in those where both parents were right-handed. He would not, on the other hand, agree that it was a mendelian recessive.

The most recent study was that carried out by Trankell[1]

1. A.Trankell, The Genetics of Left-handedness Paper read to Thirteenth International Congress of Psychology in Stockholm, 1951 (Based on Chap.11 of Vänsterhänthet hos Barn i Skolaldern. Helsinfors: Mercators Tryckeri, 1950).

who advanced a theory of the inheritance of right-handedness as a mendelian dominant. He then reviewed the earlier investigations of Ramaley[2], Chamberlain[3] and Rife[4] and stated

2. Ramaley, op.cit.
3. Chamberlain, op.cit.
4. D.C.Rife, 'Handedness, with Special Reference to Twins', Genetics, vol.XXV, 1940, pp.178-186.

that properly treated their results substantiated his own theory. Trankell's study was carried out on 1094 children in Stockholm, who were tested on his 'Impulse-Scale', while he ascertained the handedness of the parental generation by a questionnaire. His criticisms of these earlier studies are worth noting. He claimed that both Ramaley and Chamberlain failed to realise that individuals lacking the dominant factor might be right-handed as a result of other causes, which meant that these investigators were wrong in assuming that they could determine the percentage of recessive homozygotes on their arbitrary /

arbitrary criteria. Trankell pointed out a further mistake in Chamberlain's data, where a number of families are included in the calculations, families which were drawn from a different population to that under consideration, in actual fact obtained in answer to a newspaper advertisement, inclusion of which distorted Chamberlain's results. Trankell claimed to have proved, and verified from these earlier investigations, that right-handedness is a mendelian dominant; but, as he indicated, this still necessitates an investigation into what happens in the absence of the dominant factor, though he claimed for his theory that it affords an explanation of the tradition of right-handedness - as based on a biological fact.

IV. SEX DIFFERENCE IN HANDEDNESS

The evidence at present available indicates that the sex difference in the incidence of hand preference is probably due to environmental rather than hereditary factors. The variations in the difference found by investigators suggests this possibility. Jordan pointed out that in his 1914 study he obtained a greater incidence of left-handed males than females, but that in his earlier studies he found an approximate equality, and that the discrepancy he noted was not sufficiently great to have significance as contradicting the general conclusion that males and females are equally 'susceptible' to left-handedness[1] /

left-handedness[1]. Wilson and Jones[2] also noted a sex

1. Jordan, op.cit.
2. P.T.Wilson and H.E.Jones, 'Left-handedness in Twins', Genetics, vol.XVII, 1932, pp.560-571.

difference in favour of males, but stated that it was not great enough to be reliable. At the present time there seems no doubt of the greater incidence of left-handedness among boys. In the writer's recent study of the writing-hand of about six thousand Scottish children between five and twelve years of age it was found that eight per cent of the boys were actually writing with the left hand, and only six per cent of the girls. These findings have been confirmed in other recent studies. No sufficient explanation of the sex difference has, as yet, been presented, but it is at least possible that the difference can be explained otherwise than in genetic terms.

V. TWINNING AND LEFT-HANDEDNESS

Though there seems to be general agreement that left-handedness is more common among twins than among the single born, there still remains a difference of opinion as to whether it is more common in identical than in fraternal twins. It has been suggested by Wilson and Jones[3] that the discrepant

3. loc.cit.

results obtained on this subject may be explained, at least partly, by a difference in method and criteria for handedness or for determining identical twins used by the investigators. In their study of 386 twins and 521 single born Wilson and Jones found a higher incidence of left-handedness in the twins (10.7-12 per cent) than in the single born (6.5 per cent), but found no difference between the two types of twins.

Several hypotheses have been mentioned by Newman, Freeman and Holzinger[1] in explanation of the excess of left-handedness

1. H.H.Newman, F.N.Freeman, and K.J.Holzinger, Twins: A Study of Heredity and Environment, pp.12, 39-48. Chicago: The University of Chicago Press, 1937.

in twins. They suggest as two possible alternatives either that twinning and left-handedness may be genetically linked, or that the pre-natal life of twins may predispose to left-handedness more than does that of the single born. Though only a very small percentage of left-handers are actually twins, it is possible that the attempts to explain left-handedness in twins may be some guidance in determining the nature of handedness in general, and for that reason it is worth considering the relative value of the hypotheses mentioned above. It has been pointed out by Rife[2] that if left-handedness and twinning were

2. Rife, op.cit.

genetically /

genetically linked, then one would expect to find a higher percentage of left-handers among the non-twin members of the families of twins than in families with no twins, which he did not find in his investigation. The alternative suggestion was that the excess may be explained by the pre-natal life of twins, and, in particular, their crowded intra-uterine position, or by variations in delivery, often found in multiple births. Intra-uterine position is obviously different for twins and affected by the very fact that there are two foeti. In this connection it is worth noting that the excess of left-handedness in twins does not result from pairs of twins being left-handed, as might be expected were there a hereditary basis for the increase; on the contrary, in most cases it affects only one member of the pair. It was found by Wilson and Jones that between 18 and 20.4 per cent of the twin pairs they examined contained one left-handed member. This has been supported by Rife who elaborated it further by showing that if one assumes handedness to be a quantitative trait then the intermediate persons will be capable of being shifted either way by environmental conditions, among which conditions he classed intra-uterine position and crowding; this would account for one twin becoming left-handed while the other is right-handed. Strongly right- or left-handed individuals, on the other hand, would not be capable of being so shifted. A further point in support /

support of this was Rife's finding that there was more left-handedness in the relatives of the intermediate twins than among those who were strongly right-handed. A study was made by Roos[1] in order to investigate whether left-handedness

1. M.M.Roos, 'A Study of Some Factors entering into the Determination of Handedness', Child Development, vol.VI, No.2, 1935, pp.91-97.

is determined by foetal position. She found no connection between the two and concluded that some hereditary mechanism must operate to produce left-handedness. Since she did not make a study of foetal position of twins her finding does not necessarily rule out the possibility that the excess of left-handedness in twins may be explained, as Rife suggested, by intermediates becoming left-handed due to the operation of environmental causes. Wilson and Jones pointed out that not only are twins more crowded in the uterus, and, therefore, more restricted in their movements, but their actual position at birth is also considerably more varied than that of the single born. The figures they quoted were as follows:- in 96 per cent of births the head is presented first, while in twins the position is more varied, 31 per cent of individual twins being presented breech first as compared with only 3 per cent of single-born children.

It appears probable from the above investigation that one does /

does not require genetic factors to explain the excess of left-handedness in twins, and that, in fact, it is more readily and plausibly explained by the difference in environmental factors. If, as suggested here, handedness is a quantitative trait, the intermediates being capable of being shifted by environmental factors, then such an explanation might also account for the isolated instances of left-handedness which appear in some families.

Genetic studies have revealed that the development of handedness preference has a hereditary basis, in other words, that one's chances of being left-handed are greater if there are instances of left-handedness in the family. Few would deny, however, that factors other than genetic help to determine whether any particular individual will be right- or left-handed, the actual society in which one lives, and its attitude to left-handedness, other environmental factors, temperamental differences, and so on, all playing a part in determining whether latent left-handedness will be cultivated or suppressed. These factors will probably have their greatest effect on the intermediates, assuming left-handedness to be a quantitative trait. These environmental variants, resulting as they do in a considerable difference in the degree of native left-preference which, in any one individual, results in left-handedness, probably account for the slow progress which has been made in arriving at an adequate and satisfactory /

satisfactory theory concerning the actual mechanism of inheritance. The increase in apparent left-handedness in the last generation, and also the fact that so many institutions, schools and clinics make a note of the handedness of entrants, should all assist the geneticists in their attempts to determine the actual hereditary mechanism at the base of hand preference.

CHAPTER IV

DEVELOPMENTAL ASPECTS OF LATERALITY

I. EARLY STUDIES OF THE DEVELOPMENT OF HANDEDNESS

Studies of the development of handedness within the individual have been carried out by many psychologists in the last hundred years. In some instances these have been directed to providing support for a general theory or particular school of psychology. Watson[1] and his followers,

1. J.B.Watson, Psychology from the Standpoint of a Behaviourist, pp.241-2. Philadelphia: J.B.Lippincott Co., 1919.

for example, investigated the development of handedness in young children and, as one would expect, favoured the view that handedness is environmentally determined; while others have been concerned with proving its hereditary basis. Some of the studies have consisted merely of observation of the handedness behaviour of a single child, either in controlled, or, more often, in uncontrolled situations. It is commonly found that, especially in the early work, the observations were made and the report written by a parent or other interested person, a circumstance which was obviously not conducive to impartial treatment of the results. The findings of such investigations are limited in their usefulness, and

are /

are certainly not a sufficient basis for generalisations on the degree of handedness preference to be expected from children of different ages. Such generalisations were both unwarranted and dangerous, since the development of dominant handedness is highly individual, the age at which it becomes evident varying considerably in different children, and is, in addition, affected by various factors not allowed for in the early studies.

The pioneer attempts to investigate the early phases of hand preference which included, among others, those of Darwin[1], Hall[2] and Woolley[3] have been followed more recently

1. C.Darwin, 'A Biographical Sketch of an Infant', Mind, vol.II, 1877, pp.285-294.
2. G.S.Hall, 'Notes on the Study of Infants', Pedagogical Seminary, vol.I, 1891, pp.127-138.
3. H.T.Woolley, 'The Development of Right-handedness in a Normal Infant', Psychological Review, vol.XVII, 1910, p.37.

by controlled observations designed to determine the stages in the growth of handedness in pre-school children generally. The establishment of developmental clinics has given an impetus to this research, as they enabled controlled studies to be carried out, on large numbers of children, and by impartial observers, precautions sadly lacking in the early research on infant behaviour and development.

II. CONTROLLED STUDIES /

II. CONTROLLED STUDIES

The most ambitious survey of the early factors affecting handedness was that of Roos[1] who sought to discover whether

1. M.M.Roos, 'A Study of Some Factors entering into the Determination of Handedness', Child Development, vol.VI, No.2, 1935, pp.91-97.

handedness preference is determined by foetal position. Various writers had previously suggested that left-handedness is not inherited but caused by pre-natal environmental conditions, either in the form of abnormal foetal position or abnormal delivery. Roos made a study of 486 cases, and found no connection whatever between the dominant position of the foetus or the birth position of the child and left-handedness, and felt it necessary to conclude that some hereditary mechanism is at work in determining handedness. Travis[2] found that lack of dominance and retardation of certain reflexes, resulting in awkwardness, may be associated

2. L.E.Travis, Speech Pathology. New York: D.Appleton-Century Co.,1931.

with speech disorders, and may be the result of pathological intra-uterine conditions, or birth injury. He had, however, no evidence to show that the normal development of left-handedness is in any way associated with pathological pre-natal conditions, and thus his findings are accordingly not necessarily at variance with those of Roos.

Gesell /

Gesell has claimed that the tonic neck reflex, which is evident in the normal infant up to the age of three months, has predictive value in estimating laterality. He stated that all infants at four weeks of age, 'when observed in a free supine posture, spontaneously maintained the head predominantly rotated to one side; 100 per cent likewise held their arms in characteristic t.n.r. (tonic neck reflex) attitudes'. This, he claimed, is followed by a month or two of bi-lateral activity which then gives way to 'one-hand reaching, one-handed manipulation, and hand-to-hand transfer, and ultimately to well-defined dextrality or sinistrality'[1]. Gesell and Ames[2] made a study of the development of handedness,

1. L.Carmichael, Editor, Manual of Child Psychology, pp.308-9 New York: John Wiley & Sons, Inc., 1946.
2. A.Gesell and L.B.Ames, 'The Development of Handedness', Journal of Genetic Psychology, vol.LXX, 1947, pp.155-175.

and found that of nineteen cases investigated, in fourteen the tonic neck reflex was predictive of handedness. In four instances left-handedness was correctly predicted by a predominantly left tonic reflex. They claimed that emphatic constitutional left-handedness is probably correlated with a strong infantile left tonic neck reflex. Gesell and Ames undertook their study of the development of laterality within an individual in order to find out how soon manifestations of handedness become predictive. They felt this was necessary because /

because of the finding of Giesecke, which they quoted, that there was evidence of transfers of dominance even in the individual developmental history occurring at fairly definite age levels. They agreed with her in finding that certain periods in infancy are characterised by bilaterality or even by considerable use of the non-dominant hand. By the age of two years they found relatively clear-cut dominance in the majority, and of the left hand in most of the others, but at about two and a half years of age there was again a shift to a period of bilaterality. These findings are of importance to those dealing with pre-school children, revealing, as they do, that predominant but transitory use of the left hand may be found in children under two years of age without necessarily implying left-handedness. This warning is timely as there is at last appearing a more rational attitude of treating left-handers; but, as usually happens with such swings in public opinion, some are beginning to rush to the other extreme, and to assume that if a child reaches once for something with his left hand at the age of, say, six months, then he is left-handed. By all means the child should be left alone, but it must not be assumed because he uses his left hand on a few occasions that he is left-handed; two factors should be considered, first, the age of the child; and second, the action in which he used the left hand. Hildreth[1] found that

1. G.Hildreth, 'Manual Dominance in Nursery School Children', Journal of Genetic Psychology, vol.LXXII, 1948,pp.29-45.

that /

that the acts most subject to training - for example, eating with cutlery, throwing, and scribbling, show consistently more right-handedness, and appear to become stereotyped from persistent usage earlier than untrained or seldom practised acts. Even in a clinic it is difficult to eliminate the effects of training and imitation; it would appear, however, that these factors do not govern entirely the development of hand preference, although they may retard or accelerate its development.

Generalisations on the development of handedness are, nevertheless, limited in their application, as there are wide individual variations in the age at which dominant handedness is established; for whereas in some children it is found as early as six or seven months, the behaviour of others up until school age is characterised by alternating use of the right and left hand. There is apparently a close connection between the age at which dominance is evident and the degree of dominance; the earlier it appears, the stronger it is, or, according to Halverson, the degree of fluctuation varies from one individual to another and is inversely proportionate to the degree of dominancy[1]. The inference is that to persuade a child to

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1. A.Gesell et al. . The First Five Years of Life - A Guide to the Study of the Pre-school Child, p.92. London: Methuen & Co.Ltd.

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write with his right hand may be more dangerous if the child has /

has shown consistent left preference from an early age, for not only is his dominance probably very strong but it has also been established for a number of years before the interference takes place; whereas if the child does not show definite right or left dominance by four or five years of age, then his dominance, even when established, will probably be less stable. Gesell's results indicated that hand preference may be established at an earlier age in boys than in girls, but he found that in the majority of his subjects right preference had been established by the age of eighteen months, and in 92 per cent by the age of two years.

Gesell's studies at Yale Developmental Clinic, with all its up-to-date methods of recording, are probably the most extensive and reliable investigations of handedness in the pre-school child. Many other studies have been made, but one is well advised to adopt a critical attitude, and to remember Halverson's warning that:- 'The determination of handedness in childhood is at best a very complicated problem', and that 'tests which place a premium on skill or precision of movement rather than on frequency of use or amount of activity may be most revealing for the early detection of handedness'[1].

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1. Ibid. p.93

Dennis made a study of the early laterality preferences of two non-identical twins reared under a controlled regime from 36th /

36th to the 428th day of life, and confirmed the specific nature of early laterality preferences. He pointed out that many studies have assumed that handedness is a general trait:-

> It now seems that these explanations are in the embarrassing situation of having explained 'facts' which do not exist. For there is a wealth of material to show that hand preference is dependent upon the action which is performed and the situation in which it is performed.[1]

1. W.Dennis, 'Laterality of Function in Early Infancy under Controlled Developmental Conditions', Child Development, vol.VI, 1935, pp.242-252.

As this study was made of twins under a year and a half, and as it was frequency of use rather than precision which was the criterion, this may well have been the more animal type of handedness preference as differentiated from true human dominance characterised by its dependence upon the dominance of the contra-lateral side of the brain and associated with speech development - a subject which is discussed in detail in Chapter V. This suggestion gains weight from the finding of Updegraff[2] who made a study, by controlled observation and by

2. R.Updegraff, 'Preferential Handedness in Young Children', Journal of Experimental Education, 1932, pp.134-139.

test, of a group of two year old children, and found that by then definite preference had been established by most of the children, a preference which was the same for all unimanual activities.

III. DEVELOPMENT OF EYE DOMINANCE

Scheidemann and Robinette[1] carried out an investigation

1. N.V.Scheidemann and G.E.Robinette, 'Testing the Ocular Dominance of Infants', Psychological Clinic, vol.XXI, 1932, pp.62-63.

to discover at what age a child could successfully be tested for eye-dominance. They found that at about twenty-nine months eye preference could be determined by the 'hole in card' method[2], but that it was apt to be unsuccessful at the

2. Infra, Chapter VIII.

first attempts, though they pointed out that the age varies with different children. Castner[3] tested the hand and eye

3. Quoted in The First Five Years of Life, pp.96-7.

preferences of a group of children, first at three and later at seven years of age, and of the sixteen children tested twelve were consistent in their eye preference on the two tests, while the greatest changes in laterality in that period occurred in handedness, with a considerable increase in the number of right-handed children and a corresponding decrease in ambilaterality.

There is thus ample evidence to show that both hand and eye /

eye preferences are established in almost all children prior to school age; and to prove that it is untrue to say either that the school writing situation is the first indication of right-handedness in the majority, or that some form of rebellion against school authority is an explanation of left-handedness.

CHAPTER V

PHYSIOLOGICAL ASPECTS OF DOMINANCE AND THE CONNECTION BETWEEN SPEECH AND HANDEDNESS

In spite of all the investigations on handedness which have been undertaken, our knowledge of the physiological basis of that asymmetry is still limited. Psychologists have studied the problem of handedness with a view to securing a procedure for measuring the trait accurately, and of discovering whether left-handers are of lower mentality than right-handers; while biologists have considered its genetic aspects, and educationists have concerned themselves with the problem of whether left-handedness is an educational handicap. In medicine attention has been paid to handedness, not so much as a subject for investigation and research, but as a trait which should be noted in clinical cases. Mention of handedness in medical or neurological textbooks usually consists of casual reference to the handedness of patients referred for brain lesions, where a study is being made of the effect of such lesions on speech. Seldom does any suggestion appear that handedness preference is a complicated feature of behaviour, and that any difficulty might be encountered in measuring it. Usually the information provided is merely that the patient is left- or right-handed, with no indication of how extreme the preference is, whether it was ever changed, or even of the procedure /

procedure used to ascertain it.

In general, our knowledge of the physiology of hand preference has been derived from two sources - either animal studies in which part of the brain was removed experimentally, to discover the effect of this on laterality preference; or from human studies obviously confined to those cases where brain lesions have been caused by an accident or tumour necessitating the surgical removal of a section of the brain. The difficulty encountered so far in gaining information about the dominant side of the brain results from the fact that so long as the brain is working normally one cannot ascertain the dominant side, and that it is only when the brain is affected by a lesion interfering with speech that one can learn that the affected side was the dominant one.

The information on human handedness which can be derived from animal studies is obviously limited. A great deal of our knowledge about the localisation of the various areas in the brain has, nevertheless, been gained from these studies.

II. STUDIES OF HANDEDNESS IN ANIMALS.

Studies have been made of the 'handedness' of rats, by Tsai //

Tsai and Maurer[1], Peterson[2,3,4], Herren and Lindsley[5], and Milesen[6], which have revealed that laterality preference is

1. L.S.Tsai and S.Maurer, 'Right-handedness in White Rats', Science, vol.LXXII, 1930, pp.436-438.
2. G.M.Peterson, 'A Preliminary Report on Right- and Left-handedness in the Rat', Journal of Comparative Psychology, vol.XII, 1931, pp.243-50.
3. G.M.Peterson, 'The Influence of Cerebral Destructions upon the Handedness of the Rat in the Latch Box', Journal of Comparative Psychology, vol.XXVI, 1938, pp.445-457.
4. G.M.Peterson, 'Changes in Handedness in the Rat by local Application of Acetyl-choline to the Cerebral Cortex', Journal of Comparative and Physiological Psychology, vol. XLII, 1949, pp.404-413.
5. R.Y.Herren and D.B.Lindsley, 'A Note Concerning Cerebral Dominance in the Rat', Journal of Genetic Psychology, vol. XLVII, 1935, pp.469-472.
6. R.Milesen, 'The Effect of Training upon the Handedness Preference of the Rat in an Eating Activity', Psychological Monographs, vol.XLIX No.1, 1937, pp.234-243.

not a purely human phenomenon. It is, of course, only in human circumstances where fine discrimination in the operating of tools facilitates the development of such skills as carving of an intricate nature, and later writing, that the selection, and consistent training, of one hand only becomes an advantage and an economy of time and energy. An analysis of the findings on rats is, nevertheless, interesting, revealing, as it does, certain points which are relevant to the study of the human aspects of the problem, and removing certain misconceptions on the subject.

The most important findings on handedness in rats are as follows:

1. /

1. There is such a thing as a preferred hand or paw.

2. The majority of the rats studied favoured the right hand, and the minority the left, with a very small number ambidextrous, or rather showing the same tendency to use either hand.

3. The hand preference, though fairly consistent within one activity, was normally not consistent from one activity to another - for example, the rat might always prefer the right hand in reaching for food, and yet show left preference in undoing the latch in a puzzle-box.

4. The hand preference of rats could be reversed by destruction of a certain part, or parts of the cerebral cortex on the contra-lateral side to the preferred hand, or by the administration of a drug[1,2]; though Kirk's[3] results led him

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1. Peterson, op.cit. 1938.
2. Peterson, op.cit. 1949.
3. Quoted in N.L.Munn, Handbook of Psychological Research on the Rat, p.332, New York: Houghton Mifflin Co., 1950.

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to suggest equipotentiality of the hemispheres in the control of handedness.

From these results the following points arise:

1. If hand preference is found as low in the evolutionary scale as the rat, then it can not be dismissed lightly, nor explained away as being due to chance, attention, social custom or some such factor. If chance alone explained the phenomenon, /

phenomenon, this would not account for the fact that one rat always reached out for food with, say, the right hand; since reaching is not an activity needing for its performance any fine discrimination, and, therefore, not one greatly facilitated by the consistent use of one hand. Further, even if it were in any way assisted by such a habit, one would then expect to see a gradual elimination of alternating use of the right and left hand, leading finally to the use of one to speed up the reaction. That is not found; on the contrary, consistent use of one hand is seen from the first trial. Thus it would seem that the appearance of handedness preference is not something arising solely from environmental factors.

2. Right-hand preference found in the majority of rats, as in the majority of humans, disproves some of the early explanations of hand preference, for example, the primitive warfare theory. Ambidexterity, or lack of consistency in the choice of hand, appears to be rare in rats as in humans, unless the definition is extended to include different hand preference for various activities.

3. The fact that in rats hand preference is consistent only within the field of one activity, points to a similar finding, though in a less degree, in the preferences of young children. Thus human asymmetrical behaviour, before writing impresses a set /

set pattern and necessitates a degree of skill with one hand which carries over to other activities, bears some resemblance to that of animals. This is true both from an evolutionary standpoint and in the life of an individual. That this does not entitle one to dismiss handedness as of little importance, may be inferred from the following point.

4. Destruction of the cerebral cortex affected handedness preference of the rats, as shown by Peterson, indicating that there must be some physiological basis for the preference, and should also serve as a warning against attempting to transfer the handedness of a left-hander. Peterson's results show that long before the development of speech, handedness was connected with one side of the brain.

5. It appears that, provided we can generalise from the rat to man, lateral dominance may be a more localised function of a specific area of the brain, rather than something connected with the whole of one hemisphere. This suggestion, which was made by Jasper and Raney[1], was based on the finding of Peterson

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1. H.H.Jasper and E.T.Raney, 'The Physiology of Lateral Cerebral Dominance', Psychological Bulletin, vol.XXXIV, 1937 pp.151-165.

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that right-handedness could be changed to left-handedness by a circumscribed lesion in the contra-lateral precentral cortex, and that lesions in other areas did not affect the preference.

Some /

Some disagreement remains among investigators, not as to whether there is such a thing as 'hand' preference among the higher animals, but as to whether it is similar in character to that in man. Several writers, including Brain, as recently as 1945, have suggested that in animals left and right preference is fairly equally divided, and that human handedness is closely linked with speech development, and, therefore, of quite a different kind. Thus Brain suggested that right-handedness is not an explanation of left-brainedness:

> Is it not, on the other hand, more probably that it was the appearance of a motor speech 'centre' in the left hemisphere in man that made that the dominant hemisphere, and the right hand the dominant hand, in contrast to the ape, in which right- and left-handedness develop with equal frequency?[1]

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1. R.Brain, 'Speech and Handedness', Lancet, vol.CCXLIX No.2, 1945, p.840.

Roberts, in this connection, has suggested that:

> It is not improbable that the infant passes through an earlier, fleeting, simian phase in the same process of growth by recapitulation. In this phase, rudimentary random handedness may be detected. But true human handedness occurs after the beginnings of speech, by which it is directed and to which it is linked. In the great majority of cases such handedness persists throughout life. Its essential quality is its determination by speech.[2]

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2. W.W.Roberts, 'The Interpretation of Some Disorders of Speech', Journal of Mental Science, vol. XCV, 1949, p.567.

Details of the percentages of hand preference in animals are difficult /

difficult to secure, since most investigators have studied only very small numbers, and thus percentages deduced from these are likely to be unreliable, especially with the sampling methods which had of necessity to be employed. For example, Finch (quoted by Brain in support of his contention), tested only thirty chimpanzees, and found handedness preferences in twenty-five of them, left and right preferences being in fairly equal proportions. The testing of thirty chimpanzees is in itself a formidable undertaking, yet it is not sufficient to justify deducing handedness percentages for chimpanzees, far less for animals in general.

One must bear in mind the possibility that real human handedness preference is preceded by speech development, and possibly determined by it, and that earlier handedness signs are more transitory. This view would gain support from the suggestion of Orton[1] and others that children who begin to

1. S.T.Orton, Reading, Writing and Speech Problems in Children. London: Chapman and Hall Ltd., 1937.

speak early, also early reveal very definite and stable hand dominance - not necessarily for the right; whereas late speaking often goes with lack of, or unstable, hand preference. The development of speech in man, which has no place in the animal world, may mean that there is a considerable change in the /

the character of hand dominance in the process of evolution. This should serve as a warning that animal studies, though they may reveal some facts which could not otherwise have been discovered, have only limited application to the problem of human handedness. For information on the other aspects of the subject one must turn to the second source - the clinical studies of patients suffering from brain lesions.

II. THE DOMINANT HEMISPHERE AND THE PREFERRED HAND.

It is generally accepted that voluntary movements of the arm or leg are initiated by forces in a particular area of the contra-lateral side of the brain, and that damage to one side of the brain causes paralysis of the limbs on the opposite side of the body. It is also a widely recognised fact that one side of the brain is dominant in speech functions, and that this is generally the side of the brain contra-lateral to the preferred hand. Like so many general statements, this is open to criticism, and does not hold universally. It is interesting, however, that our knowledge of the side of the brain which is controlling speech can only be positive in cases where there is a brain lesion, and even then, only when this results in impairment of speech, and further, that in such cases hand preference is a clue to the site of the lesion. If a right-handed patient had his speech affected by an accident /

accident causing a brain lesion, the lesion was found to be in the speech area on the left side of the brain, while in a left-handed patient speech was only affected by a lesion in the right side. This knowledge was used by the surgeon in ascertaining where the damage was located, and it accounts for the fact that references to handedness are to be found in neurological textbooks. This discovery of the close connection between the centres controlling speech and handedness, has been used by psychologists combating the widespread attempts to enforce a change of handedness in all those with a preference for the left hand; it led also to the claim that stuttering is caused by changed handedness (a subject which will be discussed in the following chapter).

Most of our knowledge on the areas controlling speech and on their connection with handedness has been derived from pathological cases. The restriction to such cases has made it very difficult to obtain many of the same type, as less than one in ten of patients with brain injury is likely to be left-handed, and not all of these will have their speech affected; further, few cases which are the same even in other important respects will have the lesion in exactly the same position or of exactly the same magnitude. More recent studies have necessitated the modification of some of the earlier extreme statements on the subject of brain dominance and speech. Two points on which the earlier statements have been modified are: first, /

first, the statement that the area controlling speech is always on the contra-lateral side to the preferred hand; and, second, that the minor hemisphere is useless or completely unused in speech functioning. Chesher[1] has stated that

1. E.C.Chesher, 'Some Observations concerning the Relation of Handedness to the Language Mechanism', Bulletin of the Neurological Institute of New York, No.IV, 1936, pp.556-562.

though, in general, the speech area is on the opposite side to the preferred hand, that in approximately six per cent it is on the same side. Humphrey[2] has suggested that the connection

2. M.E.Humphrey, 'Consistency of Hand Usage', British Journal of Educational Psychology, vol.XXI, 1951, pp.214-225.

between speech and handedness is less clear-cut in the case of left-handers, and that in some of these cases disturbance of speech may occur as a result of a lesion in the appropriate area of either hemisphere. It has been stated by Brock that: 'If the stock of the individual is strongly left-handed, his right brain may be the dominant hemisphere, though he be right-handed'[3].

3. S.Brock, The Basis of Clinical Neurology, p.219. Baltimore: Williams and Wilkins Co., 1937.

It is possible that these right-handers who, according to Brock, are also right-brained, may have not only left-handedness in their 'stock', as he suggested, but may actually be /

be changed left-handers themselves. They may possibly have a strong congenital tendency to left-handedness and right-brainedness, and be people who would have been left-handed but for society. Brock does not indicate how searching a test of handedness was carried out on these exceptions, whether the hand used for writing was the only criterion, or even whether it is just an observation of his own not actually substantiated by any investigation. It is accordingly open to doubt whether in these cases the right-brainedness would be more adequately accounted for, not by left-handedness in the stock, but by latent left-handed tendencies in the actual individuals in question. This may explain those who are right-brained and appear right-handed, but there are also some who are left-handed and also left-brained. As Nielson stated:

> Chesher has shown that in about 6 per cent of persons, the major hemisphere in language is ipsilateral to the major hand. A lesion of the "wrong" side then causes aphasia.... These cases are encountered frequently enough so that one should never determine the side of the lesion by the handedness claimed by the patient. In some of these cases a well-meaning mentor has converted a left-handed child to right-handedness at so early an age that the patient was unaware of it. But this does not explain all the cases, because in some of them the patient is right-handed and yet becomes aphasic from a lesion on the right side.... It is impossible to state certainly whether a given person is right- or left-brained until a cerebral lesion with aphasia occurs.[1] (underlining mine)

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1. J.M.Nielson, A Textbook of Clinical Neurology, p.278. New York: Paul B. Hoeber Inc., 1944.

III. CHANGED HANDEDNESS AND BRAIN DOMINANCE.

Studies have been undertaken, not only to diagnose the connection between brainedness and handedness, but also to discover what happens when a child's hand preference is altered. Though many of the statements in this second connection are mere speculation, some are worth mentioning. Blau stated that:

> There is no doubt that after the first few years of infancy the dominant hemisphere takes on a unique construction in comparison to the non-dominant lobe. The dominance trait soon becomes a firmly rooted property.... It seems that the dominance decision must be made at about the age of two, a natural maturation boundary line between infancy and the pre-school period.[1]

1. A.Blau, The Master Hand, p.170.

Many would disagree with Blau's views, since he claimed that preferred laterality is not an inherited trait; nor would he allow that dominance in any form is congenital. Moreover he maintained that the evidence from aphasic patients has shown that 'the neurological counterpart of dominance'[2] remains

2. Loc.cit.

changeable for several years, and probably even up to early adolescence. These cases where, as a result of injury, the language functions become transferred to the other hemisphere, may be instances of the 'minor' hemisphere functioning, of necessity, /

necessity, because of the damage to the other which has rendered it incapable of its functions, and may not, strictly speaking, be as was assumed by Blau cases of a change of major hemisphere. To illustrate that point:- a person who uses the left hand because his right has been amputated is not, in reality, left-handed in the sense of having a preferred left hand - he has no alternative. It is possibly dangerous to infer from these cases with brain injury the normal development of dominance. Nielson quoted a case of a boy who acquired left-handedness, because of the loss of his right arm at the age of ten, which led to a change to right-brainedness. In his case it appears that the right brain did become completely dominant, though the original major hemisphere was on the left. This was confirmed by the fact that when, at the age of twenty-eight, he received a blow which brought about a cyst whose site was the right angular gyrus, the pressure caused aphasia. Thus the left side did not take over the function when the right was affected, even though it was originally the major side. Nielson stated that there have been cases where left-handed persons have been trained to write with the right hand and have, as a result, developed a writing mechanism on the left side of the brain, but that this usually leaves the right one still capable of functioning.

Roberts seemed to assume that handedness transfer was only /

only successful when the speech centre was also transferred, and suggested that this was more likely to occur when the change in handedness was close in time to the beginnings of speech. If this is correct, it might explain those instances where attempted change of handedness has been accompanied by retardation in speech development. These may be cases in which either the other hemisphere has not taken over control, or has taken a long time to do so, which would result in at least temporary confusion.

The early investigators seemed to imply that the dominant hemisphere was larger than the other, but it now seems that any difference in the two hemispheres is not strictly anatomical. Some have now swung to the other extreme, and claimed that any difference between the two hemispheres is a result of the different uses to which they have been put, as, for example, did Blau. Such a view does not explain the fact that in some it is the right hemisphere which does become dominant, while, in others, the left. There may be a hereditary basis for the tendency of one side to become dominant rather than the other, but the fact that there is no structural difference makes it possible for the dominant hemisphere to be transferred without much difficulty, especially in the early stages. Recovery in cases of aphasia also depends on this ability to transfer the /

the functions of one hemisphere to the other. Nielson pointed out that the characteristic of enforced use of the minor hemisphere for speech is, at first, extremely rapid fatigue; but he went on to say that patients could be trained to comprehend well enough to get along in life, and that the length of time required for the training would vary with different patients, and depend also on their age and general health.

Thus, the position of the dominant hemisphere may be summed up by saying that it is generally the controlling one, both with regard to speech and handedness; but that this is not, so far as is known, due to any structural superiority which it possesses over the minor hemisphere; which means, of course, that loss of, or injury to, the major hemisphere does not necessarily result in such permanent and irreparable damage to speech as would occur were there any structural difference to prevent a change-over.

IV. THE FUNCTION OF THE MINOR HEMISPHERE.

This aspect of dominance has importance in the study of handedness because the attitude adopted by investigators has coloured their views on handedness generally. Orton presents an extreme example of this, since both his theory of handedness, and the principles by which he directed the treatment /

treatment of his clinical cases were pre-determined by his view on the role of the minor hemisphere. He stated that: 'one side of the brain is all important in the language process and the other side either useless or unused'[1]. While

1. Orton, op. cit. p.27.

admitting that neither hemisphere is pre-destined at birth for control by any structural superiority, and that if one is damaged the other assumes control, he claimed that most children do have a hereditary tendency to develop the predominant use of either the right or the left hemisphere. Orton's results were based on a study of the development of speech in children, rather than on aphasic patients such as were used in the earlier studies. He did, however, retain the terms used to refer to the effects on functioning caused by brain lesions, and apply them to abnormal development in children. He preferred the term 'developmental' rather than 'congenital' used with aphasia to refer to these abnormalities in children, and differentiated the following categories in abnormal development in children:- developmental aphasia (speech), agraphia (special writing disability), apraxia (abnormal clumsiness), and alexia (reading disability). His use of these terms indicated that he considered them comparable, at least in some respects, with aphasic patients. Both /

Both his use of these terms and the basic assumptions upon which his theory was based have been criticised widely by Blau, Roberts, Brain and many others. The criticisms rest on several aspects of the study in particular, and it is probably best to cite these together with the findings in question. Blau criticised the actual terms used by Orton and pointed out that the findings on adults who have had speech, and later lost the power to use it, are in no way comparable with cases of children who have not succeeded in acquiring speech. He further pointed out that Orton's comparison implies that there is in these children some brain damage responsible for the delay comparable to that in adult aphasics, and that he has no justification for assuming this. While agreeing with Blau that it is stretching the term 'aphasia' too far to use it for an ability which a person has never possessed and cannot therefore have lost, it is worth noting that the recent electro-encephalographic studies have revealed brain lesions in some cases of what Orton would have called developmental apraxia, but what the layman would term abnormal clumsiness or gawkiness.

Nielson claimed that one of the great stumbling-blocks in the way of comprehension of all the aspects of aphasia was caused by ignoring the functions of the minor hemisphere. He stated further that all hope of retraining aphasics depends /

depends on the functional capacity of the minor cerebral hemisphere. This is obviously a criticism of Orton, who regarded the minor hemisphere as 'useless or unused'. Orton further developed his theory by stating that the patterns laid down in the minor hemisphere are the mirror-image of the used ones in the major hemisphere, and that when complete dominance is not established these patterns in the non-dominant hemisphere may interfere with recognition. He had really worked in the opposite direction and started with the observed fact that certain children have difficulty in recognising symbols, and in these cases are inclined to confuse them with their mirror-image, for example, mistake 'b' for 'd' or 'on' for 'no'. He observed that some of these children had been changed from left-handedness, while others had not achieved a dominant lead with either hand, and to explain the connection between these two observations he put forward his hypothesis that they are to be explained by a confusion between the patterns in the two hemispheres. His whole system was based on this assumption. From this it followed that dominance should be acquired as early as possible if it were not to interfere with the development of speech and later with reading. This led him to condemn any attempt to change the hand preference of left-handers, as, according to his theory, this would lead to confusion; /

confusion; while it also led him to discourage any attempts to achieve ambidexterity, or anything which might decrease the gap between the dominant and the non-dominant hemispheres. He summed up his views as follows:

> The view here presented that many of the delays and defects in development of the language function may arise from a deviation in the process of establishing unilateral brain superiority in individual areas, while taking account of the hereditary facts, brings with it the conviction that such disorders should respond to specific training if we become sufficiently keen in our diagnosis and if we prove ourselves clever enough to devise the proper training methods to meet the needs of each particular case.[1]

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1. Orton, op.cit. p.200.

For him the method of training included exercises to increase the skill and develop the exclusive use of the one hand, right or left, depending on that for which the child had the initial preference. This was used in cases of delayed speech, reading backwardness, and also of stuttering. Though Orton's statements on the reverse patterns in the non-dominant hemisphere have been severely criticised, it is generally agreed that late speaking, for example, is often associated with lack of, or unstable preference. However, Orton's suggestion that in these cases training of one hand should be undertaken in order to assist the development of unilateral dominance, and his assumption that speech will thereby be aided, have been contradicted by others, who have suggested /

suggested that he was mistaking a symptom for the cause, and that the root of the trouble may be late development of the speech nodes and lack of hemispheric dominance causing speech retardation bringing in its wake lack of definite handedness. Brain made this criticism, and pointed out that cerebral dominance is not itself a function but is simply a name for the fact that speech and allied functions are located in the same hemisphere. He made an interesting distinction in this connection:

> The abnormal handedness which so often goes with congenital speech disorders means in my view that incomplete development of speech pathways has left the child without normal hemisphere dominance on either side - a condition incidentally quite different from "natural" left-handedness.[1]

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1. Brain, op.cit. p.841.

Roberts also mentioned this when criticising the work of Orton, and further suggested that in these cases 'the absence of speech nodes' deprives the leading hand of the stimulus to real dominance, and means that the 'margin of preference' over the other hand must always be small.[2]

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2. Roberts, op.cit.

It is interesting to note that lack of hand preference can obviously not continue indefinitely, as the school situation necessitates the consistent use of one hand for writing/

writing at least, and further, that hand will be the right in the absence of a definite and strong preference for the left. It is well to remember that use of the right hand does not necessarily mean choice of the right; on the contrary, it merely indicates absence of determination to use the left. In these cases where use of the right hand is merely indicative of lack of a preference for either, it is probable that the 'margin of preference', as indicated by Roberts, is small; but we must await further research before we can say what is the exact effect of such a condition on the learning capacity; though it does appear that these children in the group stressed by Orton, that is, those lacking in definite dominance, or as he called them, the 'Motor Intergrades', may have characteristic learning troubles.

V. AMBIDEXTERITY AND RETARDED SPEECH.

In ambidextrous patients, the effects on speech caused by a brain lesion are more difficult to predict; though, in general, a unilateral lesion does not cause severe aphasia. In some cases, however, it has been found that a lesion in either hemisphere may cause damage, though it may not be so severe or so lasting as would be expected from the site of the lesion. These are possibly, according to Nielson, cases of sinistrality for some functions and dextrality for others.

Mention /

Mention has already been made of Orton's finding that delayed speech appears to be associated with lack of early development of dominant handedness. Some investigators have claimed that there is no such thing as true ambidexterity, and that those we are inclined to call by that name are merely instances of changed left-handers. Gesell[1] claimed

1. L.Carmichael, Editor, Manual of Child Psychology, p.307.

that asymmetrical behaviour is the normal human mode of adjustment, and that asymmetrical or ambidextrous behaviour would be abnormal. However, there are instances where lack of hand preference has been accompanied by lack of development in other respects, notably in speech. On observing these cases, Galen (quoted by Orton) coined the word 'ambilevous', to imply having two left hands, to distinguish them from the idea of skill which is conjured up by the term 'ambidextrous'. Several investigators claimed to find a higher incidence of left-handedness among mental defectives than in the normal population. Brain and Roberts suggested that there might be two types of left-handedness; namely, normal dominance of the left hand and the right brain, similar to right-hand dominance; and, in addition, that there might be an inferior type, in whom the dominance is less stable and both hands unskilful. In certain classifications these would be termed as left-handed, since they would use their left hand for some activities. /

activities. Brain suggested that these cases might explain the higher incidence of supposed left-handedness found in some abnormal groups, for example, among mental defectives. Roberts pointed out that especially in speechless defectives this type of handedness will be found, since handedness will not there be under the control of speech, which he considered necessary to its normal development. It would appear, therefore, that Galen's ambilevous group, Brain's second type of left-handers where the preference is unstable, and even some of Orton's cases of developmental apraxia, or abnormal clumsiness, have much in common. The most fruitful line for further research on this aspect of indecisive handedness, or what some would call a form of ambidexterity, would appear to be in the neurological field, by electro-encephalographic studies. No difference in the electro-encephalographic records of right- and left-handed persons have been found characteristic of the two types of dominance; but, as was mentioned earlier, there have been cases where abnormal clumsiness was connected with a brain lesion which was revealed by the electro-encephalographic tracing. It is now necessary to find out how frequently that type of case is present in the normal population, and whether so many of the cases of delayed speech, or lack of development of skill with either hand, or a combination of both are, in fact, due to some organic deficiency or developmental disorder which has /

has eluded the earlier investigators who had not such delicate instruments for measurement. The possibilities of increase in our knowledge of the functioning of the brain have increased considerably since the electro-encephalograph was devised. We may no longer find it necessary to await a lesion resulting in aphasia before being able to ascertain much about the working of the brain, and may find that, as new techniques for using the apparatus are developed, revolutionary discoveries may be made concerning the normal working of the brain, as far-reaching in their effects as the early studies of Head and Jackson on the pathological cases.

These examples from the findings of neurologists reveal at least that there is an intimate connection between the development of speech and dominant handedness, and even suggest that there may be some connection between retarded speech and lack of dominance. The following chapter will be devoted to a study of stuttering and handedness which, though actually one aspect of the subject of speech and handedness, is yet of sufficient practical importance to warrant detailed consideration. In addition, it is a topic which has been the centre of considerable controversy and for that reason it seems necessary to cite at least the more important investigations, and to state the actual facts which have been established.

CHAPTER VI

STUTTERING AND HANDEDNESS.

The relationship between left-handedness and stuttering has possibly more practical importance than any other aspect of the problem of handedness. Certainly, the suggestion that there might be some connection between these two factors led to a considerable volume of research with the specific aim of proving or disproving a direct association between changed handedness and stuttering. The first studies in which this possibility was revealed seemed to achieve widespread publicity, and were generally regarded as findings of serious import. The impression was created, as a result, that if a child who showed left-handed tendencies were forced to use his right hand, stuttering would automatically follow.

This early view produced a fear in many parents and teachers, and resulted in a 'hands-off' policy in connection with left-handedness, a fear which lasted for a number of years. This period was characterised by a more tolerant, or perhaps it would be more accurate to say, a more cautious attitude to left-handers, and during it they were allowed, though with half-suspicious contempt, to use that hand. It was pointed out at frequent intervals, however, both to them and to others, that actions performed with the left hand are considerably inferior and more awkward than those carried out with /

with the proper hand - the right. This attitude to left-handers has persisted up to the present day, and it is still very common to hear both teachers and parents express opinions on left-handedness which reflect these partly unconscious sentiments. Within the last few years evidence has been forthcoming that the connection between changed left-handedness and stuttering is not so absolute as was at first feared, and with this reassurance before them, those in authority have returned with alacrity to their earlier policy of insistence on right-hand training. They based their altered conduct on the evidence which they claimed was manifest, that actions performed with the left hand were less efficient than those with the right, and that it would therefore be better for everyone concerned if all used the right hand. Their second justification for changing left-handers was the research which, they asserted, showed that changed handedness has no effect on speech, and for further support they could cite many instances of people of their personal acquaintance who had been changed to the right hand for writing, and had suffered no visible ill-effects. It is probably true to say that this is a fairly accurate picture of the general attitude adopted today by the majority of people in most countries. Some left-handers are permitted to write with the left hand, but by no means all; while few people realise just how common it is still for left-handers

to /

to be encouraged or forced to use their right hand. Frequently the change is carried out before the child enters school; but, even when it takes place later, in this country at least, the change is still usually made by the parents rather than the school, though the same is not true of continental countries. The controversial subject of whether to change a left-handed child and make him use his right hand will be treated more fully in a later chapter. We are concerned here, though it has a bearing on that problem, more directly with:- first, a consideration of the more general aspects of stuttering; second, a survey of the research which has been carried out on the connection between stuttering and handedness; and third, a critical analysis of the significance of these for the problem of handedness.

I. STUTTERING.

Stuttering may result either from physiological or psychological causes. Though there is possibly no exact line of demarcation between the two types there are cases at one extreme where one can point at once to a physiological etiology, and at the other extreme there are cases where no such cause can be discovered, and the trouble seems to be mainly /

mainly the result of psychological factors. McAllister[1]

1. A.H.McAllister, Clinical Studies in Speech Therapy, London: University of London Press, 1937.

discussed in some detail a selection of cases where the stuttering was directly attributable to an organic defect; where it was caused, for example, either by defective conditions of the nasal passages, or by defective functioning of the respiratory muscles. There are no speech organs as such, in the sense that those used for speech are primarily designed for some other purpose; further, speech is carried out only on the expiration of breath, and necessitates for its correct production a steady even flow of breath, which means that jerkiness in the breath, from any cause, will be reflected in speech. These two facts mean that any disease of the nasal passages or of the respiratory muscles may cause that form of interrupted speech known as stuttering. Where such physiological factors are present any emotional concomitant shown by the stutterer when examined has probably been caused by the actual stuttering, resulting from the attitude of others to the abnormality, and while not in itself causative, its effects will without a doubt be cumulative. Such clear-cut instances are, however, seldom encountered, most cases having at least some psychological elements in their etiology. It is with this type that we are /

are more concerned here.

Many speech therapists have held that a number of aspects of attitude and behaviour which we are inclined to regard as part of the make-up of stutterers, are not actually present in the early stages of stuttering, but develop gradually, increasing each time the stutterer attempts unsuccessfully to make himself understood. The embarrassment, fear of speaking, shunning of company, and many introvertive characteristics which we see in the adult stutterer are, according to this view, defences built up, and resulting from the stuttering. - It is not an integral part of their nature to shun company, but an attempt to avoid situations in which their disability will be evident. This feeling is increased when the stutterer has been teased or subjected to ridicule because of his abnormality, but it appears to develop even in cases where no actual references have been made to the speech difficulty. Even in these cases there is some difference in attitude, a tendency to avoid the stutterer, and often on the part of the teacher, a tendency to avoid asking him to read or answer questions, though this is done out of sympathy or consideration for his feelings in most instances. Of all the subtle differences in treatment to which the stutterer is subjected he cannot remain unaware. The evidence in support of this suggestion, that /

that the emotional reactions which are inclined to be associated with stuttering result from the defect, is to be seen from studies of child stutterers examined in the very early stages of the stuttering, when it is found that the emotional content is slight or lacking; and also from the statements of cured adult stutterers, who frequently admit their previous fear of speaking and their avoidance of situations where they might be required to speak. Questioning of these cured stutterers reveals the numerous defences to which they resort in attempts to prevent the worst of the stuttering from being noticed by others. These interesting aspects of the subject have been dealt with at great length by Van Riper[1] who was himself a cured stutterer.

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1. C.Van Riper, Speech Correction, Principles and Methods. New York: Prentice-Hall Inc., 1947.

Part of his treatment was directed to forcing the patients out into situations which they had previously shunned, and where they would require to speak, but arming them in advance with as many ways as possible of dealing on a conscious level with the difficulties they would meet in these situations. Van Riper and others have found that when the stutterer was cured and knew that he had nothing to fear from his speech and that he would no longer have to face the likelihood of appearing odd in the company of others, then his personality underwent an apparently astonishing change.

He /

He was no longer a shy, inhibited introvert, since he had now the ability to make social communication, a power which had previously been denied him by his defective speech. It is an established fact that a number of great orators, with the ability to stir crowds, had some speech difficulty which they overcame, and having become master of the difficulty they went out of their way to use it as a means of social communication and power.

This question of the connection between emotional factors and stuttering requires to be studied as a preface to an assessment of the connection between changed handedness and speech. If it is established that stuttering results from a motor disturbance, as many have suggested, then the probability of changed handedness being a causative factor is greatly reduced. Kopp[1] insisted that more emphasis should be placed on the connection between stuttering and

1. H.Kopp, 'The Relationship of Stuttering to Motor Disturbances', Nervous Child, vol.II No.2, 1942, pp.107-116.

motor disturbances, and she stated that gross hereditary defects of the motor function and disturbances of various motor systems are usually found in stutterers. Bryngelson[2]

2. B.Bryngelson, 'Stuttering and Personality Development', Nervous Child, vol.II, No.2, 1942, pp.162-166.

pointed out that the interruptions of speech in the early stages /

stages of stuttering are short and tensionless and that at that stage the spasms resemble unobtrusive interruptions of the breath stream and that they become a specific handicap to communication later as a result of the psychological factors. He stated, however, that there is no motor trouble known in medicine where no deviation from normal speed takes place. It appears, from the range of views expressed on this subject, that one's decision on the greatest contributory causes of stuttering fits into a similar pattern to one's attitude with regard to other aspects of behaviour, and that something other than the actual stuttering is a decisive factor in determining these views, even with regard to any one instance. There is something reminiscent of the 'hereditary versus environment' conflict in this 'physiology versus psychology' in connection with stuttering, and as is usually the case, there is much to be said on both sides.

This is not the place for a detailed discussion on all aspects of stuttering, its causes and special features. In any case it would be presumptuous to attempt a comprehensive study of the subject within the confines of this discussion. One so easily finds oneself away from facts and into the realms of speculation in this as in other similar subjects. There are, however, a number of points which seem to be universally accepted and which have relevance /

relevance for this study.

1. It is accepted by all investigators that stuttering is a malady of childhood, being specially prone to commence between the ages of three and five years. Hildreth[1] stated that 85 per cent of cases show the trait before the age of six, and rarely after nine years of age; or Bryngelson's[2] figures were 90 per cent before seven years of age. It has been stated by West[3] that even in the few cases where

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1. G.Hildreth, 'Development and Training of Hand Dominance: IV Developmental Problems Associated with Handedness', Journal of Genetic Psychology, vol.LXXVI, 1950, pp.39-100.
2. Bryngelson, op.cit.
3. R.West, 'The Pathology of Stuttering', Nervous Child, vol.II No.2, 1942, pp.97-106.

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stuttering is not noticed until the adult level, it may have occurred earlier but been so slight that it did not attract attention; or the conditions of the social environment may have been so favourable at the early stage that its onset was delayed. Thus, though the period of learning to speak is comparatively short, it is of great importance, and at that stage more than any other disturbances of an emotional kind are most likely to be detrimental to normal speech development.

2. There appears to be a connection between late development of speech and stuttering, though it has often been pointed out that stuttering is found even in those of high /

high intelligence.

3. The incidence of stuttering is very much higher among boys than among girls. West stated that the ratio varies from 3.1 to 8.1, depending on the respective ages, and that very few female adults stutter.

4. Stuttering is only found in civilised races where reading and writing are taught, and where there is rigid training in social manners involving manual acts, according to Hildreth. It was pointed out by Chrysanthis[1] that racial

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1. K.Chrysanthis, 'Stammering and Handedness', Lancet, vol. CCLII, 1947, pp.270-271.

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factors affect stuttering, and that stuttering is unknown among the Chinese whose language consists of monosyllables. He carried out an investigation of stuttering among Greek school children, and found that there was a higher incidence amongst them than in European countries. The percentages he quoted were: Greece 1.85, Belgium 1.4, Hungary 1.02, Sweden 1.8 and U.S.A. 0.87.

5. Stuttering runs in families; that is, it is much more common in certain families than in others, and this cannot be accounted for by imitation, since frequently the stuttering members have had no contact with each other. It appears, in any case, that stuttering is seldom caused by imitation, /

imitation, and even if it is, there must be present in the imitator some weakness which makes him prone to stutter; further, it is often found, on examination of these supposed imitators, that the character of the stutter is quite different from the form they have 'imitated'. It would be incorrect to say that stuttering is inherited; but it may be somewhat similar to tuberculosis, in the sense that, though the disease is never inherited the tendency to acquire it may be, and that given certain conditions some individuals will develop a stutter, while others will not. Not much information on organic differences between stutterers and non-stutterers exists, but it has been claimed by West that there is a difference in metabolic rate and that there is a slowness in repetitive movements in stutterers, particularly those movements involved in speech; and also, that stutterers have a tendency to certain diseases of the respiratory tract. Hildreth claimed that stutterers show a marked disturbance of motor function.

6. It has been suggested, by West[1] for example, that in families where there is a high incidence of stuttering there is also more than the expected amount of twinning. Macmeeken[2] claimed that there is also a higher incidence of

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1. West, op.cit.
2. M.Macmeeken, Developmental Aphasia in Educationally Retarded Children, London: University of London Press,1942.

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left-handedness in families where twinning and stuttering appear, suggesting some connection between the three factors.

II. HANDEDNESS AND STUTTERING.

The six findings on stuttering mentioned above have been quoted because they all have some bearing on the relationship between handedness and speech. The first three points may be considered together:- that stuttering usually appears before the age of six years, that it may be associated with delayed speech and that it is much more common in boys than in girls. McCarthy, when discussing the 'Language Development in Children', directed attention to the fact that 'most studies report a higher incidence of left-handedness and a higher incidence of stuttering and also of reading disabilities among boys, who in comparison with girls are slightly more retarded in all measures of linguistic development'. She also suggested that there may be a relationship between linguistic development and motor development, 'and more specifically between linguistic development and the establishment of lateral dominance'[1].

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1. L.Carmichael, Editor, Manual of Child Psychology, p.546. 1946.

A direct connection between these has not been definitely established, but the same suggestion has also been put forward /

forward by others, notably Brain[1] and Orton[2], who have come

1. R.Brain, 'Speech and Handedness', Lancet, vol.CCXLIX No.2, 1945, p.837-841.
2. S.T.Orton, Reading, Writing and Speech Problems in Children, 1937.

to that conclusion from studies of quite different aspects of the problem. In support of this possibility of a direct connection between speech development and lateral dominance there are the two facts; first, that both are the concern of the same side of the cerebral hemisphere, and second, that the development runs parallel in time. It has been claimed that late speech development has often been evident in stutterers, and further that there is a connection between handedness and retarded speech; but whether we are justified in concluding that the third connection is present, that between left-handedness and stuttering, is another matter.

The other three points mentioned earlier have an even more direct connection with handedness. There are probably many ways of explaining the variation in the incidence of stuttering in different countries. It is possible that certain languages are more difficult to learn, and that the incidence of stuttering might be in some way connected with that variation. It is, however, at least possible that the countries where the amount of stuttering is higher may also be countries where a more rigid conformity to certain standards /

standards of manual behaviour is required. It may not be the actual standard which is the direct cause of the increase, but something more subtle. Perhaps the emotional consequences and the stress resulting from this insistence may precipitate stuttering in cases where, given favourable conditions, it might or might not have occurred. The fact that one country where the percentage of stuttering is low is the United States, makes the suggestion feasible, since that was one of the countries which earliest permitted children to use the preferred hand for manual tasks, including writing; while the incidence of stuttering is higher in Sweden and Germany for example, where right hand usage is adhered to more strictly. It should be made clear that this suggestion <u>does not</u> imply that changed handedness is the <u>cause</u> of stuttering, but merely that it is a possible explanation of the greater incidence in certain countries; since the changed handedness might there result in stuttering in some <u>marginal</u> cases who might not have stuttered had that event not occurred, and therefore it acted in these cases as a precipitating, rather than a causal, factor.

In the families where the incidence of stuttering is high, so is the incidence of left-handedness, and though this does not necessarily mean that the stutterers are left-handed or vice versa, it does mean that there is a greater possibility of stutterers being left-handed than there would be /

be if both 'abnormalities' were randomly distributed throughout the population. This may well explain the fact that some investigators have found a higher incidence of stuttering among left-handers. The danger is that one is inclined to jump to the unwarranted conclusion that there will be a large number of stutterers who are left-handed. An example will reveal this fallacy:

> Let us assume the percentage of left-handers to be 5 per cent. Now suppose that the percentage of stutterers among left-handers was even 4 per cent, which is about four times what is found in the normal population, this would mean only that 1 in 25 of stutterers is left-handed; further, you would require to study 500 people before you would find 1 left-handed stutterer.

In short, even were the percentage of stutterers four times as great among left-handers, this would not entitle us to consider left-handedness a major cause of stuttering. This mistake has had a great deal to do with fostering the idea that changed handedness causes stuttering; while many in their attempts to disprove that have concentrated on the wrong aspect of the problem. It appears that the contradictory findings on this subject are to some extent attributable to a confusion between the two issues:- firstly that forced changed handedness <u>may result in</u> stuttering; and secondly, the suggestion that stuttering is caused by changed handedness. The second statement does not, as some have assumed, follow from the first.

III. /

III. CHANGED HANDEDNESS AND STUTTERING.

The strongest advocates of the view that there is a causal connection between stuttering and left-handedness, or lack of dominance caused by attempts to change hand preference, have been Travis, Orton and Van Riper. Travis stated that failure to develop dominance, or and interference with the development of, a dominant physiologic lead are very closely related to stuttering. In support of this he quoted, first, the finding of Bryngelson, who reported that of his 200 stutterers, 62 per cent were originally left-handed and had been required to change to the right; and second, that 'in the University of Iowa Speech Clinic, of the several hundred right-handed stutterers who have been examined within the past three years, 43 per cent were originally left-handed'[1]

1. L.E.Travis, Speech Pathology, pp.139-140, 1931.

Orton, like Travis, emphasised the necessity for creating a dominant hemisphere, and claimed, as was mentioned earlier, that delay in acquiring this dominant lead would retard speech development. It would, according to Orton, also make the person more likely to stutter. He differentiated two types of stutterers:- those who have some speech impediment from the time they first begin to talk, that is from about two or three years of age; and secondly those /

those who speak normally until about the age of six or eight years, at which stage stuttering occurs. Thus he claimed that there are two critical periods in the development of speech, and that in those instances where a speech impediment, such as stuttering, develops at the early stage it is associated with some delay in beginning to speak and in the development of preferential handedness. The second critical period occurs just about the time when the child is learning to read and write; and he claimed that children who develop a stutter at that stage often also have a writing disability. Orton divided childhood stutterers into four categories:- (a) where an enforced shift of handedness was carried out by the parent or nurse; (b) where the child has been slow in acquiring a preference for one particular hand - or, in his words, showed 'motor intergrading'; (c) where there was no evidence of handedness shift, but a very strong family history of stuttering; (d) where there was no change of handedness, no evidence of intergrading and no other case of stuttering in the family. In connection with this last group, however, Orton claimed that 'in the majority of instances of these sporadic cases, disorders of the language faculty of other types or the presence of a familial tendency toward left-handedness can be found by proper inquiry'[1]. He

1. Orton, op.cit., p.125

laid /

laid great stress on the first two categories mentioned above, and emphasised the importance of 'motor intergrading' in stuttering and other language disorders.

Van Riper[1] also, when treating stutterers, considered that a history of any tendency towards left-handedness was of particular importance. He claimed that stutterers performed more like ambidextrous subjects than like normal right- or left-handers when tested on his Critical Angle Board[2]. This would support Orton's suggestion that the

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1. C.Van Riper, 'The Quantitative Measurement of Laterality', Journal of Experimental Psychology, vol.XVIII, 1935, pp.372-382.
2. Infra, Chapter VII for details of the test.

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hand preference of stutterers is not so firmly established as that of normal people (his motor intergrades). However, Van Riper's finding has since been criticised by Johnson and King[3], who claimed that his supposed ambidextrous subjects

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3. W.Johnson and A.King, 'An Angle Board and Hand Usage. Study of Stutterers and Non-Stutterers', Journal of Experimental Psychology, vol.XXXI, 1942, pp.293-311.

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were, in fact, actually representative of the normal population, while his right- and left-handed cases were extremes; thus implying that all he had in reality proved was that the stutterers' performance was not in essentials any different from that of the normal population.

Van /

Van Riper[1] emphasised the importance of changed handedness

1. C.Van Riper, Speech Correction, 1947.

in connection with stuttering, and drew attention to the difficulty of obtaining reliable histories of changed handedness because of the time which had usually elapsed since the change, and because also of the reluctance of parents to admit that such an action on their part might have been a causal factor in the stuttering.

Travis and Orton, like West, regarded stuttering from the neurological angle, while other schools of thought have had their bias towards the emotional, even though they have given a similar emphasis to the importance of changed handedness in the problem. The treatment prescribed for stutterers by Travis, Orton and Van Riper was greatly influenced by their insistence on the importance of changed handedness or lack of dominance, and they often prescribed, as a major part of their treatment of stutterers, that the child should be permitted to return to the preferred hand. Orton did not prescribe this in all cases, as he pointed out that it should only be attempted if the previously preferred hand was of sufficient motor ability. His emphasis on lack of dominance as connected with stuttering led him to suggest in such cases that measures should be used to increase the lead /

lead of the master hand, and thereby increase the gap between the dominant and non-dominant hemispheres. He did state, however, that where there had been an enforced change of handedness, 'retraining of all unilateral activities in the native hand is always worth the experiment and is often accompanied by a fairly prompt cessation of the stuttering'[1].

1. Orton, op.cit., p.194.

The general impression one is inclined to gain from a study of the works of Travis, Orton, Van Riper and other similar writers is to the effect that miraculous cures of stuttering are to be expected simply from a retraining of the left hand, if not in all cases then certainly in some. Orton did point out that to quote such instances where a change of handedness has cured the stuttering does give the impression that all stutterers should have been left-handed and should be retrained:

> This rests on a very superficial comprehension of the complexities of the problem of cerebral dominance and of the potential sources of difficulty. In many cases there is no superiority of the left hand and no indication of an enforced change form the native pattern. Many of them are marked motor intergrades with no clear preference for either hand, but some - and this applies particularly to those with a very strong hereditary lading toward stuttering - are as clearly as we can determine exclusively right-sided from the beginning[2].

2. Ibid, p.195.

This /

This sort of warning has not been sufficient to prevent such an impression being gained from the examples quoted, from a study of the rest of the book, and from other books in a similar vein; an impression without a doubt caused by the quotation of selections of instances where the stuttering was apparently cured by nothing but a change of handedness; since actual cases are more inclined to make a lasting impression on the reader than are the general statements. 'Apparently' is emphasised in this connection since no treatment at a clinic would in reality consist solely of training handedness. The very fact of attending the clinic has often some psychological importance, and frequently the effect is greatest on the parent - where it is most required, whose attitude to the stuttering may be incidentally as greatly changed as her attitude to the hand preference. Probably the greatest danger has arisen, not so much from quoting these cases by the original writers, but rather from their use by others, who in removing them from their context have given them an undue importance.

Johnson and Duke[1] made a study of sixteen cases where

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1. W.Johnson and L.Duke, 'Change of Handedness Associated with Onset or Disappearance of Stuttering: Sixteen Cases', Journal of Experimental Education, vol.IV, No.2, 1935, pp.112-132.

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changed handedness was associated with stuttering, and considered its importance in connection with the onset of stuttering /

stuttering and also with its disappearance. The value of their investigation results in part from the reasoned way in which they interpreted the findings, and also that they made no extravagant claims. They pointed out that in certain cases where an enforced change of handedness had been found along with stuttering, the stuttering was cured without any return to the preferred hand; and further, they drew attention to the important, but often ignored, fact that in some cases the reversion to the preferred hand was undertaken in the belief that this would in some way benefit speech - which meant that any such change had a suggestive value, the extent of which could not be estimated but which should not be overlooked. They pointed out that in the cases they investigated there were none in which all other etiological factors could be ruled out; in other words, in all cases where there was a change of handedness there was also some other factor which might have resulted in stuttering, but this other factor varied from case to case. This illustrates the difficulty which is encountered when one attempts to study the effect of changed handedness generally. It is unlikely that any two instances will ever be found where the only difference is that one is a case of changed handedness with stuttering, whereas the other is the same in all respects, except that the preference for the left hand had remained undisturbed.

The investigators mentioned up to this point, if they have /

have not considered handedness change as the cause of stuttering, have all emphasised left-handedness, changed handedness or lack of preference as a factor of some importance in speech disorders, and in stuttering in particular. Several authorities have taken a different viewpoint, and have tended to belittle the importance of handedness preference in the study of stuttering. Burt in The Backward Child made a study of the different percentages of stuttering found among left-handers, and claimed that the most significant fact about the figures is the wide divergence between different districts, indicating that it is not the mere fact of changing the handedness which affects speech, and that:

> It is, therefore, difficult to withstand the inference that, in the main, it is the general severity of the school discipline - of which the insistence on right-handedness is but a sample - that is really responsible for an excess that appears equally evident in both the right-handed and the left-handed groups.[1]

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1. C.Burt, The Backward Child, p.324, 1937.

He also cited in support of this the fact that in New Jersey schools where every child was required to use the right hand for writing, there was very little stuttering. It may be worth considering whether this gives support to the possibility that inconsistency in the treatment of left-handers may be worse than almost any other treatment. This would explain the fact /

fact that stuttering is not increased where the policy for a certain district is consistent; that is, the left-handed child there knows and accepts that he must write with his right hand - as for example in New Jersey at the time referred to by Burt. This would be particularly likely to be the case if the policy of right-hand writing was not carried out by punishment of the left-handers, but by a more reasoned approach; this raises the problem of how to maintain such a policy, and ensure that some individuals do not use force.

McAllister, though she did not ignore any evidence of left-handedness or change of handedness in her patients, did not consider that it was a factor of major importance, and in support of that cited the following figures:- of 139 cases of stuttering, only 9 were left-handed, and only 2 of that number had been forced to become right-handed. Her discussion of one case in particular is of relevance to this problem:-

> From the history of this case it appears that the cause of the stutter lay, not in the change from left- to right-handed movement, but in the severity of the treatment given to force the child to discard his left-handed habit. This severe treatment, meted out in the years of infancy on two separate occasions, by two different people, seems to have roused, in a temperament by inheritance prone to excitability of the uncontrolled type, disturbing and upsetting emotion[1].

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1. McAllister, op.cit., p.178

The danger of over-emphasising the importance of change of handedness /

handedness as a cause of stuttering is that it may lead to an apparent simplification of the problem, and may cause other equally or more important factors to be ignored. The treatment and cure of stuttering is no easy task, and the danger of imagining that one aspect will always play a central part is that this narrows one's outlook and may cause vital factors to be missed in a particular individual. Thus, though changed handedness may be present in two cases of stuttering, its importance and significance in the two instances can be totally different, while the attitude of those in contact with the child and the emotional reactions of the child will be of considerably more importance than the actual fact of the change.

IV. CONCLUSIONS.

Certain limited conclusions can be drawn from the volume of research which has been carried out on handedness and its relationship with stuttering.

1. Changed handedness does not always result in stuttering. Evidence that there is no absolute relationship between the two may be seen from the fact that stuttering does not result in those who require to change from the preferred hand because of some accident.

2. Stuttering may result from changed handedness, but whether it /

it does or does not will depend to a great extent on the procedure adopted in effecting the change. The stuttering is not, however, a direct result of the change, in the sense of some upset of the neurological balance causing abnormal speech; rather it is a possible manifestation resulting from the emotional atmosphere and resistance created by the attempts to make a child conform against his will to the wishes of the majority.

3. Certain periods appear to be critical with regard to speech development, and attempts to change handedness at these ages may have adverse effects on speech. It would seem to be desirable for the child to develop dominant handedness as early as possible; and any action which may delay that should be condemned, though, here again, the retarded speech and delay in acquiring dominant handedness may both result from some deeper neurological inadequacy.

4. All children have not the same tendency to develop a stutter even were the environmental circumstances comparable; therefore in children whose 'tolerance' is small, a change of handedness will have a greater effect, and may even act as the precipitating factor. There appears to be some weakness of speech functions in potential stutterers; which implies that, in such people, stuttering is the reaction to extreme emotional circumstances, while in others the reaction might be enuresis, or squinting - in each instance the weakest link.

It is clear that to gain a complete picture of stuttering will necessitate that attention be paid, on the one hand, to the physiological aspects of the problem, in the form of a possible weakness or inadequacy of speech functioning, with a probable hereditary basis; and, on the other hand, to the psychological aspects, in the form of emotional stresses which precipitate the stuttering in a particular instance. Only among these latter stresses would come changed handedness, and even there, only as one possible precipitating factor. There is, however, no one simple rule which will hold generally, indicating that there must be as many ways of treating stuttering as there are cases - though there may be some features common to a number of cases. The greatest danger appears to lie in having too narrow an outlook towards the problem; thus, though a theoretical study has its value, it is still necessary to approach each individual ready to consider the significance of <u>any</u> factor that may occur, and not biassed towards anticipating that certain aspects will always be paramount as that may cause something of importance to be overlooked. It is for that reason that undue emphasis of one aspect, such as changed handedness, is to be deplored.

CHAPTER VII.

THE MEASUREMENT OF HANDEDNESS.

Numerous different tests have been used in studies of handedness. Some investigators have attempted to find one reliable test and use that only, but the majority have employed a battery of tests, and tried to build up a composite picture of handedness.

The attitude of society against use of the 'sinister' hand has obviously resulted in a great deal of 'covered' left-handedness. In many early investigations, where a comparison of handedness and some other factor was being made (e.g. in many studies of the inheritance of handedness), the hand used for writing was often the only criterion. This in many instances invalidates the results, since pressure had frequently been brought to bear, resulting in the writing hand varying with the amount of compulsion imposed. A considerable number of left-handers may have been diverted to right-handedness, at least in writing, the change-over being effected with some before school-age, while later with others, when the writing habit had been established. Further, a correction for this under-estimation is made difficult because pressure towards right-handedness has varied from time to time, and from country to country.

The necessity to estimate the amount of 'covered' left-handedness /

left-handedness is a problem which confronts any investigator of this trait, even when some criterion other than writing is adopted. Thus in many studies a battery of tests has been used in the hope that some of the tests at least would disclose the residue of left-handedness in those who had changed, or been changed to right-handedness, for there are presumed to be some actions which even changed left-handers prefer to carry out, or perform better with the left hand, and these are included in the battery.

TYPES OF TESTS

I. PREFERENCE

Preference may be measured in various ways. One or two important unimanual activities in which one hand can be used, or bimanual activities in which both are used but one hand plays an important part, may be selected and the subject's preferred hand for these determined. Two points arise in this connection - first, whether to utilise a small number of selected important activities, or a large and varied number of tasks; second, whether these should be measured directly or indirectly, that is, must the subject actually perform the selected activities or can a questionnaire be used? These two considerations are bound up with each other, as the questionnaire enables a large number of subjects to be tested on /

on a variety of activities in a short time, whereas a great deal of time is required to apply extensive tests directly. The importance of the selected activities in the total picture must be considered, as also must the reliability of the results.

An interesting analysis by Hull[1] of a questionnaire on

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1. C.J.Hull, 'A Study of Laterality Test Items', Journal of Experimental Education, vol.IV, 1936, pp.287-290.

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handedness reveals how little reliance can be placed on the answers as being true of the actual performance. All questionnaires are not susceptible to a critical analysis such as Hull carried out, but her results should recommend caution in the interpretation of such studies. She gave two questionnaires to students, each questionnaire having forty identical items, but arranged in a different order. The first was followed by a performance test which tested exactly what had been asked in questionnaire, and in the same order. Four weeks later a second questionnaire was followed by a second performance test.

The following results were obtained:

1. Only fourteen of the forty items had a high reliability on the two questionnaires (i.e. were answered in the same way over 90 per cent of the time on the first and second questionnaire.

2. /

2. Only fourteen items were answered identically on the first questionnaire and the first performance test, in other words, were performed as the subject said he performed them.
3. On test and retest of performance and questionnaire, and comparison of written answer and performance, twelve items only were reliable.

This experiment has been cited in some detail because it reveals that little more reliable information is being gained from a lengthy questionnaire than from a short test. The actual twelve items which gave a reliable figure in the questionnaire were those easily tested by performance, namely, hammering, cutting with scissors, card dealing, spinning a top, winding a watch, holding a toothbrush, sharpening a pencil, writing, cutting when eating, drawing, throwing, holding a tennis racquet.

With the exception of batting, the bimanual activities used by Hull, and often used by others, showed a low relationship between written answer and actual performance.

These results should make one wary of accepting statements on the subject of handedness, when these are given with no indication of the testing method employed. Many of the early statements were based on the results of such questionnaires circulated to thousands of subjects. Obviously such errors as these indicated will not be cancelled out by the /

the use of large numbers of subjects. This may well be one explanation of the many contradictory statements and conflicting theories of handedness.

A more satisfactory method of determining hand preference is to decide on a limited number of important activities, and devise suitable tests to measure preference in these; since it is impracticable to study handedness under everyday conditions. The testing should preferably be administered without the subject realising what is being tested, since otherwise the results may be distorted, especially with children. This avoids the danger that one hand or other may be chosen to please the investigator, or because it is assumed to be the expected choice.

Typical examples of important activities in which a choice of hand has to be made are writing, drawing, throwing, cutting, screwing and reaching. When dominance is determined by preference, it is important to take the precaution of seeing that neither hand is actually favoured by the arrangement of objects for the test. In addition it is advisable that several trials be given, and a note made of the preference at each attempt, as this will reveal the stability of the preference.

A common method of dealing with the results of such a battery of tests or the results of a questionnaire, is to use some /

some such formula as:

$$\frac{R + \frac{E \text{ or } B}{2}}{N}$$

where R is right preferences,
E or B is either or both hands used,
and N is the number of items.

This is often referred to as the Dextrality Quotient, since a high score is indicative of extreme right-handedness, and a low score of left-handedness.[1,2].

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1. W.Johnson and D.Duke, 'The Dextrality Quotients of Fifty Six-year-olds with regard to Hand Usage', Journal of Educational Psychology, vol.XXVII, 1936, pp.26-36.
2. P.A.Witty and D.Kopel, 'Sinistral and Mixed Manual Ocular Behaviour in Reading Disability', Journal of Educational Psychology, vol.XXVII, 1936, pp.119- 34,

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II. STRENGTH.

The relative strength of the right and left hands is a doubtful measure of dominance as it is commonly understood. It is true that with the majority of people one hand has greater power than the other. Nevertheless there seems to be little connection between mere power and hand preference or ability in intricate movements or an elaborate association of movements such as is necessary for the learning of hand-writing. Many early studies used relative strength (as measured for example by a hand dynamometer) as an index of handedness, but the test is seldom used now, at least in isolation, /

isolation, though it is still included in some test batteries. Parson[1] in 1924 used it as his only test, while Woo and Pearson[2]

1. B.S.Parson, Left-handedness - A New Interpretation. New York: The Macmillan Co., 1924,
2. T.L.Woo and K.Pearson, 'Dextrality and Sinistrality of Hand and Eye', Biometrika, vol.XIX, 1927, pp.165-199.

in 1927 analysed Galton's material on handedness which was based on results from dynamometer testing. Roos[3] in 1935

3. M.M.Roos, 'Variations with Age in Frequency Distributions of Degrees of Handedness', Child Development, vol.VI, No.4, 1935, pp.259-268.

used as a battery a tapping test, strength of grip and a number marking test. Burt mentioned in The Backward Child that much of the evidence on primitive races was obtained on the basis of strength of grip. As he so rightly pointed out:

> But the dynamometer is primarily a test of strength; whereas right- or left-handedness as I have defined it turns primarily on capacity for skill. I find that as many as forty-one per cent of those who habitually use the left hand for skilled actions nevertheless have a stronger grip with the right.[4]

4. C.Burt, The Backward Child, footnote p.272, London: University of London Press, 1937.

The main criticisms of strength of grip as a measure of dominant handedness, especially with children are as follows:

1. The dependence of the results on incentive giving such results /

results as those of Binet and Vaschide (quoted in Whipple[1])

1. G.M.Whipple, Manual of Mental and Physical Tests Part I, pp.100-109. Baltimore: Warwick and York Inc., 1914.

who found that the average grip was increased by about three kilograms, or by such an amount that the left hand surpassed the previous record of the right hand made without any incentive.

2. The actual differences between the scores with the left and right hands are relatively slight. Using Whipple's norms, the scores for an eight-year-old girl are: Right Hand 11.16 kg. and Left Hand 10.48 kg., and for a six-year-old boy: Right Hand 9.21 kg. and Left Hand 8.48 kg..

3. The tendency is for left-handed subjects to give right-hand stronger results. Whipple stated that some right-handed children may have a stronger grip with their left hand, and that according to Hrdlicka, nearly half the left-handed people make higher scores with the right hand. The former might be explained since changed left-handers might develop a stronger right hand, but the latter consideration invalidates the dynamometer as a test of handedness.

Thus strength of one hand as compared with the other does not seem to be the basis on which hand preference rests.

III. SPEED.

Many tests of the relative motor abilities of the right and left hands have been used as a measure of dominance. The Tapping Test is one frequently employed, the usual method being to adapt a laboratory Tapping Test and allow the subject a certain period with each hand, taking the necessary precautions to eliminate practice effects. A calculation is then made of the relative number of taps performed by each hand, usually given as $\frac{L}{R}$ or $\frac{L}{R} \times 100$, which is an Index of Handedness; thus an index greater than unity or over one hundred indicates left-handedness.

The main criticism of such tests is that the practice gained by one hand in writing (usually the right) will probably transfer considerably to tapping and such skills, and may cover any greater native ability in the other hand. However, if the actual grading of indices is considered, then it is possible to distinguish those who are extremely right-handed from those whose left is almost as efficient as their right. This would be of importance when considering whether a child should write with his left hand, or whether he could safely use his right. The Index of Handedness brings out the degree of handedness, but it does not show whether the subject is good with both hands or poor with both, which is after all an important consideration. To illustrate, a score of 60 with the left and 30 with the right gives an index of 2; but so also /

also do scores of 20 and 10 respectively. Both indicate the same proportion of left-handedness, yet there is little similarity between the ability of the two subjects. The former is better with his right hand, though he is left-handed, than the latter is with his left. If these were the scores of two children aged five, and the question was whether they could manage to learn to write with the right hand, then obviously far more data than the actual index would be required. It is possible that the first child might be perfectly successful, while the second case would present a different problem, and might indicate poor motor co-ordination of both hands. The procedure to be adopted might well be to make the best of a bad job, and allow the second pupil to use his less bad hand, that is, his left. A more detailed discussion of this problem of changing handedness will be offered later. It does, however, illustrate that an Index of Handedness as calculated from a test of speed is evidently of no great practical value by itself. It must be backed by details of the actual ability of each hand, and the results of other tests of handedness.

Roos[1] tested handedness at the kindergarten, high school

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1. Roos, op.cit.

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and college levels. She claimed that the logarithmic handedness index (Log.R/L) of a group of infants, as measured by the Tapping Test, is distributed normally, and does not form a /

a bi-modal curve. She also stated that 75 per cent of those who have greater native ability with their left hand as indicated by a test such as the Tapping Test, develop preferential use of the right hand, probably due to the effect of living in a right-handed world. That is, she found 81 per cent right-handed on the Tapping Test, and 96 per cent on the Number Marking Test which involved writing. Even a test of tapping will not reveal all cases of native left-handedness, which means that it would be safe to say, even as a conservative estimate, that there are more left-handed people using their right hand than their left since even 19 per cent left-handed, as found on the Tapping Test, is more than twice the percentage writing with the left.

IV. OTHER MOTOR TESTS.

Other physical tests, less frequently used, which give a comparison of the relative motor performance with right and left hand, are the steadiness, aiming and tracing tests, similar to those detailed by Whipple[1].

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1. Whipple, op.cit. pp.147-160.

V. SIMULTANEOUS BIMANUAL DRAWING.

Those who were not revealed as definitely right- or left-handed were either omitted altogether in the early studies, or placed /

placed on the side of the hand most often preferred. Alternatively, some investigators arbitrarily determined intermediate classes, some making as many as seven, while others had three or four. For details of these see Witty and Kopel[1], Ojemann[2], Rife[3], Downey[4]. Obviously the numbers

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1. Witty and Kopel, op.cit.
2. R.H.Ojemann, 'Studies in Handedness: 1A-Technique for Testing Unimanual Handedness', Journal of Educational Psychology, vol.XXI, 1930, pp.597-611.
3. J.M.Rife, 'Types of Dextrality', Psychological Review, vol.XXIX, 1922, pp.474-480.
4. J.E.Downey, 'Laterality of Function', Psychological Bulletin, vol.XXX, 1933, pp.109- 42.

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placed in the intermediate classes would depend on the strictness of the criterion for right-handedness, the number of tests and of trials on each test. Thus, the results of one experimenter were in no way comparable with those of others, and the percentages of right- and left-handed and of ambidextrous individuals would vary in different experiments. Little headway could be made, since each experiment had to stand on its own, no co-ordination being permissible in the circumstances. Matters were made worse by the fact that in some reports of research the actual criteria were not stated.

The wide variations in percentages for right-handedness, left-handedness and ambidexterity given by different investigators do not necessarily mean, as some have supposed, that there is no such thing as a general trait of handedness, or /

or that it is specific to the act performed. The masking may be the result rather of the right-handed influence of society, which makes it the socially acceptable procedure to use the right hand in preference to the left. Some actions are more affected by this social pressure than others (e.g. writing and also the handling of cutlery). Accordingly, if that type of action is sampled by one's tests, the percentage of apparent left-handedness will fall, and that of right-handedness will rise correspondingly, or if ambidexterity is used as the classification for doubtful cases, then the number in this group will rise considerably.

In view of this confusion Van Riper[1,2], attempted to

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1. C.Van Riper, 'A New Test of Laterality', Journal of Experimental Psychology, vol.XVII, 1934, pp.305-313.
2. C.Van Riper, 'The Quantitative Measurement of Laterality', Journal of Experimental Psychology, vol.XVIII, 1935, pp. 372-382.

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devise a new type of test, which he claimed would measure native handedness. He stated that an adequate test of laterality should fulfil certain requirements:

1. It should show striking differences, and little overlapping.
2. Have a high degree of reliability.
3. Avoid as far as possible skills susceptible to previous environmental training.
4. Show degrees of laterality if these exist.

His original test involved drawing an asymmetrical pattern with /

FIGURE 1. THE VAN RIPER CRITICAL ANGLE BOARD

with both hands at the same time, on opposite sides of a vertical board. It was found that only one hand drew the diagram correctly, while the other made a mirror-image, that is, reversed the diagram. The hand which copied the diagram correctly was considered to be the dominant one, while that drawing a mirror-image was the non-dominant. This test was claimed by Van Riper to reveal instances of changed handedness, since it was possible for the hand used for writing to draw the diagram with clearer, bolder strokes, and yet actually do it in reverse, in which case it was shown to be in reality the non-dominant hand.

The Van Riper Laterality or Critical Angle Board was an elaboration of that idea in an attempt to measure degrees of laterality. The apparatus consists of a horizontal board with two vertical boards so placed on it that each can be rotated through 90 degrees. The testing is started with the vertical boards parallel to the chest, and paper is so arranged on the vertical boards that the records for the right and left hands will be on opposite sides of the paper. The subject is seated with the apparatus at chest level, and is instructed to copy the diagram which is placed in front of him and at about 30 degrees above eye level, as shown in Figure 1. He must copy the diagram with both hands at the same time and as quickly as possible, keeping his eyes fixed on /

on the diagram all the time he is drawing. The angle of each of the vertical boards is increased by 10 degrees at each trial, thus making the task more difficult each time, and the testing is repeated until a point is reached at which mirroring takes place with one hand. The experiment is then carried out with one further angle to test that this is consistent. The first angle at which mirroring takes place is regarded as the critical angle, and if the subject still does not mirror with either hand when the boards are back to back then he is termed ambidextrous.

Van Riper used three types of pattern, Visual, Kinaesthetic and Script. With the Kinaesthetic Pattern, the subject learned the diagram first by tracing it with both hands by means of a stylus while blindfold. When the pattern had been learned in this manner, the subject was given two pencils, and made to repeat it on the apparatus, still with eyes closed. The Script Pattern was a word such as 'catch', which the subject had to write with both hands at the same time. Here again he was blindfold. These patterns were found to vary in difficulty, the Kinaesthetic Pattern giving the lowest Critical Angle, the Visual next, and the Script giving the highest.

The theoretic basis for this experiment, according to Van Riper, was the fact that the natural orientation of the two hands in simultaneous activity is 'isotropic' with reference /

reference to the body axis, and the converging boards used in the experiment facilitate this. Increasing the angle increases the distraction, and therefore results in mirroring by the non-dominant hand.

Hildreth[1] made a study of the performance of young

1. G.Hildreth, 'Bilateral Manual Performance, Eye Dominance and Reading Achievement', Child Development, vol.XI, No.4, 1940, pp.311- 17.

children in using both hands simultaneously for copying figures, in order to investigate the developmental trends in this performance through successive age groups. She stated that the neuro-muscular apparatus favouring reversals is always potentially present, and that reversing the direction of the two hands in drawing the same figure simultaneously is a normal performance, which the higher intellectual processes can inhibit through learning or conscious attention. Hildreth found that with the five-year-old children there was little evidence of conscious effort to make both hands move in the same direction, but that the tendency to mirror declined with age or, more accurately, with maturity. Thus the mirroring given also by older children and adults on the Van Riper Test is probably to be explained as a result of the removal of the cues of vision and attention which normally inhibit such a performance.

Van /

Van Riper claimed that his test is the most reliable and best standardised test of handedness[1,2]. The evidence does

1. Van Riper, op.cit. 1935.
2. C.Van Riper, Speech Correction, 1947.

not support such a sweeping contention and, in fact, many criticisms can be made of the test. Part of Van Riper's early investigation was carried out on two groups of subjects, one group being ambidextrous and the other a group of stutterers. He claimed that the stutterers gave results on his apparatus comparable to those of the ambidextrous subjects. The only real attempt by other investigators to evaluate the Critical Angle Board was that of Johnson and King[3], who carried out an investigation similar to that of Van

3. W.Johnson and A.King, 'An Angle Board and Hand Usage Study of Stutterers and Non-Stutterers', Journal of Experimental Psychology, vol.XXXI, 1942, pp.293-311.

Riper's on stutterers. On the basis of their results they contested his claim for the apparatus. Adopting a procedure similar to that of Van Riper, they found:

1. that the correlation between the pattern scores and those obtained on a hand-usage questionnaire were low.
2. that using two groups, one of unselected stutterers, and one of unselected non-stutterers, the two groups were not definitely different in terms of their Critical Angle scores, or /

or in terms of the hand with which the reversing was done.

From a comparison of their findings and those of Van Riper, they deduced that his highly right-handed and highly left-handed subjects were quite extreme groups, while his ambidextrous subjects were fairly representative of non-stutterers generally. Johnson and King did point out, however, that from the Van Riper Test results a unimodal curve of handedness was obtained, which tended to be strongly normal in form. There would only be a bimodal curve, such as is found on many tests of handedness, if there were two distinct types of handedness. They suggested the possibility that the more differentiating the measure, the more nearly will the obtained scores from a random population approximate a normal distribution, and that if this is so, the theoretical significance of handedness as traditionally considered would require to be re-examined.

Some of the criticisms of the Van Riper Test are intrinsic in the nature of the test, while others are difficulties in testing technique which could probably be overcome.[1]

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1. Infra, Chapter XIX for more detailed study of the test.

In view of the unique nature of the Van Riper Test, and the fact that it is used in many clinics as a diagnostic instrument, it is surprising that no systematic study has been made of these points nor any attempt to get rid of some of the more /

more obvious objections. The apparatus has either been accepted or condemned. Johnson and King made one of the few constructively critical studies of the test. It would appear that some information can be obtained from a test such as the Van Riper, which other tests do not reveal. An example of that was the finding of Smith, who made a study of a matched group of retarded readers and a group of successful readers. She found no significant difference between the two groups on any of an extensive battery of tests of laterality including tests of handedness, eyedness and earedness. She discovered, on the other hand, that:

> Retarded readers and reading achievers differ significantly in their performance on the Van Riper Test of "Central" Dominance at the critical angle of 360 degrees. At this angle, the retarded readers reverse more often with the right hand; the reading achievers, with the left.[1]

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1. L.C.Smith, 'A Study of Laterality Characteristics of Retarded Readers and Reading Achievers', Journal of Experimental Education, vol.XVIII No.4, 1950, p.326.

It would consequently appear that the test should not just be dismissed, though, as Van Riper himself admitted, it is at present crude, 'and any attempt to determine a critical angle which would represent finally and forever the exact state of a person's laterality would be foredoomed to failure /

failure'[1]. Van Riper's Test, or one designed on similar

1. Van Riper, op.cit. 1935, p.381.

principles, may be of service in clinical diagnosis by revealing whether confused laterality is a factor in cases of speech defects, mirror-writing or backwardness in reading.

CHAPTER VIII.

THE MEASUREMENT OF EYE DOMINANCE.

Dominance in eyedness is a conception of quite a different character from dominant handedness. Handedness difference is motor in nature, and unimanual activities are of far greater importance than bimanual. A significant stage in evolution was reached when the hand became skilful in serving man's needs, a process which was obviously facilitated by the consistent use of the same hand. Many people have claimed that the initial difference between the two hands is actually small, that it is a matter of chance which hand is initially selected, and that the practice which the arbitrarily selected hand receives explains the gap between the abilities of the two hands and the increase of dextrality with age. With eyedness on the contrary, binocular vision is obviously the commoner, and the more important mode of vision.

Extreme views have been proposed on the importance of eye dominance. On the one hand, eye dominance has been claimed to be one aspect of sidedness, and actually the clearest manifestation of cerebral dominance. Gould stated that right-handedness follows generally on more perfect development of the right eye. 'Thus vision is the father of action, of right-handed action, and righteyedness is bound up as a precedent, synchronous, /

synchronous, and causal factor of righthandedness'[1]. Parson[2],

1. G.M.Gould, Righthandedness and Lefthandedness, p.103. Philadelphia: J.B.Lippincott Co., 1908.
2. B.S.Parson, Lefthandedness - A New Interpretation. New York: The Macmillan Co., 1924.

though he modified Gould's view also claimed that there was a close connection between eyedness and the preferred hand. At the other extreme, some have maintained that there is no such thing as dominant eyedness and that it is a product or artefact of the tests, only arising under the artificial conditions of a laboratory experiment. They have pointed out that our normal mode of vision is binocular, and that though we do on occasion have to sight with one eye, that is rather the exception. Warren and Clark, for example, have stated:

> Eye dominance as a single unitary factor does not exist. Laterality of eye functioning is specifically determined by the situation in which the measurement is made....Sensory neural organisation indicates that the problem of central functioning involves determining relationships of the two halves of the retina rather than the two eyes as a whole.[3]

3. N.Warren and B.Clark, 'A Consideration of the Use of the Term Ocular Dominance', Psychological Bulletin, vol.XXXV, 1938, p.302.

More recently Walls[4] has made a similar statement, pointing out

4. G.L.Walls, 'A Theory of Ocular Dominance', A.M.A.Archives of Ophthalmology, vol.XLV No.4, 1951, pp.387-412.

that though superficially each retina is a complete sense organ, /

organ, that neither eye moves alone except in the laboratory situation. These facts must be borne in mind when considering tests of eyedness especially those which purport to reveal thereby, once and for all, the dominant sidedness, or cerebral dominance of the subject.

Though many talk about the dominant eye, or the master eye, their meaning can vary considerably, the type of test used depending on the conception of the phenomenon. Just as in handedness one can mean the better hand, or the preferred hand; so in eyedness, by the dominant eye can be implied the eye with better visual acuity, that is, which can actually see better, or the preferred eye. Matters are further complicated by the fact that, whereas in handedness most important actions are carried out with one hand only and require a certain amount of skill, resulting in a choice of the same hand at each attempt, in eyedness, the normal method of using the eyes is as 'a pair of structures'. Thus dominance can either be considered when one eye only is being used, or in binocular vision, when fixating or sighting, when one eye takes the leading role.

TYPES OF TESTS.

I. SIGHTING PREFERENCE IN MONOCULAR VISION.

In spite of the fact that binocular vision is the normal type, some investigators have used tests to determine the preferred eye for sighting where a deliberate choice of one has /

has to be made. Examples of such tests are: sighting through a tube, looking through a small hole, sighting along a toy gun[1]. The type of situation in everyday life where such a

1. B.Crider, 'Unilateral Sighting Preference', Child Development, vol.VI No.2, 1935, pp.163-164.

choice has to be made is in shooting with a rifle, or in using a microscope. Care must be taken in tests of eyedness to eliminate as far as possible the effects of the dominant hand; in some investigations, a high correlation was obtained between handedness and eyedness, due to taking inadequate precautions to ensure that the preferred hand did not affect the results. Brock stated that the eye with which we aim a fire-arm is usually the same as the 'handedness'[2]. It is

2. S.Brock, The Basis of Clinical Neurology, Baltimore: Williams and Wilkins Co., 1937.

obvious that in such a case the task actually demands, or at least is facilitated by, such an arrangement. The effect of handedness is not quite so evident in some other tests, but is there nevertheless. Thus in tests of eyedness the subject should not hold the apparatus, or if he does, it must be held in both hands. With these precautions, the correlation between handedness and eyedness is low. The connection between hand and eye preference will be discussed in the following chapter.

II. VISUAL ACUITY.

In early studies of eyedness, visual acuity was sometimes the only measure of dominance which was used. Woo and Pearson[1], in reporting on Galton's material, stated that the

1. T.L.Woo and K.Pearson, 'Dextrality and Sinistrality of Hand and Eye', Biometrika, vol.XIX, 1927, pp.165-199.

measure used was the superiority of the right over the left eye, measured by the distance in inches at which type could be read with each eye separately. It has since been pointed out by Downey[2] and others that comparative visual acuity should not

2. J.E.Downey, 'Laterality of Function', Psychological Bulletin, vol.XXX, 1933, pp.109- 42.

be confused with the dominant eye. Further, the results of Gahagan[3] have shown that in only fifty-five per cent of his

3. L.Gahagan, 'Visual Dominance-Acuity Relationships', Journal of General Psychology, vol.IX, 1933, pp.455-459.

cases where there was a difference of acuity, was the eye with the better acuity the preferred one, and he therefore concluded that dominance and acuity were independent visual phenomena. It may be that in the majority of people, the difference in visual acuity is actually of too slight a degree to be of importance. Gahagan found that forty per cent of his subjects had visual acuity equal or almost equal for the two eyes. However, when the dominant eye has less than normal acuity and the /

the non-dominant eye is better than normal, as Gahagan found in a number of cases, the individuals concerned have a pronounced lack of visual efficiency. Recently studies have been made by Spache[1], Robinson[2] and Smith[3] on the connection of visual

1. G.Spache, 'A Binocular Reading Test', Journal of Applied Psychology, vol.XXVII, 1943, pp.109-113.
2. Clinical Studies in Reading I; Chapter V, Supplementary Educational Monographs, Chicago: University of Chicago Press, 1949.
3. L.C.Smith, 'A Study of Laterality Characteristics of Retarded Readers and Reading Achievers', Journal of Experimental Education, vol.XVIII, No.4, 1950, pp.321-329.

acuity and dominance with reading difficulties. Obviously reading efficiency may be lowered if the dominant eye is of below average efficiency. It does not seem possible, however, to train the non-dominant eye to become dominant. So far as the connection between visual acuity and dominance is concerned, it is at least clear that though the better eye may be the preferred one, visual acuity is not the basis of eye preference.

III. SIGHTING PREFERENCE IN BINOCULAR VISION.

Under normal conditions when both eyes are apparently functioning it is not evident that one eye is dominant. Some of the tests of eye dominance require the subject to have both eyes open: he is under the impression that he is using both but the situation necessitates the use of only one.

One /

FIGURE 2. THE CONE TEST OF EYEDNESS (Left-eyed Subject).

One of the simplest tests of dominance when both eyes are apparently in operation, is a sighting test, either through a cone or through a small hole in a piece of paper. The subject is instructed to hold the cone in both hands and place it up to his eyes. He is then directed to look through it directly at the experimenter, keeping both eyes open. Such is the situation, that only one eye is actually sighting, and that eye is seen by the experimenter through the end of the cone, as is illustrated in Figure 2. A similar technique is employed if using a card with a small hole in the centre. The card is held in both hands, at arms' length, while the subject, with both eyes open, fixates an object held by the experimenter. Here again, the eye seen through the hole is the dominant one. If the subject were asked to close the dominant eye, without moving the paper or the cone, he would see nothing, whereas closing the non-dominant has no effect. This is the basis of various other tests where the subject looks at an object along his finger, or through a ring with both eyes open; he closes one eye, then the other. When the dominant eye is closed, the object appears to move, while closing the non-dominant has no effect. This is explained by the fact that he is actually, and can only be, fixating with one eye, since there is only one sight-line that joins the point, from one eye to the point of the pencil or finger, and then to the object. The advantage of /

of using some test such as the 'cone' or 'hole in card' is that the investigator sees for himself which is the dominant eye, and does not have to rely on the subject's report; this is obviously advantageous, especially in testing children. It also enables children to be tested for eye dominance at a very early age. More elaborate apparatus on similar principles has been devised by Parson[1], Cuff[2], Lund[3] and others. Parson used a small darkened box which he called a

1. Parson, op.cit.
2. N.B.Cuff, 'A Study of Eyedness and Handedness', Journal of Experimental Psychology, vol.XIV, 1931, pp.164-175.
3. F.H.Lund, 'The Monoptometer: A New Device for Measuring Eye-Dominance', American Journal of Psychology, vol.XLIV, 1932, pp.181-183.

'Manuscope', which had movable shutters to permit blocking of either eye. Cuff went even further, since he attempted to measure the amount of dominance by an elaboration of this. Using his 'Manoptometer', and an easel arrangement whereby the subject, as with Parson's Manuscope, fixated a picture, Cuff brought in from the side to the field of vision a second picture, and asked the subject to say when he could see it. This was then repeated, bringing the picture in from the other side. The back of the easel was marked off in centimeters, which, according to Cuff, made it possible to secure quantitative results. Miles[4] used a much simpler measure of

4. W.R.Miles, 'Ocular Dominance, Demonstrated by Unconscious Sighting', Journal of Experimental Psychology, vol.XII, 1929, pp.113-126.

dominance which he termed a V-Scope, which was similar to the cone described earlier, and claimed that with this simple test the reliability was nine-five per cent, and that even then the indecision may be in the child and not the apparatus.

A warning was given by Crider[1], about placing too great

1. Crider, op.cit.

stress on the findings of so called tests of dominance. He carried out an investigation to discover the cause of the wide variation in figures found in different studies of eyedness, and pointed out that in over a hundred studies of ocular dominance which had appeared, it was found that right-eyedness varied from 55 to 90 per cent: left-eyedness from 6 to 33 per cent: and impartial eyedness from zero to 26 per cent. This he claimed was the result of the criteria set up by different investigators. Using a variety of common unilateral sighting tests Crider gave his subjects forty-five opportunities of sighting, and designated them as right-eyed if they were right on all the tests, left-eyed, only if left at all tries, while any variation he listed as impartial-eyed. If one sighting opportunity is given, obviously subjects are designated right or left only, therefore leaving no impartial-eyed, but Crider found that as the number of sighting opportunities increased, so did the impartial-eyed, being 13 per cent with six trials, and /

and 50 per cent with forty-five trials. From this he concluded that by increasing the opportunities indefinitely, theoretically, a point will eventually be reached where all subjects will be impartial-eyed. That of course assumes that the limit had not been reached with the testing he did. It is possible that dominance in the remaining 50 per cent was stable and would not vary, no matter what test was used, nor how many opportunities were given. However, in view of Crider's findings, it is worth remembering his statement that:

> In brief any investigator can take any set of data and by varying the criterion of consistency can vary the percentage of eye preference. Consequently the data of no two investigators are comparable unless the number of sighting opportunities and the criterion are stated, and are in accord.[1]

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1. Crider, op.cit., p.164

Crider's findings are supported by those of Buxton and Crosland, who gave a selection of four tests of eyedness to their subjects, and worked out the correlation between the tests. Those used were the Manuscope, Hole in card, Sighting and Aiming Tests, as being representative of the various eyedness tests utilised by experimenters. From their results they concluded that:

> (1) typical simple tests of eye-preference, when repeated in slightly varying ways a relatively large number of times, prove to be statistically reliable; and
>
> (2) /

> (2) the existence of a 'unitary' trait of eye-preference as such is not indicated. The latter finding may be interpreted to mean that a whole battery, not a single example of eye-preference tests, is necessary to determine which is the eye most likely to be preferred. As previously mentioned, clinicians and experimentalists who have determined eye-preference by a single test or very few tests should take into account the fact that no one test is sufficient to show various degrees of preference. It may be that eye-preference, as hand-preference, is better defined in terms of the number of activities for which the eye is preferred.[1]

1. C.E.Buxton and H.R.Crosland, 'The Concept of Eye-Preference', American Journal of Psychology, vol.XLIX, 1937, p.461.

Crider[2] carried out an investigation to learn whether unilateral sighting preferences were related to characteristic

2. B.Crider, 'The Relationship of Eye Muscle Balance to the Sighting Eye', Journal of Experimental Psychology, vol. XVIII, 1935, pp.152-154.

differences in the ocular muscle balance of the two associated eyes. He made a study of the speed, direction, and extent of movement in one eye with respect to similar movements in the opposing eye, and found that the eye with muscle insufficiency, as he defined it, was seldom the sighting or dominant eye.

IV. THE PHI TEST OF EYE DOMINANCE.

This Phi Test of Jasper and Raney was claimed by them to determine 'unilateral dominance as opposed to the peripheral ocular /

ocular aspects of the visual-perceptive system'[1], by making

1. H.H.Jasper and E.T.Raney, 'The Phi Test of Lateral Dominance', American Journal of Psychology, vol.XLIX, 1937, pp.450- 7.

use of the direction of apparent movement between near and far points of fixation. Two lights were used in the experiment, and were so arranged that conditions for the perception of Phi movement were simultaneously presented to both eyes. The subject was then made to fixate the near light, which meant that a double image was seen instead of the far light, similarly when the far light was fixated, the near light appeared as a double image on either side of the fixated light. While the subject watched the near light, the far one was switched off, and when it was again switched on, the fixated light appeared to move. Since stimulation was equal for perception of movement both to the right and to the left simultaneously, movement seen only in one direction would, according to Jasper and Raney, indicate a lateral dominance in some part of the visual mechanism. They further claimed that from the direction of movement could be deduced not only the side of dominance, but also whether it was ocular or central dominance.

The Phi Test of dominance is very elaborate, and further it takes a considerable time to administer, some subjects not seeing /

seeing the movement for fifteen to twenty-five minutes. In addition, the correlation of this test with tests of monocular sighting is very low. For these reasons it would be well to avoid the use of such tests, except for experimental purposes, since eye dominance, as measured by such a test, has not yet been convincingly shown to be any more fundamental than the more readily observed types of dominance.

V. RETINAL RIVALRY TESTS.

In these tests the eye whose image is in consciousness for a longer time in a retinal rivalry situation is regarded as dominant. This can be measured by means of a stereoscope where a different view is presented to each eye, and the subject sees each alternately. Washburn, Faison and Scott made a comparison of this type of test and a Cone test, and found that in only 33.3 per cent of the subjects was there consistency between the results of the two tests. They claimed for the rivalry test that it 'is quite possibly freer from the handedness factor and certainly gives a finer scale of measurement, since the results can be expressed in the difference between percentages of time during which each of the fields is dominant'[1].

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1. M.F.Washburn, C.Faison and R.Scott, 'A Comparison between the Miles A-B-C- Method and Retinal Rivalry as Tests of Ocular Dominance', American Journal of Psychology, vol. XLVI, 1934, p.636.

Walls pointed out in connection with the Phi Test and those of Retinal Rivalry, that they are 'asymmetries without the least possibility of an oculomotor element'[1], and could not agree with brainedness except by chance, but that at least the

1. Walls, op.cit.

phi and rivalry phenomena show that there is at least one kind of 'ocular dominance' that is not connected with brainedness and is in no way related to the asymmetry underlying sighting dominance. A new explanation of eye dominance was offered by Walls, which he called a theory of 'Directectional Dominance'. He suggested that the binocular percepts of visual direction are formed from the records of the innervations to the muscles of one eye only. Further, that the directionalisation of a visual point is governed by this one eye, whether the eye sees the given point or not, and that the motor activities of the other eye are not made use of in space perception. He gave diagrams illustrating this theory, claiming that it explains all the properties of the dominant eye in binocular vision and of one from the other when one is used alone.

Many people do not know their dominant eye, and when learning to use a microscope, for instance, have a period of experimenting with either eye, and finally settle down to the use of one. This is their dominant eye, not by virtue of the fact that it received practice, the practice has merely revealed /

revealed the dominance. It is interesting to note in this connection a fact pointed out by Walls, that after practice, the microscopist becomes able to keep both eyes open, without thereby distracting his attention from the slide. If, when using the microscope, he should attempt to use the other eye, the contents of the field of view of the dominant eye seem to interfere with good observation of the slide. Miles pointed out this phenomenon earlier, when he suggested that ocular dominance clears the field by 'giving the right of way to the image that belongs to the dominant eye, making it appear more substantial than the other which then tends to be more or less suppressed'[1].

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1. Miles, op.cit., p.113.

This survey of the commonest tests of eyedness reveals the range of factors considered important by various investigators, and reveals also the importance of caution in the acceptance of the findings on such tests. In spite of this it must be inferred that the dominant eye is a reality, though some of the statements on the subject have been rash and many of the findings of dubious validity.

CHAPTER IX

CROSSED LATERALITY.

I. CROSSED LATERALITY OF HAND AND EYE

When the dominant hand and eye are not in accord, the condition is termed crossed laterality. Many have suggested that the ideal arrangement is for the favoured hand and the dominant eye to be on the same side, as this would facilitate co-ordination of movements. Since dominant eyedness, unlike dominant handedness, is not evident to the casual observer, and therefore not subjected to any social pressure, some have claimed that it is the better indication of true laterality, and that crossed laterals (at least of the right-handed and left-eyed type) are native left-handers. Alongside this view that like-dominance was the natural position, and also the ideal, has grown the belief that crossed laterality is an educational handicap, and that it may even be the cause of backwardness in reading and of various behaviour disorders. A critical analysis of such statements is not possible without some knowledge of the actual findings on the correlation between handedness and eyedness in the normal population, and for that reason, several of the more important studies will be mentioned.

Gould /

Gould[1] in 1908 made the most extreme statement on the

1. G.M. Gould, Righthandedness and Lefthandedness, Philadelphia: J.B.Lippincott Co., 1908.

relationship between handedness and eyedness, claiming that the centres for right-eyedness, right-handedness, speech and writing must be in the left cerebral hemisphere for speed, accuracy and co-ordination. No evidence has yet been adduced in support of the view that eye-dominance is in any way connected with one side of the brain, let alone connected with the same side as handedness. Parson somewhat modified Gould's view stating:

> Man has also developed certain dominant single faculties such as speech and memory which cannot be classed as belonging to either side of the body exclusively, but rather to the organism as a whole. In a general way it can be stated that we find the neural areas which innervate these highly complex single faculties grouped in the same hemisphere that contains the centre controlling handedness and eyedness. This affords the most direct and speedy co-ordination of sight impressions with intellect, will and action.[2]

2. B.S.Parson, Lefthandedness - A New Interpretation, p.22, New York: The Macmillan Co., 1924.

Parson then attempted to test, or rather to justify his hypothesis by examining the handedness and eyedness of his subjects, using strength of grip as a measure of handedness, and testing eyedness by means of his Manuscope. He did not find a perfect correlation as he expected, but on analysing the cases of disagreement, he claimed to find some explanation.

Where /

Where crossed laterality was of the nature of right-hand, left-eye, he found that the subject had originally shown left-handed tendencies, whereas in those who were left-handed and right-eyed, he found some ocular defect in the left eye to explain this unexpected preference. He made no analysis, however, of the cases of agreement, where he might have found just as many changed left-handers. Parson's findings have not been confirmed by any other investigator since, and Cuff[1]

1. N.B.Cuff, 'The Interpretation of Handedness', Journal of Experimental Psychology, vol.XI, 1928, pp.27-39.

actually repeated the experiment with Parson's instrument, and found that the exceptions to Parson's theory of handedness as a result of eyedness amounted to approximately twenty per cent of the number tested. In other words, crossed dominance is common.

Woo and Pearson[2] investigated this problem more

2. T.L.Woo and K.Pearson, 'Dextrality and Sinistrality of Hand and Eye', Biometrika, vol.XIX, 1927, pp.165-199.

scientifically to find out if the amount or frequency of ocular dextrality bears any relation to the amount or frequency of manual dexterity. Their data were wholly opposed to the view of a master eye. They did not even find any evidence of a correlation between the two, on the tests they used - that is, between /

between relative strength of grip and relative visual acuity. In all these studies the tests used must be considered, as they frequently give a clue to differences in the findings. These studies were all made on adults, but more recently tests have been applied to school children, and even to pre-school children.

Cuff[1] in 1931 pointed out that statements have been made

1. W.B.Cuff, 'A Study of Eyedness and Handedness', Journal of Experimental Psychology, vol.XIV, 1931, pp.164-175.

in studies of eyedness and handedness suggesting that the left-eyed are naturally left-handed and that even if trained to use the right hand, they will reveal sinistral tendencies or some indication of an inherited tendency to sinistrality. He made a study of 237 children and 109 college students, and found that all the left-handed children were left-eyed with one exception, who was equal-eyed; one cannot infer from this that all the left-eyed were left-handed. In fact, he also stated that the correlation between eyedness and handedness is apparently low.

A recent study of pre-school children which enables one to see the correspondence of handedness and eyedness before the writing situation has effected handedness preference is that of Updegraff[2], who made a study of seventy-four children

2. R.Updegraff, 'The Correspondence between Handedness and Eyedness in Young Children', Pedagogical Seminary, vol. XLII, 1933, pp.490-492.

aged from two to six years old, using an adaptation of the Miles Cone and her own handedness test. Her findings were as follows:

Right-handed children who are Right-eyed - 72 per cent.

Left-handed children who are Left-eyed - 66 per cent.

Right-eyed children who are Right-handed - 95 per cent.

Left-eyed children who are Left-handed - 21 per cent.

She pointed out that a right-eyed child is evidently more likely to be right-handed than a left-eyed child to be left-handed. However, it must be borne in mind that she had only eight left-handed children in her study. Her figures accord fairly closely with those found by other investigators working on older subjects. In summing up her findings, she also stated:

> There is the possibility that even at these early ages 'native handedness', if it exists, has been changed through training in some cases...Possibly the concept of unilaterality as varying in degree and of that degree expressed in terms of different manifestations of dominance, of which handedness and eyedness are only two, is the most plausible hypothesis at present.[1]

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1. Ibid, p.492.

It is clear from the various studies of dominance on normal subjects, that crossed laterality, with regard to hand and eye, is much commoner than is often realised, the figures being /

being about seventy per cent uncrossed and thirty per cent crossed, with the majority of the latter being right-handed and left-eyed. While it is possible that there exists in this latter group a number of changed left-handers, this cannot account for the whole group. Further, one cannot assume that all changed left-handers are left-eyed - some may be right-eyed; it is quite legitimate to suggest that they might owe their success in effecting the necessary shift to the fact that they were already right-dominant with regard to one aspect, eyedness.

Although it is established that crossed laterality is common, this does not exclude the view that unilateral dominance is the ideal. Frequent assertions have been made to the effect that it is an asset to have the preferred hand and eye on the same side, as was assumed in the theories of Gould and Parson. This is of importance, particularly in education, since it has a bearing on the problem of whether a left-handed child who has been changed to right-handedness should be encouraged to change back or not. If the child were right-eyed then it might be advisable to allow him to continue using his right hand; whereas if he were left-eyed, and of changed handedness, this would result in his labouring under the double disadvantage of using the non-preferred hand, and also the hand on the opposite side to the preferred eye.

At present one cannot make a definite statement on that aspect, since it is not known in what activities crossed laterality is a disadvantage. Its effect may be limited to certain situations, for example, monocular sighting in such activities as rifle shooting. Whether it is important in binocular situations is not established. The educational aspects of this problem will be dealt with later, but mention may be made at this stage of a study by Lund[1], on the

1. F.H.Lund, 'The Dependence of Eye-Hand Co-ordination upon Eye-Dominance', American Journal of Psychology, vol.XLIV, 1932, pp.756-62.

connection between eye dominance and eye-hand co-ordination. He used, in his investigations, a test in which eye-hand co-ordination was obviously important for skilled performance, an accuracy test similar to that in Whipple's Manual of Mental and Physical Tests[2]. The subject attempted to strike

2. G.M. Whipple, Part I, pp.147-151, Baltimore: Warwick and York Inc., 1914.

accurately on crosses marked on a target placed at such a distance that his pencil would touch it when his arm was outstretched. Lund compared the results when both eyes were open, when only the dominant, and when only the non-dominant. He found that the best scores were gained with both eyes open, and the poorest with only the non-dominant. However, it is interesting to note:

In /

> In the case of the left-eyed dextrals the non-dominant eye yielded the better score in almost as many cases as the dominant eye. This would seem to indicate that the right eye, though not the dominant eye in the case of these subjects, has nevertheless been brought more into use than might otherwise have been the case, since it is the nearer eye so far as the functionally dominant hand is concerned. The data in this case point definitely to the advantage of consistent lateralism.[1]

1. Lund, op.cit., p.762.

Thus we may say that crossed laterality appears in the normal population in the ratio of approximately 3:7, and that certain actions may be facilitated by having consistent laterality, though we have no proof that it is of sufficient importance to warrant attempting to change the dominance of either hand or eye that they may be in accord. The suggestion that the left-eyed dextrals may have been native sinistrals who were changed to right-handedness, appears to be an unlikely explanation of the whole group, though it may explain certain cases, and these may in fact be the ones where crossed laterality is a handicap. Not only are they using the non-preferred hand, but that on the opposite side from the dominant eye. Confusion is understandable in these cases. Finally, a tentative suggestion in this connection is the possibility that pure sinistrals (LH-LE) and pure dextrals (RH-RE), may be extremes and that crossed laterals (LH-RE and RH-LE) may be intermediates even with regard to handedness, and /

and perhaps a change is also easier with them for that reason. This possibility has been mentioned recently by Humphrey, who made a study of the variability of hand preference for different activities. From the results which he obtained on the basis of a questionnaire given to male students, he graded the subjects for handedness, giving them an index to represent the degree of left-handedness. When he studied the eye preferences of his left-handed subjects, he found that:

> It will be seen that total unilaterality is relatively more frequent in the control group than in the left-handed subjects. Of the latter, the more strongly left-handed show an appreciably higher incidence of left-eyedness (27 out of 38, i.e. 71 per cent.) than the less strongly so (14 out of 32, i.e. 44 per cent). Ambilaterals and others whose laterality index is less than .75 show an almost equal division between left-eyedness and right-eyedness.[1]

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1. M.E.Humphrey, 'Consistency of Hand Usage', British Journal of Educational Psychology, vol.XXI, 1951, pp.220-1.

Some caution must be shown in accepting these results as final, as no actual test of eyedness was given to the subjects, the results being based on a statement in the questionnaire. Further, the two groups of left-handers were constituted on the basis of writing with the left hand, the extreme group writing with the left hand, while the other group comprised those who were left-handed in other important activities but not in writing. Since many of these students started school at a time when left-hand writing was frowned upon, even more than it /

it is to-day, one cannot be certain that Humphrey's group of less extreme left-handers were natively less extreme; many in that group may have been forced to write with the right hand.

Many of the findings on crossed laterals are susceptible to numerous interpretations, and care must be taken in examining them to note the possibility of some more important and feasible interpretation than that put forward by the author. Such difficulties, frequently confront investigators of what are, after all, not even the strictly physiological aspects of behaviour. All factors cannot be kept constant except those being studied as may be possible in the physical sciences; one must be aware of them, estimate their effect, and allow for them when drawing conclusions. The actual figures given in the results are not of prime importance, nor can they stand in isolation from the context, as is possible in physics, they are only applicable within a certain field, which must be comparable in essentials with that in which the experimenter gained the results. More important than the actual results is how they were arrived at, the number of subjects, what tests were used, and, most important of all - what conclusions were drawn from the figures, and with what justification they were made. Many investigators of handedness, eyedness, and of the connection between the two, have /

have set out with a hypothesis which they wished to prove, and in their desire and anxiety to do so, have seized upon all confirming evidence, and ignored or overlooked the negative aspects, dismissed them in a word, or excused them as caused by the type of sample.

II. OTHER ASPECTS OF CROSSED LATERALITY.

When reference is made to crossed laterality hand and eye dominance is usually implied; although two equally valid aspects are hand and foot preferences, or indeed any other pair of structures in which asymmetrical functioning is displayed. Attention has frequently been directed to crossed laterality of hand and eye, because of its potentialities for educational disability. Thus, many studies, even if not specifically a consideration of the educational effect of crossed laterality, have had that as a background, or justification for the work. Studies have been carried out on the relationship between hand and foot preferences, and with fewer contradictory results than were evident in those on hand and eyes by Cuff[1], Eyre and Schmeckle[2] and Dart[3], to mention

1. N.B.Cuff, 'A Study of Eyedness and Handedness', Journal of Experimental Psychology, vol.XIV, 1931, pp.164-175.
2. M.B.Eyre and M.M.Schmeckle, 'A Study of Handedness, Eyedness and Footedness', Child Development, vol.IV,1933, pp.73-78.
3. C.Dart, 'The Hand, Eye and Foot Preference of Two Hundred Mentally Subnormal Subjects and Two Hundred Subjects of Normal or Superior Intelligence', Psychological Bulletin, vol.XXXI, 1934, p.593.

only /

only a few. Investigators, though finding a low correlation between hand and eye preference, have usually found it high between hand and foot. The findings in this connection will not be discussed in detail as crossed laterality of these is comparatively rare, and in some cases exemplified by right hand and left foot preference resulting from change of handedness. Left-footers have their obvious sphere of usefulness, but possibly ability to use either foot is of more value in sport. The most commonly tested aspects of footedness are kicking, stepping and hopping, which do not require for their performance such a high degree of skill and precision as manual activities; and for that reason foot preference is not so consistent as is hand preference. 'Kicking' is the most consistently performed foot activity, and, as might be expected, the one which correlates most highly with handedness.

CHAPTER X

LEFT-HANDEDNESS AND WRITING PROBLEMS.

I. GENERAL DISCUSSION.

Until very recently only a small minority of those with left-hand preference were actually using that hand for writing, though many of them were using it for almost every other skilled action. It has been found that some adults, even though forbidden to use the left hand for writing at school, have, when they left school, changed over to writing with the left hand of their own accord and quickly acquired great facility with it. The existence of people who in spite of years of training are so poor or ill-at-ease with the right hand that within a few months the left hand surpasses it in skill, reveals that even many strongly left-handed children are not writing with the left hand. Thus the group of left-hand writers is peculiarly constituted, a fact which should be borne in mind when any comparison is being attempted between left-hand writers and those who use the right hand, since the latter group contains many extremely left-handed people. The efforts to change a left-handed child to using the right have varied in strength from year to year, district to district, school to school, and even from one family to another. One of the most unfortunate aspects of the treatment meted out to left-handers /

left-handers has been its inconsistency not only from one child to another, but also with an individual child. What happens frequently is that in the infant classes no objection is raised to the child using his left hand; but for nearly all pupils there comes a stage in his school career - often about the age of eight when he should be acquiring some speed in his writing - when a teacher suggests to the child, or insists that he try the other hand. Sometimes the suggestion is even less direct than that, and he is just made to feel so awkward and different that he changes over of his own accord; this is more frequent with girls. As a result of this transfer one of three things may result:

1. If the child is fairly skilful with both hands, he may find that he manages to acquire right-hand writing of a character which is not far short of that of his right-handed companions. If this occurs the transfer has been successful; since its ill-effects on the child are probably negligible, and it makes the teacher's task easier. In this category belong many who are commonly termed ambidextrous. They are not necessarily of equal skill with both hands, but are of above average skill with the right hand and can therefore hold their own with their right-handed fellows. In addition they are extremely 'dextrous' with the left hand, and remain so in spite of the fact that it receives less training. Many investigators have /

have maintained that there is no true ambidexterity, and that those to whom the name ambidextrous is given are, in reality, changed left-handers. Some people, in spite of a left preference, change over to the right hand before or when they start towrite, but those who appear ambidextrous even in writing frequently started writing with the left hand, and were later successfully changed to the right. Mention might be made in passing of a cult at the beginning of this century initiated by Jackson who founded the 'Ambidextral Cultural Society' for the promotion of educational reform and two-handed training. Jackson even advocated that children should be trained to use both hands simultaneously in writing, and, as a final step, taught to write different things with both hands at the same time. His book Ambidexterity is a rather extravagant but entertaining advocacy of the benefits to be derived from becoming equally skilled with both hands.[1] As a

1. J.Jackson, Ambidexterity p.244, London: Kegan Paul & Co.Ltd., 1905.

result of Jackson's work many infant schools introduced two-handed training and copy books were even prepared to that end, but the craze did not survive long. Its main interest now is that it accounts for the view held so often by people of a certain age group that ambidexterity is the ideal.

2. The second group with a left preference are in quite

a /

a different position. Many children, either due to excessive pressure or a desire to conform to custom, having once changed to the right hand, do not attempt to use the left again for writing, though they may be very much poorer with the right than the majority of right-handers, and also poorer than they are with their own left. Many of these are found in the category of bad writers. This cannot be advanced as the sole cause, or even a principal cause of bad writing in general, but it is safe to say that it is the explanation of a number of cases of illegible or slow writing. These people might have been good writers had they been permitted to use their left hand, as also might many left-handers if they had not been forced to use the right hand from infancy. Orton, when discussing cases of special writing disability, stated in this connection:

> The second type of this disability is that in which the quality of the writing suffers. In speed, these latter children are variable; some of them are slow, as well as poor writers, while others achieve a good speed but the quality of their product is far from acceptable and often quite illegible.
>
> In many cases of this difficulty there is a history of a shift from the left to the right hand in early infancy, or an enforced training of the right hand for writing in spite of a strong preference for the left as exhibited in all spontaneously acquired skills. These shifted sinistrals seem a little more apt to fall into the group of slow writers rather than poor writers, although there is no consistency in this.[1]

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1. S.T.Orton, Reading, Writing and Speech Problems in Children, p.101.

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3. We must also consider those who write with the left hand, but for a period of weeks or months, probably about the age of eight, and at the instigation of a teacher, had a period when they attempted to write with the right hand. At some time or other most left-hand writers are compelled by someone to use the other hand. For many it is only after a period of such experimenting, causing not only a delay in acquiring speed with the left hand, but also a sense of failure and frustration, that they are allowed to revert to their preferred hand. Thus, many left-hand writers only write with that hand on sufferance or because, as several have admitted to the writer when asked why they changed back to the left - 'When she saw I was worse with my right hand, I was allowed to change back to the left'. The danger of such a policy is that those children are retarded in school as a result of struggling to write their work with the poorer hand for a period, and what is worse, they have a sense of failure if they do not succeed in learning to write with the right hand. It is no triumph for them to be permitted to revert to their preferred hand; on the contrary, it is only tolerated because they failed to adapt to the other.

The following points should be borne in mind when estimating the truth of statements on left-handedness and its connection with writing:

(a) Not all those with an innate preference for the left hand /

hand write with that hand. Many who are proficient with the left, are yet sufficiently proficient with the right to have adapted to right-hand writing.

(b) Most left-handers, even those writing with that hand, have been subjected at some time to a period of enforced use of the right hand.

(c) The inconsistency in the treatment of left-handedness means that the background of each individual must be studied, since some have a struggle before they are permitted to use that hand, while others are automatically permitted to use the left hand provided they show a strong preference for it. Thus, comparisons between groups of left-handers should be regarded with caution, while comparisons between right- and left-handed groups as far as writing is concerned are actually dangerous.

It must still be admitted that there is some truth in the suggestion that left-handers are bad writers. It is, however, one of those generalisations with a certain amount of truth in it, and for that reason all the more dangerous since frequently the wrong conclusions are drawn from it. By no means all left-hand writers are bad writers, on the contrary, some are as legible and as speedy as the better right-hand writers, though their style may be different. The majority of those writing with the left hand produce writing which is either neat or speedy, but seldom both; which is admittedly a failing not entirely confined to them. They do, however, suffer more from fatigue /

fatigue than those using the right hand if subjected to prolonged periods of writing.

II. COMMON CHARACTERISTICS OF WRITING WITH THE LEFT HAND

1. THE ACTUAL WRITING

Writing done with the left hand is sometimes neat, and sometimes quickly done; but is seldom both legible and speedy. Most left-handers given time can write neatly; their most common failing is their inability to acquire the necessary speed to meet everyday requirements. This is not, however, a necessary characteristic of writing with the left hand, but only a failing commonly found as a result of lack of proper guidance. The slope of their writing is seldom naturally the orthodox forward slant, and where it has been insisted upon by the school, the slant frequently varies from letter to letter, and from page to page. No definite style is acquired, as if a left-hand writer were still seeking some new adjustment or more comfortable technique, even at the adult stage. The writing of left-handed children is often messy and when written in ink is frequently smudged. This is not so true of the adult left-hander who usually develops some technique whereby this is avoided, but often at the cost of considerable strain.

2. POSITION WHEN WRITING

When writing is done with the left hand an awkward position is frequently adopted. A cramped position of the arm and /

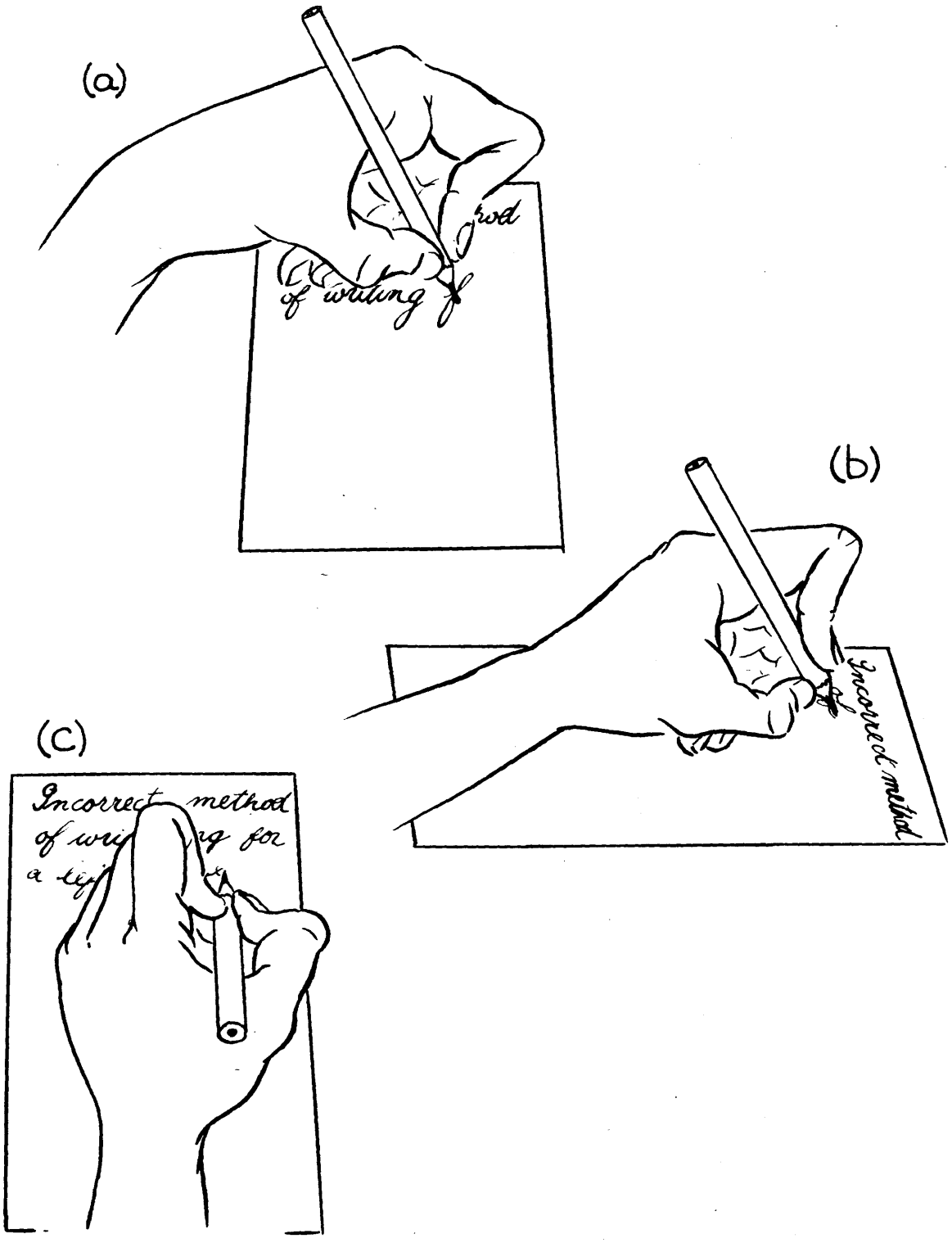

FIGURE 3. ILLUSTRATION OF INCORRECT WRITING POSITIONS ADOPTED BY LEFT-HAND WRITERS

(a) arm hooked above writing
(b) writing in towards body
(c) with arm cramped in to side

and twisted position of the whole body is very common; as also is an awkward tense grip of the pen or pencil. Left-handers seem to remain conscious of the writing movement for a long time; they have accordingly jerky effortful movements when writing. They use many odd methods of writing; though a warning is necessary in this connection, since those who write in an odd manner are those who are noticed, while those writing in a normal easy way are seldom apparent to the casual observer as being left-handed. Thus people are inclined to generalise from the few awkward left-handers they have noticed, and to assume that awkwardness to be a characteristic of left-handedness. However, a considerable number of left-handers do have some peculiar method of writing. This is true not only of adults who grew up at a time when left-handedness was even less tolerated than it is now, but is also true of young children in the schools to-day. There are various types of peculiarity in the way the pen is held, the commonest being 'the hook', where the hand is actually above the line of writing as shown in Figure 3(a). In fact this position is so common that it is even regarded by many teachers as the normal method of writing with the left hand. There is nothing normal about this position, and some consideration of the differences between writing with the right and left hand readily explains how it develops. When one writes with the right hand, the hand is ahead of the writing; while to achieve this /

this when writing with the left hand, the writing would require to be done from right to left. Thus a left-handed child finds when he starts writing that the grip which his right-handed neighbour takes of the pencil, and which the teacher demonstrates, is not suitable, and since he is shown no alternative, he adjusts for himself. He must so grip the pencil that he can see what he is writing; and he therefore grips it at the same distance from the point as does the right-hander, but curves his hand slightly to enable him to see under it. This is quite satisfactory with pencil writing, but when he begins to write in ink he finds this is no longer satisfactory for two reasons; first, the point of the pen pokes into the paper; second, it results in continual smudging of the writing, as the hand is still rubbing over the writing - he accordingly completes the 'hook', placing his hand right above the writing. This is unsatisfactory for several reasons, though it is one adaptation which teachers permit left-handed children to acquire. It is difficult to achieve neat writing by this method and it is a continual strain to the hand, thus anyone adopting this technique will readily become fatigued if required to do much writing. Another method used by left-handers is to turn the paper sideways and write down towards the body, this again being another attempt to acquire a comfortable position. Teachers are inclined to correct this position, but seldom suggest an acceptable alternative. One child /

child pointed out as a neat writer though left-handed, was questioned as to his method of writing. It was found that he had no peculiar grip of the pen and a fairly free movement somewhat similar to that of a right-handed child. On enquiring how he avoided smudging his writing, it was found that he blotted the writing after every word. The product was neat but extremely slowly performed and with considerable unnecessary labour. Cole[1], who made a study of the development

1. L.Cole, Psychology of the Elementary School Subjects, pp.121-125. New York: Farrar and Rinehart, 1934.

of these habits, found that the three types illustrated in Figure 3 appeared frequently. Thus, these are not isolated cases, but are typical of left-hand writing positions.

III. CAUSES OF THE CHARACTERISTICS OF LEFT-HAND WRITERS

All these points are not true of all left-hand writers, but they are the type of deficiency revealed by a study of the writing and writing method of left-handed adults and children. It would be a useless generalisation to say that left-handed people are bad writers, and just leave it at that. To discover an explanation of this fact, and offer a method of improving the writing, an analysis of the type of faults is required. Only then can one decide whether the faults are a necessary feature of writing with the left hand, when a transfer /

transfer to right-hand writing might be the most satisfactory procedure, or whether they can be cured by a different technique of writing with the left hand in which case reform of the teaching is the solution.

All the faults listed above could easily be prevented by some guidance in the early stages. Writing with the left hand is not the same as writing with the right, with only a change of hand. For the movement to be the same with the left hand, the writing would require to be performed from right to left, as only then would the hand be moving away from the body while progressing along the line of writing, as happens with the right hand. In view of this, other adjustments are necessary or situations such as these already mentioned develop, and result in slow awkward writing. What is worse is the fact that by the time the person is old enough to be aware that his technique is uncomfortable and inefficient, it has become too stereotyped to be changed without great difficulty. In many schools those with a strong preference for the left hand are now allowed to use the left hand for writing; but they are not taught to write with the left hand, only permitted. Usually the result is that they grip the pencil wrongly; place the paper as for right-hand writing which inevitably results in a cramped arm movement, since, while the right arm moves away from the body in writing, the left arm moves in towards and across the body; and since the ink-well is on the wrong side of /

of the desk, necessitating the carrying of the pen filled with ink across the paper, continually smudge the writing.

It may be asked whether one need look and feel awkward when writing with the left hand, and, if not why that does so frequently happen. Many have assumed that all these symptoms are typical of what inevitably happens when one writes with the left hand, this is, in fact, one of the excuses given for the insistence on writing being carried out with the right hand. It is now some years since authors suggested that bad writing need not necessarily result from using the left hand and since constructive suggestions were made for the proper guidance of left-handers in learning to write. As early as 1927, West pointed out the need for a set of directions for dealing with the left-handed child.

> There is a great deal of uncertainty among teachers as to what to do with the left-handed writer. Some proceed to make him over into a right-handed writer as expeditiously as possible. Others will do so only on condition that the child is below a certain age. Some will permit the child to write 'backhand' if it is natural for him to do so, others insist on the imitation of the formal slant. Definite and detailed recommendation is needed with regard to these and many other points bearing on the left-hand writer, the mirror-script writer, the subnormal, and the physically defective child. These pupils though in the minority, are often encountered, and the problems relative to their instruction are very confusing.[1]

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1. P.V.West, Changing Practice in Handwriting Instruction, pp.55-56, Bloomington, Ill.: Public School Publishing Co., 1927.

Cole, in 1934, in her book on the Psychology of the Elementary School Subjects, devoted considerable space to a discussion on how to teach left-hand writers. As she pointed out:

> If the left-handed child is independent enough to succeed literally single-handed in his contest with his teachers, some at least of whom will try to change him, his troubles have only just begun. All systems of writing are based on the assumption that the writer will use his right hand. The youthful and determined left-hander is usually forced into a system not in the least adapted to his needs.[1]

1. Cole, op.cit., p.122.

She then went on to state that the correct posture for the left hand is as comfortable and relaxed as that for the right. Orton[2] also discussed the correct position for the paper and

2. Orton, op.cit., pp.179-185.

technique for writing with the left hand; while Freeman stated that the left-handed child is apt to acquire a highly awkward method of writing if left to himself, but if properly taught he may develop a habit of left-handed writing which is nearly as convenient as is right-hand writing[3]. In 1939 Cole[4] discussed

3. F.N.Freeman, Solving Handwriting Needs As We See Them To-day, pp.2-16, Columbus, Ohio: Zaner-Bloser Co..
4. L.W.Cole, 'Instruction in Penmanship for the Left-handed Child', Elementary School Journal, vol.XXXIX, 1939, pp.436-448.

in great detail all the points of importance in teaching left-hand /

left-hand writing, and also explained how the peculiarities in their writing arise under the present system which is quite unsuited to their needs. In 1945 an instruction manual was published to serve as a guide both for teachers and for adults who had developed inefficient writing methods with the left hand. This is the only manual which has been prepared specially for this purpose, according to the Editor's Foreword; and Gardner's[1] aim in the manual was to assist left-handers to

1. W.H.Gardner, Left Handed Writing - Instruction Manual, Danville, Ill.: The Interstate Co., 1945.

acquire an easy movement in writing, and through that effortless, speedy writing. The exercises are so planned that they can be used by the left-hander himself with a minimum of guidance.

These examples may suffice to show that there is material on how to teach a left-handed child to write; thus any suggestions which are made here have at some time been given by others, though the emphasis may be slightly altered. They are assembled and repeated here in the hope that their inclusion in a book specifically on left-handedness may at last direct the attention of those actually concerned with teaching writing to the basic essentials and may result in a more positive attitude to the teaching of writing to left-handers; they may even instil a new spirit into the whole of handwriting instruction, making it more directed to writing needs in later life /

life and based on an awareness of the differing abilities of individual pupils.

IV. SUGGESTIONS FOR THE TEACHING OF LEFT-HAND WRITERS.

The following three improvements, if adopted and applied, would in themselves eliminate the awkward type of postures common in left-hand writers, and make their writing movements smoother and less effortful.

1. POSITION OF THE PAPER

Authorities on handwriting instruction have for many years been contending that the correct position for the paper when writing with the right hand is at an angle, with the left hand top corner of the paper nearer the body than the right, and that the reverse angle is correct when writing is performed with the left hand, while in the latter case the effect of the wrong position is more unfortunate. If the paper is placed horizontally and directly in front of the person writing with the left hand several difficulties arise: (a) with the paper in the horizontal position a backward slope in the writing is easier, a regular forward slope being almost impossible; (b) as the hand progresses across the page the arm becomes more and more cramped in towards the body, whereas in right hand writing, which is moving away from the body all the time, the movement across the page becomes continually freer; (c) it is very difficult to see what has been written as the hand /

hand covers the words, which of course also leads to smudging of the ink. Accordingly, from the early writing lessons a left-handed child should sit slightly to the right side of the desk, with the paper placed alongside him on his left, thus allowing a freer arm movement. In this connection Gardner's manual gives the following instructions:

> Now study the position of your paper. At the end of the first line of writing, your pencil will start far to the left. As you finish at the right edge of the paper, your pencil will still be slightly left of the mid-line. This is the reverse of the movement used by the right handed writer who starts to the right of the mid-line of the body and writes far to the right.[1]

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1. Ibid, p.7.

The paper should also be angled with the left-hand top corner higher than the right (as in Figure 4), the actual angle depending on the individual child and the slant of writing desired. If the paper is so placed, a freer movement develops; it eliminates the tendency to use the 'hook' movement; and it makes possible the development of vertical writing, or even a forward slant, without any strain. Many left-hand writers adopt this position of the paper themselves, but at the moment it is frequently done in face of the opposition of teachers who still insist on the straight central position of the paper.

2. TYPE OF PEN

The plain pen and extra fine nib used in most school writing /

writing lessons was introduced at a time when the aim was slow meticulous writing of an elaborate type with fine up-strokes and heavier down-strokes. It is ridiculous to see children struggling along with these nibs in the writing lessons, while they will use a fountain pen at any other time. Since repeated attempts to achieve a rigid conformity to a given standard in writing have obviously not been successful, would it not be better to recognise and even encourage signs of individuality in the writing, provided always that it conforms to the primary essentials of legibility and speed? In this connection choice of the type of nib is one simple deviation which could be permitted. Hard as it is for a right-handed person to write with an extremely fine nib, it is actually almost impossible for the left-hand writer, as the push and pull movement with that hand does not permit the efficient working of the nib. Fountain pens do not present the same difficulty, as their nibs tend to be much broader and more flexible, and, in addition, they avoid the necessity of carrying the nib full of ink across the page; this difficulty could, however, be overcome if the ink-wells were able to be fitted on either side of the desk. Even if the pupils are not permitted to use fountain pens, it is essential that left-handed children should use broader and more flexible nibs, so that they will not be unnecessarily slowed up or caused to jab holes in the paper when writing. The most suitable type of nib is one with a slightly turned up point or in a fountain pen, one with a slightly bulbous /

bulbous end. It is possible to procure a nib cut with a reverse oblique point, which then prevents the side being rubbed off the nib with continual use, which is inclined to happen, especially with a fountain pen, where the nib is not changed frequently.

3. GRIP OF THE PEN

It is necessary when writing with the left hand to grip the pen or pencil at least an inch or even an inch and a half from the point, in order to keep the hand below, and well clear of the stems of the letters, thus enabling the child to see what he is writing and also to prevent him from smudging his writing, a precaution which is unnecessary with a right-handed child since his hand is usually alongside and to the right of the writing and consequently clear of it. A further precaution which is specially necessary with a left-handed child is to ensure that he does not grip the pencil or pen too tightly. This is a very common failing with all children when beginning to write; it causes tension and increases fatigue. Usually this grip is relaxed as the writing develops, but many left-handers, even adults still clutch their pen in a vice-like grip and push hard in their attempts to write. Part of the explanation is again the fine hard nibs used in the early stages which will not work efficiently with the left hand, and frequently the ink will not come out at all, in which case the child tightens his grip and pushes harder. If, however, the nib is of such a type that it will work when guided across the

page, /

page, without actual pressure having to be asserted down on the page, this difficulty will be avoided.

These three recommendations concerning - the position of the paper, the type of nib and the grip of the pen - are the most important aspects to be considered when making adjustments for the left-handed child, and they are also the simplest to apply. Various writers have stressed other points; for example, that the light should come over the right and not the left shoulder for the left-handed child so that his hand will not cast shadows on the writing. That is an adjustment, which, though desirable, would disturb the normal routine of the class, and is only suggested as an additional, and not an essential, improvement. Cole and Gardner have both suggested that left-handed children should have their first writing practice at the blackboard since this encourages a full arm movement with greater freedom and a less cramped position. It also prevents the development of any such odd grips as the hook, since the hand is of necessity below the writing. Frequent practice of large writing on paper should at least be provided. It is dangerous to make the child write in very small letters in the early stages when his muscular co-ordination is not yet sufficiently developed for such fine movements, as that then results in tenseness and a tightening of the grip on the pencil. If the child is allowed to do big bold /

bold writing at the start, as he develops better control he reduces the size of the letters of his own accord. Economy was probably behind the insistence on small writing even in the early stages; with this went insistence on perfect formation of all the letters, which meant that only a line or two of writing was achieved in a writing period. As in many other skills, the character of the skill changes as the writing is speeded up; which means that slow careful writing is not a training for speedy legible writing. Elaborate curls and twists on letters which can be achieved in slow writing are actually detrimental to legibility when the writing is speeded up, when a simpler style would be easier to write and to read. Gardner's manual[1] for left-handers gives a series of exercises

1. Loc.cit.

for developing this simple easy flowing writing at high speed without fatigue. Examples consisting of groups of similar letters are given as exercises to be practised repeatedly. Cole mentioned similar exercises for the right hand, and suggested that they should be practised at greater and greater speed until they could be performed at a high speed with no decrease in legibility.

> It is the object of these drills to establish rhythm, which is a highly desirable element because it contributes to both speed and ease of writing. Other speed drills consist of writing a single sentence as many times on successive days as possible (without diminishing the legibility) in a short period of time - perhaps three minutes.[2]

2. L.W.Cole, Psychology of the Elementary School Subjects, p.137

The speed of writing at the end of the primary school stage is not sufficient to serve the needs of the children even during the remainder of their school career, and yet no further training is given, and decrease in legibility results very quickly. A more utilitarian outlook to writing is necessary combined with a more individualistic approach. This is specially necessary since the number of errors making for illegibility is considerable; while the number actually found in the writing of any one child is relatively small, these few errors are repeated over and over again. Davis[1] mentioned a

1. R.A.Davis, Psychology of Learning, pp.146-7. New York: McGraw-Hill Book Co.Inc., 1935.

study by Newland who examined samples of writing from over a million letters written by about two thousand individuals ranging in age from first-grade children to adulthood, and found over forty thousand specific illegibilities in hand-writing. The results further showed that the frequency of illegibilities increased with age. Writing is a subject readily adapted to an individual approach and one where the results of individual teaching would be quickly evident. If such a procedure were adopted then the left-handed child would benefit considerably and would be spared the continual strain at present caused by attempting to fit into a stereotyped system quite unsuited to his needs. In The Backward Child , Burt /

Burt pointed out:

> I have seen teachers going round a class, showing other pupils how to place the paper and hold the pen, but leaving the left-hander to discover these things entirely for himself. Actually he needs more help, not less, if he is to learn how to manage his left hand efficiently. His paradoxical task is to produce with the left hand a style of writing evolved for the right....There is, however, no necessity to describe in detail the requisite adjustments: they will be evident to the teacher after a little reflection, particularly if he first tries the experiment of left-handed writing himself.[1]

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1. C.Burt, The Backward Child, p.340.

In view of the type of faults which are current among left-handers this policy of assuming that each teacher will know what to do and, what is more important, will do it, does not seem to be successful. As Cole stated in her article on the subject of teaching left-handers:

> Because so few of them are found in any one place they will be trained in penmanship methods appropriate for right-handed children. Day after day throughout their first six school years, they will be taught by conscientious teachers to write badly. Six years from now most of them will emerge from elementary school using handwriting which is barely legible and which is produced awkwardly and at the cost of unreasonable effort. Teachers, parents and pupils will expect this situation; they do not know that these one hundred and fifty thousand pupils will, under ordinary conditions, be merely the innocent victims of an inappropriate method of instruction.[2]

(150,000 pupils is Cole's estimate of the number of left-handers entering the first grade in American schools in any one year).

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2. L.W.Cole, op.cit., 1939, p.436.

It is a sad indictment of our school system that the standard of writing in adults varies inversely with the amount of use to which it has been put. Skills are ordinarily perfected by use, provided the basic principles are correctly mastered. Practice does not make perfect, or rather only makes perfect what is practised, ingraining the habits which are being practised; but frequently the habits which are being practised in writing are the incorrect ones. Individual analysis of the errors is the only efficient way to eradicate them. It is almost true to say that children would write as well without the school writing lessons as with them, at least if they grasped the basic points, since the writing lessons are so little directed to their needs outside the lesson. When their writing is studied, one frequently finds that they have two standards of writing, that used in the writing lesson and that used at any other time, and it is obvious which will be retained after school-days. This is partly due to the fact that the type of writing used in the lessons is not suitable for use at other times, improvement could be expected by using as the basis of remedial work in writing the writing produced under stress in other lessons. It is also due, in part to a peculiar attitude to writing which exists even among intelligent people, or rather particularly among those, who do not regard bad writing as something of which they should be ashamed. That bad writing is /

is not a sign of low intelligence has been reiterated to such an extent that some people take a defiant pride in their poor or illegible writing, a typical example being the medical profession. In the modern world so much depends on our ability to make ourselves understood in writing that more attention ought to be paid to relieving our readers of the double necessity of deciphering the words we have used and of understanding our meaning. The development of typing has not, as one might have expected, reduced the amount of writing done by hand; on the contrary, there has been a considerable increase in the amount of written material including that done by hand.[1] All children should acquire as a bare minimum the

1. W.S.Monroe, Editor, Encyclopedia of Educational Research, p.524-5, New York: The Macmillan Co., 1950.

ability to write legibly at a high speed - anything else in writing should be added only in so far as it is compatible with these two requirements. A new attitude to writing is long overdue, not only towards the 'sinister minority', but towards all who are suffering as 'merely the innocent victims of an inappropriate method of instruction'.

FACSIMILE OF A "LOOKING-GLASS LETTER" FROM LEWIS CARROLL TO MISS EDITH BALL.

FIGURE 5. EXTRACT FROM A LETTER IN MIRROR-WRITING BY LEWIS CARROLL

(From S.D.Collingwood, The Life and Letters of Lewis Carroll, p.415. London: T. Fisher Unwin, 1898.)

CHAPTER XI.

MIRROR-WRITING.

I. DEFINITION OF MIRROR-WRITING

Mirror-writing is the term used to describe writing which appears normal only when reflected in a mirror. The term usually refers to script in which the mirror-image is produced laterally - that is, the type in which all the letters and words are correctly formed in reverse and the whole proceeds from right to left, since other types are extremely rare. It has been found that some people have a peculiar facility for producing such writing spontaneously even without previous practice. The most famous of such persons was Leonardo da Vinci, whose notebooks were written in mirror-script. Another example is the 'Looking Glass Writing' illustrated in Figure 5, which Lewis Carroll used when writing to some of his young friends.

The inclusion of this phenomenon in a study of left-handedness is justified by the fact that almost without exception mirror-writing is produced either by left-handed persons or, at least, by use of the left hand. It has been established that Leonardo da Vinci drew with his left hand, and this can be verified from the manuscripts where it is clear that the lines and shading were performed with the left hand, as also was /

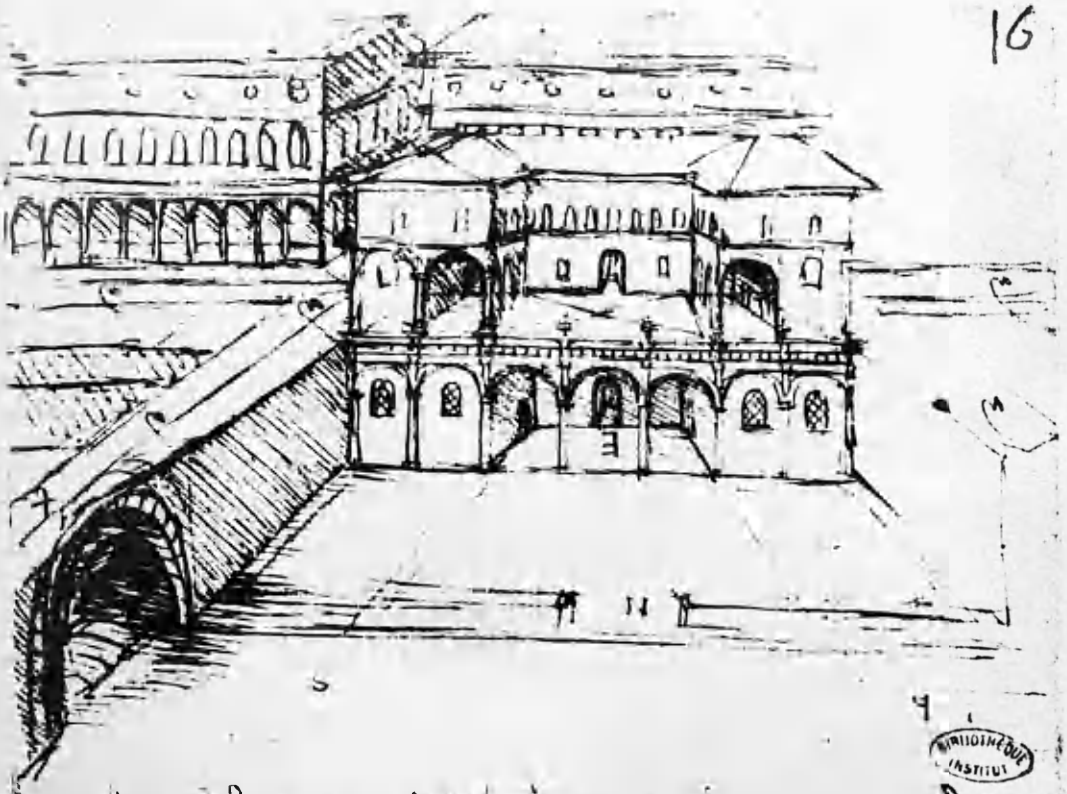

FIGURE 6. A PAGE FROM THE 'NOTEBOOKS' OF LEONARDO DA VINCI ILLUSTRATING HIS USE OF MIRROR-WRITING

was the accompanying mirror-writing, as may be seen in Figure 6. There has been a controversy as to whether Leonardo was natively left-handed or whether he only used his left hand as a result of paralysis which he is known to have developed in his right arm in later life. Contemporary writings indicate that he did in fact use his left hand even as early as the age of twenty. Lewis Carroll is known to have stammered, and it is suggested by Burt[1] that he may have been a changed left-hander. It is

1. C.Burt, The Backward Child, pp.342-3.

interesting to note, incidentally, that it is easier to track down left-handers among artists than, for example, among writers since, even when forced to use the right hand for writing, if they have a strong left-preference artists will probably use it for drawing and painting. This may even be seen in children who, when forced to use the right hand for writing, still draw and even rule lines with the left. The two examples cited above reveal that mirror-writing may be found in highly intelligent persons. It has been shown by Gordon[2], however, that its incidence is much higher among the mentally defective than in the normal population; while Fuller[3] has shown that it

2. H.Gordon, 'Left-handedness and Mirror-Writing, Especially among Defective Children', Brain, vol.XLIII, 1921, pp.313-368
3. J.K.Fuller, 'The Psychology and Physiology of Mirror-Writing', University of California Publications in Psychology, vol.II No.3, 1916, pp.199-265.

appears /

appears in certain personality disorders. Fragmentary mirror-writing is actually found even with the right hand in some children in the early stages of writing; which is understandable when one considers that there is nothing absolute about a left to right direction, and that in some countries in fact writing does actually proceed from right to left. Fluent mirror-writing is actually a left-hand production, for reasons which will be discussed later.

Mention of mirror-writing in individual patients is quite common in medical literature, but one of the few competent and comprehensive studies is that of Fuller[1], who studied the

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1. Loc.cit.

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different types of situation in which it appears spontaneously and ways in which it can be artificially induced, also attempting to explain its occurrence. He pointed out that left-handed mirror-writing can be a symptom of

(a) physiological weakness through disease

(b) weak-mindedness in children

(c) left-handedness or

(d) mere absent-mindedness in a normal person; though, the more nervous a person is, the more likely he is to slip into mirror-writing. He also showed that it is a phenomenon which can be induced under hypnosis or the influence of certain drugs, including alcohol, or by the attempt to write simultaneously with /

with the two hands. He found, further, that there is a direct connection between the intellectual control and the amount of dissociation necessary to bring about the mirror-writing. Seeking some factor common to all these types of situation in which mirror-writing occurs spontaneously, or in which it can be artificially induced, Fuller concluded that the common basis is dissociation.

II. THE EXPLANATION OF MIRROR-WRITING

The most natural direction for movement with either hand is away from the body; the normal direction of our western writing is accordingly from left to right which is the natural direction of movement with the right hand. In early times, in Greece for example, writing was for a time left to right then right to left on alternate lines, with the actual letters reversed in the right to left line. Some investigators have suggested that leftward writing, as for example in Hebrew and Arabic to-day, may be indicative of predominant left-handedness, but they have not considered the fact that it is only in our type of continuous, flowing writing, where the characters are joined, that one direction, namely the outward one, is so favourable. For the left hand the movement away from the body, the easier movement, is from right to left; thus if there is no inhibiting factor, either visual or intellectual, or if this is temporarily removed, the left hand may produce mirror-script. It /

It has been suggested that the transfer of training produced by teaching the right hand to do normal writing is towards mirror-writing with the left hand, at least in the absence of visual cues. Few left-handers have until recently been permitted to use their left hand for writing when at school which would have impressed the left to right direction and inhibited mirror-script. Their spontaneous writing with the left hand, therefore remains mirror-wise and is one explanation of the considerable facility with which some adults can produce mirror-writing. This facility will probably become less common in left-handers except among those who are forced to write with their right hand, since the practice in the left to right direction which the left hand will receive in producing the normal writing will inhibit it, while it will probably become more common among left-handed children in the early stages of learning to write. It is accordingly important that those in charge of children should be aware of the explanation and causes of mirror-writing so far as these are known, and that they should know how to prevent and treat cases which they do encounter.

Mirror-writing is not a sign of mental deficiency, though its prolonged occurrence is common in mental defectives. This is partly explained by the greater number of mental defectives who actually use the left hand for writing, and also by the absence of the factors which lead to its disappearance in a normal /

normal child. The realisation that one is actually producing a type of writing different from that produced by others, and unintelligible to them, is necessary before its prevention will be attempted. Such a realisation will be dependent on a certain level of intelligence, perceptual ability and vision. In short, though an intelligent left-handed child may produce mirrored letters or words in the early stages more frequently than does a right-handed child, visual cues and comparison with the writing in books will lead to the realisation that his writing is in some way different, and will thus lead to a correction of the tendency; while such a realisation may not be present in a dull child. Probably if teachers were aware that a right to left direction in writing may be normal to a left-handed child and may be attempted by him they could, by suitable methods, prevent the habit from developing. As individual schools and districts began to permit children to write with the left hand, the teachers were seldom aware of the difficulties which might be encountered by such children, such as those mentioned in the preceding chapter. Another problem is this unconscious feeling for writing out from the body, which when encouraged with the right hand gives the correct direction, but with the left is incorrect. Lack of understanding of this may result in some teachers giving instructions or demonstrations which may encourage rather than prevent /

prevent mirror-writing.

Spontaneous mirror-writing is not actually a very frequent occurrence in the normal child; though the potential ability to produce it is present in many left-handed adults, usually those who write with the right hand. The actual percentage of mirror-writers found in the school population has varied with the criterion, since one may either ask the teachers to note all children who have ever produced mirror-writing, or may note those who produce it under experimental conditions. The figure given by Burt[1] is about one in five hundred children, while the figure quoted by Gordon[2] is 0.48 per cent in the

1. Burt, op.cit., p.341
2. Gordon, op.cit.

ordinary elementary schools and 8 per cent in schools for mental defectives.

The most frequent factor acting against mirror-writing is probably vision. Some children are evidently not aware that this writing in any way differs from the normal, since they can, in fact, read the product.[3] Others who produce mirror-writing

3. Monroe has suggested that mirror-reading, that is the ability to read mirror-script or tendency to read mirror-wise, may be connected with left-eyedness rather than left-handedness.
M.Monroe, Children Who Cannot Read, pp.87-8. Chicago: University of Chicago Press, 1932.

are /

are unable to read their product, but do not see that it is different because they are also unable to read ordinary writing, which inability may be due to low intelligence or a specific reading disability. The idea that all people can be classified into visiles, audiles and motiles, and that one's learning is predominantly or completely of one type has been abandoned in recent years, or, at least the view that teaching should be directed through different sensory channels for different children. It does, nevertheless, remain true that certain individuals are more affected by, and employ visual stimuli to a greater extent, than other sensory stimuli, whereas others are more inclined to learn by the feel of things. It is probable that mirror-writers are among the latter type, since the feel of the writing is correct in mirror-script. This suggestion was discussed in great detail by Burt:

> As the mirror-writer forms his letters, the correctness of the particular shapes and the wrongness of the general direction seem alike attributable to the fact that the nervous centres for motor control and the nervous centres for visual control may at times function in total independence. With nearly all of us, immediately an action becomes completely automatic, it tends to slip away from the control of the attentive eye, and to be left to the half-unconscious guidance of the muscle-sense.[1]

1. Burt, op.cit., p.345.

With the guidance of the 'muscle sense' the result would be correct, provided the person were using the right hand, but when the /

the hand used is the left, this reliance results in mirror-writing.

III. PREVENTION OF MIRROR-SCRIPT

The prevention of mirror-writing in the early stages does not present great difficulty if handled correctly. The teacher should be aware that such a tendency may be potentially present in a left-handed child, particularly if he is more motor than visual in his learning. Mirror-script proceeds in a leftwards direction, and can thus only be produced when the person commences at, or towards, the right hand side of the page. To prevent such writing one must use some device to ensure that a potential mirror-writer always starts at the left of the page. This may be done by marking the starting place with a cross. If a child is nevertheless found to be producing mirror-writing then it may be necessary to stop all free writing for a time, and allow only slow careful writing from a copy until a rightward direction has been developed. Tracing over letters may also assist provided that the starting place is marked and that vision is emphasised as a further guide to the correct direction.

There is nothing normal about one direction of writing and abnormal about the other. It should be remembered that in some countries it is the leftward direction which has to be cultivated. /

cultivated. It is true, however, that some people have greater difficulty than others in accustoming themselves to the rightward direction of western writing. It should be remembered that mirror-writing does not necessarily have pathological significance, and that its appearance in a left-handed child in the early stages of learning to write is not a matter of great concern, provided steps are taken to prevent it from becoming a habit. Only when it continues in an older child as his only, or usual, form of writing is it likely to be associated with mental deficiency. It most commonly accompanies left-handedness and nervousness or lack of attention, though the lack of attention may actually be concentration on some other aspect of the writing, speed for example. In conclusion, it is most important to remember that one should not regard, or appear to regard it as a sign of mental retardation. Parents and teachers who adopt this attitude are creating in the child an emotional attitude and nervousness which is just the type of situation in which mirror-writing is produced unconsciously; while the emotional attitude may even develop into hostility and a negative attitude to all school work.

CHAPTER XII

LATERALITY PREFERENCES AND READING DIFFICULTIES

The realisation of the tendency discussed in the previous chapter for a right to left direction to be more natural with the left hand, combined with observations of the frequency with which reversals occur in the reading of backward readers, has led investigators to consider the possibility that there may be some connection between laterality preferences and backwardness in reading. The studies carried out may best be considered under three main heads:

1. those suggesting a definite connection between left-handedness and reading disability
2. studies of the effect of left-eyedness
3. studies of the effects of crossed laterality

In each of these three aspects some investigators have claimed to establish a connection between the two factors, while others have denied that any exists. The discussion on these will be somewhat simplified if a selection of the findings is presented briefly as follows:

1. Left-handedness

For: Dearborn[1] who claimed that one-third of 25 cases of backward readers were left-handed; Smith[2] who, when testing

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1. Quoted by A.I.Gates, 'The Improvement of Reading, pp.342-3 New York: The Macmillan Co., 1937.
2. L.C.Smith, 'A Study of Laterality Characteristics of Retarded Readers and Reading Achievers', Journal of Experimental Education, vol.XVIII, 1950, pp.321-329

50 backward readers and 50 normal readers, found a significant difference on their results with The Van Riper Critical Angle Board.

Against: Woody and Phillips[1], on studying matched groups of

1. C.Woody and A.J.Phillips, 'The Effects of Handedness on Reversals in Reading', Journal of Educational Research, vol.XXVII, 1934, pp.651-662.

136 pairs of right and left-handed pupils, concluded that actual handedness had no effect on the type of reading responses made. The groups selected were deliberately chosen as representing pure types of left or right-handedness.

2. Left-eyedness

For: Macmeeken[2] found a significantly higher percentage of

2. M.Macmeeken, Developmental Aphasia in Educationally Retarded Children. London: University of London Press, Ltd., 1942.

left-eyedness in her retarded group of 140 children than is found in the normal population (58.6 and 37.28 per cent respectively), and she also found that the intelligence level of the left-eyed retarded children was significantly higher than that of the right-eyed children.

Against: Gates and Bond[3] found no significant difference in

3. A.Gates and G.L.Bond, 'Relation of Handedness, Eye-Sighting and Acuity Dominance to Reading', Journal of Educational Psychology, vol.XXVII, 1936, pp.450-6.

the numbers of any laterality type represented in two matched groups, one of 65 retarded readers and the other of 65 normal readers, and found no tendency for any particular type of eye-dominance or single eye superiority to be associated with any particular error.

3. Crossed Laterality

For: Schonell[1] and Monroe[2] agreed in finding a greater

1. F.J.Schonell, Backwardness in the Basic Subjects, pp.162-169. London: Oliver and Boyd, 1942.
2. M.Monroe, Children Who Cannot Read, pp.83-91. Chicago: University of Chicago Press, 1932.

incidence of mixed hand-eye dominance in backward readers than in normal pupils (Schonell 52 per cent, Monroe 45 per cent, normal 36 per cent.)

Against: Witty and Kopel[3] studied 100 backward readers and 100

3. P.A.Witty and D.Kopel, 'Sinistral and Mixed Manual Ocular Behaviour in Reading Disability', Journal of Educational Psychology, vol.XXVII, 1936, pp.119-134.

of a control group, and found no more reversals in the mixed dominant group than in the others.

For a detailed study of these various investigations the reader is referred to The Improvement of Reading by Gates[4].

4. A.I.Gates, The Improvement of Reading, pp.342-352. New York: The Macmillan Co., 1937.

The /

The examples selected here from the mass of information and numerous conflicting studies on aspects of laterality and their connection with language difficulty reveal that it would be impossible to state with any certainty the precise effect of left-preference generally on progress in learning to read. It is evident at least that the sole cause of backwardness in reading is not left-preference; though it seems possible that in some individuals, especially if it is combined with attempts to change the native preference, left-dominance may lead to confusion, and therefore to delay in acquiring a left to right approach in reading. As was mentioned in connection with mirror-writing, there is nothing normal about one direction and abnormal about another. Every child has, in fact, in learning to read, to learn to approach each word in a rightwards direction, and not in the manner of the interesting cases cited by Gates[1], who try a word from left to right, and on failing to

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1. Loc.cit.

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recognise it that way, try again, this time from right to left, and so on alternately, becoming more and more confused. A final point in this connection is the observation made by Fernald that whatever the effect of left-preference on reading:

> The right-handed cases and the cases of matched eye-hand dominance resemble the cases in which the dominance is not matched, are as serious in their deficiency, learn by the same methods, and are as successful in the final outcome. The eye and hand dominance is not changed as a /

> a result of the remedial work: that is, the subject with unmatched eye and hand dominance learns to read and is able to read in an entirely normal manner with eye and hand dominance opposite.[1]

1. G.R.Fernald, Remedial Work in the Basic Skill Subjects, p.150. New York: McGraw-Hill & Co., 1943.

It may be that the investigators who have attempted to prove a connection between retarded reading and left-preference of some kind have, for that reason, tended to over-emphasise the place of reversals in the creation of bad reading. Frequent reversals do occur in reading at an early stage of learning, but they may reveal no more than that the backward reader is at that stage, and they may be, in other words, a symptom of a certain stage of reading, not a cause of poor reading. An extreme example of this tendency to over-emphasise reversals is to be seen in Orton and his followers. In his discussion of language difficulties, Orton[2] considered at great length what he called 'strephosymbolia' or the tendency to twist symbols; while Macmeeken[3] distinguished in her study

2. S.T.Orton, Reading, Writing and Speech Problems in Children, 1937.
3. M.Macmeeken, Ocular Dominance in Relation to Developmental Aphasia. London: University of London Press, 1939.

between static and kinetic reversals. Though many criticisms have been made of Orton's theory, it does lead to some interesting observations on laterality which are worth considering. /

considering. His explanation of learning and recognition of words is based on what many claim to be untenable neurological assumptions. It has been discussed in some detail earlier (in Chapter V), and will not be reconsidered here except in so far as it is of particular relevance to the problem of reading difficulty. Orton emphasised the importance of the early establishment of a dominant hemisphere, and claimed further that what he termed 'engrams' are formed in the associative tracts of both hemispheres, but that those in the non-dominant hemisphere are not usually employed. Should, however, clear-cut dominance not be established or should something interfere with its development, then this may result in a balance or indecision between the two hemispheres; and since the 'engrams' in the non-dominant hemisphere are mirror-wise, this may result in difficulty in recognising letters and words in their correct orientation. Without subscribing to Orton's theoretical assumptions it is possible to agree that confused laterality, either as a result of delay in acquiring dominant laterality, or of attempts to change handedness preference, may result in poor orientation to words and therefore in backwardness in reading. Such a possibility is not ruled out by any of the studies to date, even those which have denied a connection between left-preference of hand or eye, or crossed laterality and retarded reading. It was suggested by Witty and /

and Kopel[1], for example, that though left-preference in general

1. Witty and Kopel, op.cit.

may not result in poor reading, that unwise attempts to change handedness, or in some cases left-eye dominance may result in right to left eye movements, and they suggest, for that reason, that it may be of value to employ speedy and reliable methods of determining hand and eye dominance in backward readers. In their investigation, Woody and Phillips[2] deliberately

2. Woody and Phillips, op.cit.

selected groups with 'pure' handedness preference, and concluded that left- or right-handedness per se is not a cause of reading difficulty. They did suggest the possibility, however, that different results might be obtained from groups of naturally left-handed pupils who had been trained to be right-handed, or from groups which had no really dominant hand. In this connection, Smith's[3] results on the Van Riper Critical

3. Smith, op.cit.

Angle Board may be of some importance, since that was the only test which did show a significant difference between the two groups of readers. It is necessary to distinguish between the two types of study - first, these in which two groups have been built /

built up on the basis of success or failure on reading tests, with no regard to hand preference; and second, those where the groups have been arranged on the basis of hand preference. Since only a small percentage of the population actually use the left hand, and an even smaller number use the left hand and left eye, it is necessary to take particular care in drawing conclusions from groups of the first type mentioned; while because of the small number of left-handers, few investigators have selected their groups on the basis of left or right-hand preference. The best known study of the second type mentioned is that of Haefner[1]. Unfortunately, though he

1. R.Haefner, The Educational Significance of Left-handedness. New York: Bureau of Publications, Teachers' College, Columbia University, 1929.

took great care in his selection of the two groups, he did, on the whole, confine his study to the less important aspects of the educational difference between left- and right-handers - for example, height, weight, strength, interests and play activity. In the study of school achievement which he did make he found no reliable differences between the left-handed group and the other group, though he did find a tendency towards greater variability in school achievement, though not in intelligence in the left-handed group.

It /

It seems conclusive that neither left-handedness, left-eyedness, nor crossed laterality are in themselves important causes of backwardness in reading; nor do they appear to result in a greater number of reversals in children learning to read. It may be that differences in the methods of selection, such as those mentioned above, explain to some extent the differences in the results of the investigations on reading and laterality. Such contradictions reveal, however, the necessity for care in the selection of the groups, and in the methods of testing. The possibility cannot be ruled out that in individual cases left-preference, particularly if it develops an emotional significance, may act as a precipitating factor. Further, there is at least a distinct possibility that lack of dominance in hand or eye may lead to directional confusion and therefore to difficulty in recognition of words, unless some positive guidance is provided. In this connection, it may well be that finger-pointing, far from being a cause of bad reading as some teachers believe, actually arises from this insecurity in directional orientation. For this reason teachers giving instruction in the elements of reading should not assume, but should ensure, a consistent left to right approach not only to the actual printed line but also to each word, and thereby reduce the likelihood of backwardness from a difficulty which could be avoided - directional confusion.

Word /

Word methods of teaching to read, such as 'Look-and-Say', may tend to increase this confusion, unless supplemented by some technique which emphasises the importance of direction. Tracing of words in an attempt to become familiar with them, as suggested by Fernald[1] in her treatment of backward readers, or emphasis on the importance of the first letter in attempted recognition, as suggested by Gates[2], which can be assisted by

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1. Fernald, op.cit.
2. Gates, op.cit.

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the encouragement of use of a dictionary, are but two possible ways of providing this. The number of reversal errors made by children in learning to read, and particularly by backward readers, is probably influenced by the method employed in teaching reading much more than by any laterality characteristics of the individual pupils.

P A R T II

AN INVESTIGATION INTO THE LATERALITY CHARACTERISTICS OF A GROUP OF 330 CHILDREN.

CHAPTER XIII

DISCUSSION OF THE THEORETICAL ASPECTS OF LATERALITY DISTRIBUTION IN THE NORMAL POPULATION.

Any line drawn between left-hand and right-handedness on a criterion such as the hand used in writing, or even on the results of any test or battery of tests, is arbitrary and to some extent artificial as far as basic hand preference is concerned. Contradictory percentages for left-hand and right-handedness found by different investigators, because of a different criterion, reveal the arbitrary nature of such a clear-cut distinction . The artificiality of a discriminating line is not so immediately apparent; which has led to a belief that it is a sufficient precaution in testing handedness to select a measure of hand preference suitable for one's purpose, and to state the criterion. Some slight consideration of the position reveals the dangers in such a policy. Free operation of hand preference does not operate in any community, even when the official policy of school authorities is claimed to be one of non-enforcement. Before and parallel to his contact with school the child has his home environment where most adults with/

with whom he comes into contact will attempt to enforce, or at least encourage, right-handedness and the very composition of many implements will direct him rightwards. Testing is, however, made more difficult by the further complication that pressure towards conformity and right-handedness varies not only from community to community but also from one family to another. Thus, the strength of the initial tendency towards left-handedness determines only in part whether or to what extent the child will become left-handed, and makes the development of balance of preference between the two hands at least as individual as any other aspect of development. It was suggested earlier that it is often possible to guess the handedness of an author of a work on left-handedness from a subtle variation in his attitude to the 'abnormality'. Similarly, the attitude of parents to a child with left-handed tendencies is affected perhaps more than anything else by whether either they or any close relatives happen also to be left-handed, by the sort of treatment they received, and by their estimation of the effect of such treatment on them. In a field where there are so few authoritative findings, and even these are frequently contradictory, personal experience counts for even more than it would otherwise. It is, for that reason, improbable that one could ever find two children with the same degree of initial hand preference who/

who had received even comparable treatment in their general environment of home or school.

Awareness both that the appearance of left-handedness is affected by pressure towards right-handedness, and that the inequality of such pressure towards right-handedness in different children depends not on the strength of initial preference but on chance environmental factors, led the present writer to consider that an analysis of left-hand preferences in a normal unselected group would be an important aspect of the subject, though it is one which has not received much attention. In particular it was felt that the educational implications of left preference, or a tendency towards that, could better and more adequately be studied by a consideration of the whole range of preference rather than an isolated group of left-hand writers. It even seemed possible that those for whom left-hand preferences might be a handicap might be found among those not usually labelled as left-handed. This suggestion was made in several of the earlier studies, in particular by Orton[1] and his followers in America, and by Macmeeken[2,3] in her Scottish

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1. S.T. Orton, Reading, Writing and Speech Problems in Children, London: Chapman and Hall,Ltd., 1937.

2. M. Macmeeken, Ocular Dominance in Relation to Developmental Aphasia , London: University of London Press,Ltd.,1939.

3. M. Macmeeken, Developmental Aphasia in Educationally Retarded Children, London: University of London Press,Ltd.1942

Scottish studies, a suggestion which influenced the design of the present writer's earlier investigation[1], in which a small

1. M.M.Clark, 'Dominance, Equipoise and Amphiocularity', Unpublished Ed.B. thesis, Glasgow University, 1949.

group of thirty-eight children was studied from this angle. The results obtained in that research indicated that a more extensive and detailed study of a larger group might have worthwhile results, and led to the planning of the present study.

Before turning to the experimental details of this study it may be well to give some consideration to the range of hand preferences to be anticipated in the normal population. Most people would agree that there exists in the normal population the following range of tendencies: extreme right-and left-handedness, ambidexterity, or lack of preference, and slight right-or left-handedness. Difference of opinion would, however, arise concerning the exact range of each type. Some, like Jackson[2] for example, would extend the range of indifference, while others such as Brain[3] would consider ambidexterity or indifference to be rare. The following discussion is not

2. J. Jackson, Ambidexterity .London: Kegan Paul & Co.,Ltd.,1905.

3. R. Brain, 'Speech and Handedness', Lancet, vol.CCXLIX No.2., 1945, pp. 837-841

necessarily at variance with any of these views, since all must agree/

agree that, whatever one's initial preference or tendency in infancy, the use and skill of one hand and not both is generally perfected in man; further, that in a right-handed society using the right hand will be preferable to using the left.

One must now consider what happens to those born 'not right-handed'; that is, those whose left hand is initially preferred even to a slight degree.

If the child is only slightly left-handed then the chances are that he will become right-handed. This requires little elaboration, since it is clear that imitation, training and the right-handed nature of everyday objects are all an inducement to his adoption of the right hand.

An ambidextrous child, or to be more exact, one who has no preference for either hand, will quickly appear to be right-handed for similar reasons. This group consists of those who are equally good with both hands, and would for that reason have been able easily to adjust to left-handedness had society required that. There is also another group which has received little consideration until recently. These were termed 'ambilevous' by Galen (mentioned in Orton [1]), that is

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1. Orton, op.cit.

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having two left hands, and included in this group are those for whom it would be a matter of indifference which hand they used,/

used, since they would be equally clumsy and unskilful with either. These will also veer over gradually to right-handedness.

Thus even without the employment of force to ensure right-handedness the original distribution quickly becomes hidden. In short, the left handed group now contains only the more extreme left-handers, with, as suggested by Wile,[1] the possible addition of a few with a slightly lesser degree of preference but of too low mentality to make a complete transfer, and a few who for temperamental reasons 'prefer to be different', as did some of the patients referred to by Blau[2], a finding which unfortunately led him

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1. I.S. Wile, Handedness: Right and Left. Boston: Lothrop Lee and Shepard, 1934.

2. A. Blau, The Master Hand, New York: The American Orthopsychiatric Association, 1946.

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to assume that left-handedness and negativism were necessarily connected.

Thus a general trend towards right-handedness becomes evident, though there will be no clear line of demarkation between the two groups in the sense that some exact amount of left-handedness will result in a person remaining left-handed. The variations in environmental pressure will, however, have the greatest effect on the borderline persons.

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It is interesting to consider the method of representing the distribution employed by Ojemann[1], who

1. R. H. Ojemann, 'Studies in Handedness: IA Technique for Testing Unimanual Handedness,' Journal of Educational Psychology, Vol. xxi, 1930, pp.597-611.

plotted his results and found them to form a bi-modal curve, and also the discussion of this question by Johnson and King[2] whose study has already been mentioned. On the Van

2. W. Johnson and A. King, 'An Angle Board and Hand Usage Study of Stutterers and Non-Stutterers', Journal of Experimental Psychology, Vol.xxxi, 1942,pp.293-311.

Riper Critical Angle Board the results, as they pointed out, formed a unimodal curve which was somewhat normal in shape. A bi-modal curve, as found by most investigators, would indicate two distinct types of handedness; but they suggested that this might be merely the result of the type of tests employed rather than of the trait being measured.

The more one considers the problem, the clearer it becomes that there is no real way of knowing the exact distribution of native hand preferences. It is possible, at best, only to reason back from the observed perferenees and attempt to allow for the effects of pressure, both direct and indirect; while any test which is claimed to measure native/

native hand preference should be viewed with suspicion. From the preceding discussion it may be seen that among the right-hand writers the following will appear, when considered in terms of initial hand preference:

a) those naturally and extremely right-handed

b) those slightly right-handed

c) ambidextrous individuals, in the sense of having two skilful hands

d) those natively poor with both hands

e) any slightly left-handed

f) any strongly left-handed who have been either subjected to strong pressure or even compulsion, or who were of such a temperament that they found it preferable to conform to the majority rather than use the genuinely preferred hand.

The supposition that such a distribution is to be found among right-hand writers is the justification for a study of left-handedness which does not concentrate on those customarily termed left-handed. It was hoped that such a study would facilitate an analysis of these various gradings, for that reason was thought advisable to take a group which was unselected for hand preference, and to test each individual intensively. The following chapters will present the details of that study.

CHAPTER XIV

AIMS OF THE STUDY AND SELECTION OF THE GROUP FOR INVESTIGATION.

I THE PROBLEM

This investigation was undertaken with the aim of making an analysis of the type and degree of laterality characteristics to be found in the normal population, and a comparison of the nature and degree of different laterality characteristics in any one individual. It was felt that in spite of the quantity of material on the subject of left-handedness which already existed there had been no adequate study of this aspect, and certainly no analysis had previously been made of the comparable degrees of the different laterality characteristics in a single individual, though vague statements had been made suggesting there was, or was not, some connection between hand and eye preferences [1]

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1. Supra, Chapter ix.

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or that weak eye dominance might accompany weak hand dominance. This latter seemed particularly worth following up in view of the suggestions discussed earlier concerning the effect of lack of dominance or retarded development of dominance on educational/

educational achievement.

In short, the initial problem was to study the amount and range of different types of handedness, eyedness, earedness and footedness as they do actually appear in a normal group, and to make a comparison of these in different children. The discussion in the previous chapter illustrated the range of hand preference anticipated in an unselected group of right-hand writers; while it was hoped in addition to obtain, incidentally during the testing periods, a considerable amount of qualitative data on many of the aspects which affect a child's hand preferences, on pressures towards right-handedness, the children's own attitudes to left-handedness and on left-handedness among their relatives. The investigator's own use of the left hand would, it was hoped, help to create an atmosphere for such confidences, especially among those who had some reason to anticipate the disapproval of society for their left tendencies. In many instances the subjects noticed her use of the left hand in writing, but if they did not, sometimes an admission that she used that hand, helped with certain children. Information on the educational achievement and intelligence of the subjects would,it was hoped, throw some light on the important problem of the effect of laterality preferences on educational achievement, or at least indicate lines for a further study.

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II. SELECTION OF THE EXPERIMENTAL GROUP.

Three related aspects had to be considered in establishing the experimental group, the composition and size of the group, and the method of testing. One reason for taking an unselected group as far as hand preference was concerned was discussed in the preceding chapter. It was felt that though this would result in relatively few left-hand writers it would yield many interesting degrees of left-hand preference in the right-hand writers; while this policy was also necessitated by the desire to make a comparison of hand preferences with other laterality preferences, eyedness and footedness for example. The nature of the testing and the size of the group were obviously closely connected, since it would be possible either to test a large group with a few tests or a questionnaire, or a relatively smaller group with a more complete battery of tests. The latter method was decided upon in view of the research on the reliability and validity of questionnaires[1], and also since the nature of the aims

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1. Supra., pp. 105-6.

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of the study seemed to be better served by such a method, since it would yield more qualitative material than could possibly/

possibly be gained if each child were tested for only a short time.

The complete 'Qualifying' class in eight Glasgow schools was used for the study,which gave an experimental group of 330 children (162 boys and 168 girls),with an age range of 11-12 years of age. The following points were considered in making the selection:

1. Children were selected as subjects since the educational significance of the problem is an important aspect, and since the attitude to left-handedness has altered so much in recent years that relatively few adults do actually write with the left hand. For that reason it was considered important to study the distribution under present conditions when the official policy is to permit left-hand writing.

2. Both sexes were included and it was considered important that they should be in approximately equal numbers since a sex difference in handedness had been found by previous investigators, and that they should be in the same class, so that their school conditions at least should be comparable.

3. Complete classes in the various schools selected were considered the most suitable units from which to constitute the group, in order to make the conditions of learning as comparable for the group as possible, which seemed important/

important in a study such as this.

4. The 'Qualifying' class in the Primary School was felt to be most suitable for the testing for the following reasons:

a) At that stage the children are still, in Scotland, unselected as far as ability is concerned (except for those with IQ under 70 who may have been sent to a Special School). This is the highest class in which this position with regard to selection holds true.

b) It was possible at that stage to find classes containing both boys and girls being taught together.

c) This stage was thought to be preferable to an earlier one since the children had been at school long enough to be affected by the school attitude to left-handedness.

d) At that stage it would be easier to test with a comprehensive battery of tests, while with younger children it would be difficult to make the duller members of the group comprehend the instructions.

e) Children in that class had been long enough at school, -seven years - ,for it to be particularly valuable to consider their educational achievement, since they had in fact completed a stage of their school career.

f) Their presence in that class meant that it was possible to supplement the test results with considerable additional/

additional information on their intelligence and achievement scores, information which had been gathered by the authorities in connection with the promotion of these children to suitable secondary school courses.

5. Glasgow was the district selected for the investigation. Since it was clear that it was impossible for one investigator unaided to make an intensive study of the type planned and also cover a sufficient sample of the population of Scotland to make generalisations for the whole country, it seemed wiser to limit the study to one district, for which Glasgow seemed admirably suited, both because of its size and the wide range of home backgrounds represented in the schools.

The approval of the Director of Education was obtained, who agreed that the testing might take place in a selected number of schools. A selection of schools had next to be made, and in order to have as representative a group as possible, it was decided to include schools classed by the authorities as above average, average, and below average, in the ratio 1:2:1. Since all children in the 'Qualifying' class of the schools selected were going to be tested, this grading of the schools was only an approximate one, and the estimate of the authorities was used as the guide in the rough grading. Two limiting factors had to be considered in/

in the choice of the actual schools to be used in the investigation; first, the willingness of the headmaster of a school to co-operate in what was after all a 'pure' research project with little immediate and apparent practical value to the school, and second, the availability of some space in the school which could be used for the testing, which is a considerable problem with the present overcrowding of the schools. Since aspects such as these were unlikely to bias the results, it seemed advisable to abide by the decision of the authorities, who suggested suitable schools. In practice this method worked very well and yielded a fairly well-defined pattern of below average, average, and above average distribution of the selected schools on the official Promotion Schedule which was made available to the investigator. This was in spite of the fact that no deliberate selection of pupils does take place for entrance to most public schools at this level, except possibly that made as a result of the district in which the schools is situated. In order to represent the large Roman Catholic population in Glasgow, which has its own schools within the state system, and which therefore constitutes something in the nature of a selection, 2 of the 8 schools used for testing were Roman Catholic.

The testing was planned to include one complete class in each of eight primary schools, the class in each instance/

instance being the 'Qualifying', or Seventh Grade. No difficulty was encountered in obtaining parallel classes in each of the schools, since most of them had only one such class, while in one instance where there were three classes at that stage, one contained girls, one boys only, and the third was a mixed class; thus the mixed class was the one used for testing to keep it comparable with those in the other schools. For details of the numbers tested in each school and in each grade of school see Tables I and II.

TABLE I

NUMBER OF CHILDREN TESTED:

BY SCHOOLS

School	Number of Subjects.		
	Boys	Girls	Total.
A1	20	21	41
A2	22	25	47
B1	20	19	39
B2	23	25	48
B3	21	18	39
B4	21	19	40
C1	19	19	38
C2	16	22	38
Totals	162	168	330

TABLE II

NUMBER OF CHILDREN TESTED: BY GRADE OF SCHOOL [a]

Grade of School	Number of Subjects		
	Boys	Girls	Total
Above Average	42	46	88
Average	85	81	166
Below Average	35	41	76
Totals	162	168	330

a. Above Average A 1, 2
Average B 1, 2, 3, 4
Below Average C 1,2
} on Table I

CHAPTER XV

SELECTION OF TESTS AND METHOD OF TESTING.

I. SELECTION OF TESTS

Since the aim of the study was to make a comparison of the various aspects of laterality preferences, in particular those of hand, foot, eye and ear, a battery of tests had to be designed which would measure all these aspects as effectively as possible. In the group of tests of handedness, which was more extensive than the others, each test was selected to measure a particular aspect of hand dominance. Experience gained in an earlier study[1] was of great assistance to the investigator

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1. M.M. Clark, 'Dominance, Equipoise and Amphiocularity', Unpublished Ed.B. Thesis, Glasgow University, 1949.

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in indicating the most effective tests to apply in the present study, and also in enabling her to avoid many difficulties which might have been encountered in the actual testing. No lengthy discussion of earlier investigations is necessary at this point, since a detailed analysis of these is contained in Chapters VII and VIII, and since all the tests used were adapted for this particular investigation/

investigation to suit both the aims of the study and the age of the children being tested. This section will be devoted to a short discussion on the reasons for selecting the type of tests employed in each group, followed by exact details of the method of applying the tests and the instructions used.

1. HANDEDNESS.

The hand used for writing had, clearly, to be ascertained, which was done by questioning the subject, whose statement was checked in the course of the testing when he was required on several occasions to write his name on test papers. The actual tests can be divided into those which determined the child's preference for the right or left hand in various selected tasks, and those which measured his relative ability with right and left hand. Three tests of the former type were employed, giving a measure of the hand preferred in throwing, in reaching, and in screwing and unscrewing. 'Throwing' was an obvious choice since it is an activity in which a child frequently indulges and in which he acquires a considerable degree of skill, making him, for that reason, acquire a definite preference for one hand or other, frequently, though not always, that used in writing. Most previous investigators have noted the 'throwing' hand either by means of a questionnaire or in the form of a test, and have found/

found it to correlate highly with the hand used in writing. The existence of any discrepancy between the hand used in a learned, skilled task such as that and the hand used in writing, would suggest that the former test was probably revealing instances of left-handed persons who had been encouraged or forced to use the right hand for writing. Various investigators have claimed that the arm used in reaching is on the same side as the dominant hand. Certainly if an object is directly in front of a person he does usually reach for it with a particular hand; while even in instances where it would be more effective to reach with the other, many persons still use the 'preferred' hand. 'Screwing' is another activity for which, though it requires strength rather than skill, most people do consistently prefer one particular hand. Though relative strength of the two hands, as measured for example by a hand-dynamometer, seems to have little connection with the dominant hand in other respects, as shown by Whipple[1] and Burt[2]; and was for that reason

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1. G.M.Whipple, Manual of Mental and Physical Tests, Part I pp. 100-109.

2. C. Burt, The Backward Child, pp. 271-2

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omitted from this battery, it was felt that the preferred hand for screwing would be worth noting. One test measuring/

measuring relative ability of the two hands was employed, in which speed was compared. The test was designed to be fairly close to the movements involved in ordinary writing, to ascertain how far the untrained hand was below the trained with regard to speed. Obviously in those extremely right-or left-handed the margin would be great; whereas those whose scores were relatively comparable in spite of the training received by the writing-hand would reveal either that there had been comparable potential skill in the two hands, or even that the untrained one would have been superior had it received the training. The Van Riper Critical Angle Board[1] was included in the investigation to test the test

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1. Supra., pp. 115-8 for discussion of the test.

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rather than to study the children. The test of simultaneous writing which was also included was a somewhat simplified version of the Van Riper's test, but with similar principles behind it, in that the hand which reverted to mirror-writing under the testing conditions was regarded as the non-dominant hand. Two other tests were included which do not fall exactly into either of the above-mentioned categories. One was a test of 'fine' movement; where, though the performances were actually timed, the skill of the two hands was actually being observed./

observed. The remaining test was one of alternating movement, and was included in the battery because of suggestions that the dominant hand has greater facility in actions quite divorced from skill. In this test the relative ability of the two hands to maintain a simultaneous alternating movement of the wrists was observed.

2. FOOTEDNESS.

Some investigators have claimed to find a high correlation between footedness and handedness, while others have claimed it to be low. The studies of Cuff[1] and Haefner[2] are examples of that disagreement,

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1. N.B.Cuff, ' A Study of Eyedness and Handedness', Journal of Experimental Psychology, vol. xiv, 1931, pp. 164-175.

2. Quoted by J. E. Downey, 'Laterality of Function', Psychological Bulletin, vol. xxx, 1933, pp.109-142.

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since Cuff found all his subjects who were right-handed were also right-footed, while Haefner reported that only a few of his subjects showed foot dominance, and that the coefficients between hand and foot tests were likely to be low. It appears that the findings in this connection depend on whether one or several measures were employed in measuring footedness. In short when the only criterion was the foot used in kicking, the correlation appears to have/

have been high, while on a battery of tests it seemed to be low. To examine that, the foot used in kicking was observed in this battery, and two other tests were also included, and were, the foot used in hopping, and the foot used in stepping off. Thus the tests of footedness were directly comparable with each other since they were all measures of preference for one foot or the other.

3. EAREDNESS.

Though batteries of tests of laterality usually include eyedness, they have rarely contained any tests of earedness. In view of the definite preferences shown by persons when, for example, answering the telephone, it was considered worth including two tests of earedness to discover how closely the choice in that compared with the dominant hand. In order to ascertain that two tests were designed, in one of which the object was actually held to the ear to give the dominant hand its maximum play; whereas in the other test, the ear had to be placed down to the object which was not touched with the hands. A third test which it was thought might have some connection with the preferred ear was tentatively included in this group and was designed to measure the direction in which the head was turned as a result of a sound coming from behind but equi-distant from the two ears. All the tests included in this group were, it should be stressed, tests of preference and not of aural acuity.

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4. EYEDNESS.

In view of the study made by Crider[1] on

1. B. Crider, 'Unilateral Sighting Preference', Child Development, vol. vi, No. 2, 1935, pp. 163-4. (Supra. pp. 131-2 for discussion of significance of this.)

tests of eye dominance, it seemed necessary to select these with special care. Previous investigators found, however, that simpler tests have as good results as the more complicated and elaborate; and for that reason, after considering the earlier studies it was decided to select four of the simpler tests of eye dominance and include them in the battery. Two of the tests were of the type which required a deliberate choice of one eye only; while the other two ascertained the sighting eye when both were actually open.[2] The four tests selected

2. Supra., Chapter viii for a detailed discussion of the different types of eyedness.

made it possible to study the consistency of use of one eye in a particular test; to compare the eye used in two very similar tests, to see whether this was still consistent for two types of eyedness; and finally to compare the results of these tests with the results obtained on the tests of other aspects of laterality preferences.

II. METHOD OF TESTING

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In Table III are listed the various tests used and the order of applying the tests to each child.

TABLE III

TESTS USED AND ORDER OF APPLYING[a]

Laterality Characteristic.	Name of Test	Order of Applying	Total Numbers of Tests
Handedness:			8
	Screwing	1	
	Reaching	12	
	Throwing	18	
	Fine Movement	14	
	Speed of Crossing	9	
	Simultaneous Writing	4	
	Van Riper Test	6	
	Alternating Movement	16	
Footedness:			3
	Kicking	5	
	Stepping	8	
	Hopping	17	
Earedness:			3
	Sound in Box	11	
	Stop Watch	15	
	Head Turning	3	
Eyedness:			4
	Cone Test	7	
	Hole in Card	13	
	Peep Show	2	
	Cylinder	10	
Total			18

a. Infra p. 223 for details of the tests.

The testing was so arranged that one complete group of schools in the range was tested; that is one above average, two average, and one below average, then the second group was tested to complete the eight schools in the final group. This precaution was taken in order to make certain that any slight changes resulting from practice gained in testing should not influence any particular grade of school. Each child in a class was tested individually, boy and girl alternately, and the testing was more or less in alphabetical order, with the exception of absentees who had to be left until the end. In some instances it was necessary to return to the school to test absentees, but it seemed important to do this, as the aim was to test complete classes. Information was requested from each child on the number of siblings, their age and their handedness, and on any other left-handed relatives. The presence of any twins in the families was also noted. If a child wrote with his left hand, or had ever done so, additional questions were asked in connection with that, on difficulties he might have encountered, and attempts to change his handedness. Any other details thought to be of value were also noted. The actual time required to test and question each child was approximately thirty minutes. The greatest problem, and the place where most time was lost, was in actually catching/

Name ..... No. .....
Age ..... Sex .....
L.H. Relatives: No. of brothers.... No. L.H. .....
No.of sisters ..... No. L.H. .....
Other L.H. relatives .....
Total known L.Handers in family....
No. of twins in family .....

Order	Tests	Results	Comments
		1 2 3 4	
1	Screwing		
12	Reaching		
18	Throwing		
14	Fine Movement		
9	Speed of Crossing	See Below	
4	Simultaneous Writing.	See Below	
6	Van Riper Test	See Below	
16	Alternating Movement		
5	Kicking		
8	Stepping		
17	Hopping		
11	Sound in Box		
15	Stop Watch		
3	Head Turning		
7	Cone Test		
13	Hope in Card		
2	Peep Show		
10	Cylinder		

4	Simultaneous Writing	No.of Figures mirrored	R	L	Actual figures mirrored
		1st Trial			
		2nd Trial			
		Total			

9	Speed of Crossing	No.of Crosses	R	L	Ratio R/L
		1			
		2			
		Total			

6.	Van Riper Test	Hand which mirrored at -			
	Diagram	0^{o}	30^{o}	60^{o}	90^{o}
	1				
	2				
	3				
	4				
	Total				

Figure 7. Copy of Testing Sheet for Recording Results[a]

[a] A copy of the attempted on the Van Riper Test and any other additional information was recorded on the back of test sheet.

catching the last one or two in a class. On the average about two weeks was spent in each school, during which time the individual testing was carried out; information copied from the Promotion Schedule on intelligence test scores and achievement scores in English and Arithmetic and on the placing of the children by the Promotion Board. A writing test was also given to each class at some time during the two weeks. The Paul West Test[1] was selected as the most suitable

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1. P.V. West, Manual for The American Handwriting Scale, New York: The A.N. Palmer Co., 1929.

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because it was claimed to measure both speed and quality of writing. It was impossible to wait until the complete class was present to give the test, so it was given when there were as few absentees as possible, who had later to be given the test under comparable conditions, either in a group or individually.

III DETAILS OF TESTS

Before any discussion of the results can be understood it is necessary to be familiar with the exact details of the method of carrying out the testing. A copy of the test sheet used with each child may be seen in Figure 7. In tests which were measuring preference the child was given four attempts, since that was a number great/

great enough to show inconsistencies in choice which would not have been shown any better by a greater number of trials.[1] Harris actually found that three trials

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1. A. J. Harris, Harris Tests of Lateral Dominance: Manual of Directions for Administration and Interpretation. New York: The Psychological Corporation, 1947.

---

were sufficient. Details of the tests, and of the instructions given to the children will be given in this section, set out in the order in which they were given to the subjects, not grouped according to the laterality characteristic they were designed to measure. Several considerations had to be borne in mind when deciding the order for the tests and the phrasing of the instructions. It was important that similar tests of a particular aspect should be as far separated as possible so that the results of one should not affect the other. Since left-handedness is greatly influenced by the disapproval of society it was necessary to design the tests so that the child was not aware of what was being measured. Each test had accordingly some other apparent motive to prevent the child becoming aware of what was being tested, so that his genuine preferences would be ascertained and not some displayed in the hope of pleasing the investigator, a precaution also stressed by other investigators. For the same reason, each aspect was tested instead of taking the/

the child's word in some instances. Finally in a battery containing as many as eighteen tests it was important that the tests should be so designed that they would retain the children's interest. In other words, they were planned and worded to suit children of about twelve years of age and would, therefore, require to be adjusted and reworded for younger or older children in order to work satisfactorily.

TESTS AND INSTRUCTIONS

TEST 1. SCREWING (Handedness).

For this test a small screw-top bottle, filled with coloured counters, was used. The test consisted of screwing and unscrewing the top of the bottle, and of arranging the counters.

The child was seated at a table, and instructed to place his hands behind his back. When in that position, the bottle was placed directly in front of him, equi-distant from each hand.

Instructions: When I say 'Go', take the top of the bottle, clap your hands once, then put the top back on the bottle, as quickly as you can. Ready - Go.

Put your hands behind your back again. This time, when I say 'Go', take the top off the bottle, empty out the counters, then arrange them in piles, a separate pile for each colour, as quickly as you can. Ready - Go.

Now put the counters back in the bottle, and screw on the top.

Though speed was deliberately emphasised, the test was in reality one of hand preference, and not of relative speed. The hand used at each trial, to remove and to replace the lid, was noted, and also details of the method of arranging the counters, whether with one hand, or both. This test yielded quantitative results from the number of times each hand was used for screwing; but the methods of arranging the counters were so variable that they could only be recorded verbally. Though the results of this second part of the test were vague they were of some interest in particular instances.

TEST 2. PEEP SHOW (Eyedness.)

The test involved looking through a small hole into a box, which made it necessary for the child to make a choice of one eye. A circular hole, half an inch in diameter, was cut in the front of a small cardboard box. Half an inch was also cut off the back of the lid to allow light to enter the box, and also so that printed cards could be slipped down inside facing the hole. Four white cards, each bearing a printed word, were cut to fit the space at the back of the box.

The child was seated with his hands behind his back./

back. The box with a card in place was held a short distance from his eyes with the hole towards him at eye level and equi-distant from each eye.

Instructions: Put your eye up to the little hole and see if you cam tell me what is written on the card inside the box.

What is on this one?

The test was given four times with a different card each time. The instructions were worded to imply that the task was to read the word, while the result noted was the eye put to the hole at each trial.

TEST 3. HEAD TURNING (Earedness.)

This test involved turning of the head at a sound made directly behind the subject. The child was seated at the table, looking straight ahead, and with his hands behind his back. The experimenter stood directly behind the child, making certain that he was sitting straight.

Instructions: I am going to make a sound with a pencil just behind your head. Whenever you hear it, turn your head. Are you listening?

This test was repeated three more times and the child was encouraged to turn more quickly each time. Speed was again emphasised in this test, and at the fourth trial, having done this, the sound was then delayed/

delayed a few seconds, which sometimes resulted in the child anticipating it, and made him realise that attention was being paid to whether or not he listened for the sound. The result noted was the side to which he turned his head at each of the four trials.

TEST 4. SIMULTANEOUS WRITING (Handedness.)

This test consisted of writing numbers with both hands at the same time. The child was seated at the table with a quarto sheet of plain paper in front of him and a pencil in each hand.

> Instructions: You are going to write with both hands at the same time. You are going to write a figure '2' with each hand, side by side and at the same time. Below that write a '3' with both hands, then '4' and so on, as I say the numbers up to '9', but we'll miss out '8'. Just to make it really difficult, you must shut your eyes while doing it. Ready - 2,3,4,5,6,7,9.
>
> Now that you know exactly what to do we will try once more on the other side of the paper, and a little quicker this time.

As this task gives most people a great deal of trouble, it seemed better to assure the child that one was aware of the difficulty. A note was made of the number of times either hand drew a mirror-image instead of the correct one. This was noted separately for each attempt, and details were also taken of the figures which were mirrored.

TEST 5. KICKING (Footedness.)

TEST 5. KICKING (Footedness.)

This test was to determine which foot the child used in kicking. He was placed at a distance of several feet from a chair, then given a ball of paper.

Instructions: You are going to try and kick the ball of paper between the legs of that chair. You will have four turns. See how many times you can kick it right through.

Accuracy was emphasised here to give point to the test from the child's point of view, and also so that he would kick with the foot he was in the habit of using. A note was made of the foot used in kicking at each of the four attempts.

TEST 6. THE VAN RIPER TEST. (Handedness.)

The task in this test was to copy a diagram correctly with both hands at the same time and on opposite sides of a vertical board.

The Van Riper Laterality Apparatus or Critical Angle Board[1] was used. Essentially this consists of two

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1. C.Van Riper 'The Quantitative Measurement of Laterality: Journal of Experimental Psychology, vol. xviii, 1935, pp. 372-382.

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vertical boards on a horizontal base, so arranged that each vertical board can be rotated from a position parallel to the chest through ninety degrees, until the boards are back to back. Paper is arranged on these boards/

boards so that a record may be kept of the drawings with each hand. The paper is unwound from one roller and on to the other as the test proceeds. Thus, finally, the left-hand drawings for all subjects are on one side of the paper, and the right-hand drawings on the other. The apparatus was somewhat adapted for the present study, in order to make it portable. The horizontal base was made to hinge in two places, so that it would fold up and protect the rollers, and a cover was made for the top. This did not, however, alter the apparatus in any essentials.[1]

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1. Supra., pp. 115-8 for a more detailed study of the apparatus and illustration clarifying the explanation.

The child was seated with the apparatus on the table in front of him. The vertical Boards were set at zero degrees, or parallel to the chest. A diagram was placed on the wall some feet away, and about thirty degrees above eye-level. The child was then given a pencil in each hand.

> Instructions: I want you to try and copy that drawing with both hands at the same time. Do it with the left hand on here (indicating the left vertical board), and with the right hand on here, (indicating the right vertical board). You must keep looking at the drawing, follow it with your eyes, don't look down at your hands. Put the pencils ready on the paper. Ready - Go.

At the first attempt the child was permitted to go at his own speed, but when he had grasped the procedure he/

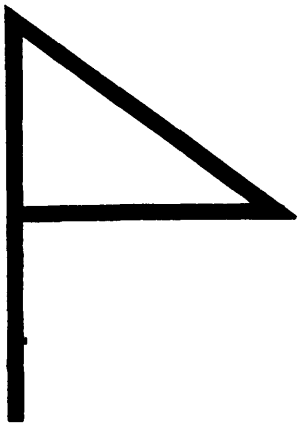

DIAGRAM 1.

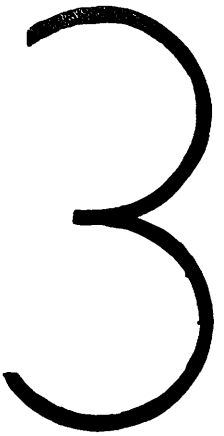

DIAGRAM 2.

DIAGRAM 3.

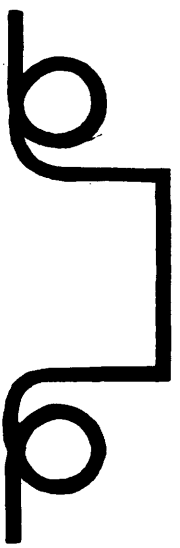

DIAGRAM 4.

FIGURE 8. ASYMMETRICAL DIAGRAMS USED IN THE VAN RIPER TEST[a]

a. Diagrams 1,3 and 4 were shown to the child: while for Diagram 2 the word 'three' was given orally to be reproduced as a figure.

he was made to draw more quickly, and after beginning the diagram, was not allowed to pause until it was completed. Next, each vertical board was moved back through thirty degrees, and the paper turned to a new part. The child was again instructed to draw the diagram with both hands at the same time. This was repeated with the boards at sixty and ninety degrees.

The test was next carried out with the boards at the same four angles, but instead of asking the child to copy a visual pattern, he was instructed:

> When I say the number '3', I want you to draw a '3' with both hands at the same time. Have your pencils ready on the paper. Shut your eyes. Ready - 3.

The test was also carried out with a third and fourth diagram, which were both visual patterns, the fourth being the reverse of the third. For illustrations of the diagrams used in the testing, see Figure 8.

The results noted were, for each diagram, the hand which drew a reversed or mirror-image of the diagram, and the angles at which this happened.

TEST 7. CONE TEST (Eyedness.)

This test involved looking through a cone-shaped object, apparently using both eyes, but the situation was such that only one eye could actually be used. A cardboard cone, about eight inches in length, was used. It was wide enough at one end to go over both eyes, and tapered/

tapered to about an inch at the other end. The child stood several feet from the experimenter, and held the cone in both hands.

Instructions: When I say 'Go', hold up the cone, putting it over both eyes. Look through it with both eyes, and tell me how many fingers I am holding up. Ready - Go. How many fingers?

This was repeated three more times, and the eye which was visible through the narrow end of the cone at each trial was noted as the sighting eye. It may be seen from Figure 2 how this test looksto the experimenter.[1]

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1. Supra., p.129

TEST 8. STEPPING (Footedness.)

This test was to find which foot the child preferred to use in stepping, when circumstances were such as to favour neither. The child was instructed to stand against a wall, but with his heels touching it.

Instructions: When I say 'Go', take two big steps out from the wall. Step as far as you can. Ready - Go.

Three more trials were given. At each one the child was encouraged to greater effort. A note was made of the foot with which the child stepped first at each trial.

TEST 9. SPEED OF CROSSING (Handedness.)

This test was designedto measure, as simply as possible, the relative speed of the right and left hand. The/

The child was seated with a quarto sheet of plain paper along the table in front of him, and with a pencil in the hand with which he was accustomed to write.

Instructions: When I say 'Go', start making crosses along the paper as quickly as you can. Just little ones like this (indicating thus X). If you finish one line before I say 'Stop', start another at once. Make them as quickly as you can. Ready - Go.

The time allowed was twenty seconds, measured by means of a stop watch. The child was then instructed to change the pencil to the other hand, and a similar trial was given with that hand. The test was then repeated with each hand. The results noted were the number of 'crosses' made with each hand at the first and second trials, and the total number of crosses with each hand.

TEST 10. CYLINDER. (Eyedness.)

This test indicated which eye was preferred when only one might be used, but differed from Test 2, in that the cylinder was actually held to the eye.

The apparatus consisted of a cardboard cylinder twelve inches in length and one inch in diameter. The child was handed the cylinder, then told to stand at a distance of several feet.

Instructions: Take that tube in both hands. When I say 'Go', put it up to your eyes, and look through it. Tell me the colour of the counter I will hold up. Ready - Go.

This was repeated three more times, and a note made/

made of the eye to which the cylinder was placed at each of the four trials.

The emphasis placed on speed, together with the fact that he was expected to name colours, directed the child's attention away from the actual placing of the cylinder to his eye, and thus gave his natural preference.

TEST 11. SOUND IN BOX (Earedness.)

This test indicated which ear was preferred when a choice had to be made. The child was seated at the table with his hands behind his back. A stop watch which was ticking was placed in a box, and laid on the table directly in front of him.

Instructions: Tell me if that watch is ticking. You may put your ear down to it if you wish, but do not touch it with your hands. Is it ticking? (or: Can you hear it ticking?)

This was repeated three more times, twice with the watch stopped, and once when it was ticking. The result noted was the ear placed to the watch at each trial.

TEST12. REACHING (Handedness.)

This test revealed which hand, or rather, which arm, was used in energetic reaching. The child was seated at a table, with his hands behind his back. The experimenter stood directly behind him, holding the cylinder above the child's head, almost out of reach, and in an equally favourable position for either hand.

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Instructions: When I say 'Go', reach up with one hand, and try to touch this tube. Ready - Go.

This test was repeated three more times, and for each trial the cylinder was held slightly higher than for the preceding one. A note was made of the arm used for reaching at each of the four trials.

TEST 13. HOLE IN CARD (Eyedness.)

This test showed the eye used in sighting when both were open, but only one could be used. Thus it was similar to Test 7, but a different apparatus was used. The child stood at a distance of several feet, facing the experimenter. He was given a piece of cardboard, eight inches by eleven, with a half-inch hole in the centre.

Instructions: When I say 'Go', take the card in both hands and hold it up in front of your eyes so that you can see through the little hole. Stretch out your arms in front of you, and look with both eyes. Ready - Go. Tell me how many fingers I am holding up.

This was repeated three more times, and a note made of the eye which could be seen through the hole at each of the four trials.

TEST 14. FINE MOVEMENT (Handedness)

This test was an attempt to measure the relative speed and accuracy of the left and right hand. Small silver beads, three-sixteenths of an inch in diameter; a narrow glass tube; small tweezers and a stop watch were used. The child was seated with the box of beads, the tweezers/

tweezers and the glass tube in front of him.

Instructions: I want to find out how quickly you can put five of these little beads into the tube. Pick them up with these (indicating the tweezers), one at a time. Ready - Go.

This test was repeated with the other hand. A note was made of the hand used first, the time taken with each hand, and any undue clumsiness with either hand.

TEST 15. STOP WATCH (Earedness)

This test was to determine which was the preferred ear in a situation where a choice had to be made, but differed from Test 11 since there, the child was not permitted to touch the watch, while here, it was actually held in the hand. This was to discover the influence of the dominant hand on the choice. The child was seated with his hands behind his back, and a watch on the table in front of him. The watch was placed at an equal distance from each hand.

Instructions: When I say 'Go', pick up the watch with one hand, hold it to your ear, and count how many ticks you can hear before I say 'Stop'. Ready - Go.....(about fifteen seconds later) Stop. How many did you hear?

This test was repeated three times. Before each trial the watch was replaced in such a way that it favoured neither hand, and the child was instructed to start with his hands behind his back. A note was made of the ear to which the watch was placed at each of the four trials, and also of the hand used to lift the watch.

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TEST 16. ALTERNATING MOVEMENT. (Handedness)

This was a test of the relative ability of the left and right hand to carry out simultaneous rapid alternating movements. The child was seated with his arms in a bent position. A demonstration was given, the hands being rotated rapidly in opposite directions, movement being from the wrists.

Instructions: See for how long you can make both your hands move like this. Make them go opposite ways, as quickly as you can. Go on until I tell you to stop. Ready - Go.

Usually within a very short time one of the hands ceased to make the correct movement. The test was continued until some difference such as that was observed. A note was made of the relative ability of the two hands at the start and, where one tired more quickly, that was also noted. In one or two instances, the child found it impossible even to make both hands perform the task simultaneously.

TEST 17. HOPPING (Footedness)

Here the foot preferred for hopping was tested. The child stood with his back to the wall and his feet together.

Instructions: When I say 'Go', you will start hopping towards the end of the room. See how far you can get before I say 'Stop'.
Ready - Go.....Stop.

At each trial the time allowed was reduced and the child encouraged to attain greater speed. A note was made

of/

of the foot selected for hopping at each of four trials.

TEST 18. THROWING. (Handedness)

This test was to discover which hand the child selected when throwing. A small box was placed on a chair, and the child stood at several feet distance, holding a paper ball.

Instructions: Try and throw that ball into the box. You will have four chances, see how many times you can get it in the box.

No mention was made of the hand to be used, and after each attempt the ball was thrown back to the child who selected which hand he would use. When four trials had been made with the selected hand, the child was then given one trial with the non-preferred hand. A note was made of the hand selected, and also of his relative ability in throwing with the non-preferred hand.

WRITING TEST

In addition to the battery of eighteen tests of laterality characteristics just described, a writing test was given to all the subjects. After studying the various available writing tests it was decided that the American Handwriting Scale, full details of which are to be found in the manual,[1] was the most suitable for the purpose

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1. West, Op. cit.

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of/

of this investigation, since it was designed to measure quality and speed of writing and there were no such writing tests standardised on Scottish children. It seemed worth experimenting with this test in the absence of a better; since even if the quality scale provided with the test were found not to be fully applicable to these subjects, the test would at least give a quantity scale and possibly some indications of differences in writing between left-hand and right-handed subjects, and would provide a sample of the school writing of each of the subjects under similar conditions. In the light of findings on left-handed writing[1], it was felt that there

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1. Supra., Chapter x.

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would be some differences between right-and left-handed subjects in the type of writing they produced, their method of producing it, and also in their speed of writing. In view of the handicaps of the left-handed pupils and the lack of expert guidance on how to overcome these, it seemed probable that they would be incapable of achieving both the speed and quality of writing produced by their right-handed contemporaries. Though realising that only a small sample of left-handers would be found in the present study, it was felt that valuable guidance for future research on these lines, which would be of practical importance,/

importance,might be obtained. Further, the study would include most shades of hand-preference, and it was hoped this might make possible some analysis of the relative abilities in writing of the right-hand writers who had a greater or lesser degree of right-hand dominance. Obviously the best way to standardise the conditions under which the samples were obtained was to set a test such as the following.

DETAILS OF WRITING TEST AND METHOD OF APPLYING.

The American Handwriting Scale contains several sample sections of writing, with wording suited to the various ages of children. Each sample is divided into groups of twenty-five letters for ease in checking; and except for the first two samples each passage contains a total of one hundred letters. The sample used in this investigation was that designed for American Sixth Grade children. Copies of the passage were prepared on sheets of paper, one for each child. The passage read as follows:

Teacher gave us writing tests, and found quite a few very poor. Even lazy boys like the drills, and will improve the next time.

This test was administered to the subjects in groups,each class forming a group, and taking approximately one hour to test. The first stage was to make certain that every child in the class learnt the section by heart; since, as West pointed out, one cannot make a fair estimate of speed of writing when a child is copying, he must be concentrating/

he was made to draw more quickly, and after beginning the diagram, was not allowed to pause until it was completed. Next, each vertical board was moved back through thirty degrees, and the paper turned to a new part. The child was again instructed to draw the diagram with both hands at the same time. This was repeated with the boards at sixty and ninety degrees.

The test was next carried out with the boards at the same four angles, but instead of asking the child to copy a visual pattern, he was instructed:

> When I say the number '3', I want you to draw a '3' with both hands at the same time. Have your pencils ready on the paper. Shut your eyes. Ready - 3.

The test was also carried out with a third and fourth diagram, which were both visual patterns, the fourth being the reverse of the third. For illustrations of the diagrams used in the testing, see Figure 8.

The results noted were, for each diagram, the hand which drew a reversed or mirror-image of the diagram, and the angles at which this happened.

TEST 7. CONE TEST (Eyedness.)

This test involved looking through a cone-shaped object, apparently using both eyes, but the situation was such that only one eye could actually be used. A cardboard cone, about eight inches in length, was used. It was wide enough at one end to go over both eyes, and tapered/

tapered to about an inch at the other end. The child stood several feet from the experimenter, and held the cone in both hands.

Instructions: When I say 'Go', hold up the cone, putting it over both eyes. Look through it with both eyes, and tell me how many fingers I am holding up. Ready - Go. How many fingers?

This was repeated three more times, and the eye which was visible through the narrow end of the cone at each trial was noted as the sighting eye. It may be seen from Figure 2 how this test looks to the experimenter.[1]

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1. Supra., p.129

TEST 8. STEPPING (Footedness.)

This test was to find which foot the child preferred to use in stepping, when circumstances were such as to favour neither. The child was instructed to stand against a wall, but with his heels touching it.

Instructions: When I say 'Go', take two big steps out from the wall. Step as far as you can. Ready - Go.

Three more trials were given. At each one the child was encouraged to greater effort. A note was made of the foot with which the child stepped first at each trial.

TEST 9. SPEED OF CROSSING (Handedness.)

This test was designed to measure, as simply as possible, the relative speed of the right and left hand.

The/

The child was seated with a quarto sheet of plain paper along the table in front of him, and with a pencil in the hand with which he was accustomed to write.

Instructions: When I say 'Go', start making crosses along the paper as quickly as you can. Just little ones like this (indicating thus X). If you finish one line before I say 'Stop', start another at once. Make them as quickly as you can. Ready - Go.

The time allowed was twenty seconds, measured by means of a stop watch. The child was then instructed to change the pencil to the other hand, and a similar trial was given with that hand. The test was then repeated with each hand. The results noted were the number of 'crosses' made with each hand at the first and second trials, and the total number of crosses with each hand.

TEST 10. CYLINDER. (Eyedness.)

This test indicated which eye was preferred when only one might be used, but differed from Test 2, in that the cylinder was actually held to the eye.

The apparatus consisted of a cardboard cylinder twelve inches in length and one inch in diameter. The child was handed the cylinder, then told to stand at a distance of several feet.

Instructions: Take that tube in both hands. When I say 'Go', put it up to your eyes, and look through it. Tell me the colour of the counter I will hold up. Ready - Go.

This was repeated three more times, and a note made/

made of the eye to which the cylinder was placed at each of the four trials.

The emphasis placed on speed, together with the fact that he was expected to name colours, directed the child's attention away from the actual placing of the cylinder to his eye, and thus gave his natural preference.

TEST 11. SOUND IN BOX (Earedness.)

This test indicated which ear was preferred when a choice had to be made. The child was seated at the table with his hands behind his back. A stop watch which was ticking was placed in a box, and laid on the table directly in front of him.

Instructions: Tell me if that watch is ticking. You may put your ear down to it if you wish, but do not touch it with your hands. Is it ticking? (or: Can you hear it ticking?)

This was repeated three more times, twice with the watch stopped, and once when it was ticking. The result noted was the ear placed to the watch at each trial.

TEST12. REACHING (Handedness.)

This test revealed which hand, or rather, which arm, was used in energetic reaching. The child was seated at a table, with his hands behind his back. The experimenter stood directly behind him, holding the cylinder above the child's head, almost out of reach, and in an equally favourable position for either hand.

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Instructions: When I say 'Go', reach up with one hand, and try to touch this tube. Ready - Go.

This test was repeated three more times, and for each trial the cylinder was held slightly higher than for the preceding one. A note was made of the arm used for reaching at each of the four trials.

TEST 13. HOLE IN CARD (Eyedness.)

This test showed the eye used in sighting when both were open, but only one could be used. Thus it was similar to Test 7, but a different apparatus was used. The child stood at a distance of several feet, facing the experimenter. He was given a piece of cardboard, eight inches by eleven, with a half-inch hole in the centre.

Instructions: When I say 'Go', take the card in both hands and hold it up in front of your eyes so that you can see through the little hole. Stretch out your arms in front of you, and look with both eyes. Ready - Go. Tell me how many fingers I am holding up.

This was repeated three more times, and a note made of the eye which could be seen through the hole at each of the four trials.

TEST 14. FINE MOVEMENT (Handedness)

This test was an attempt to measure the relative speed and accuracy of the left and right hand. Small silver beads, three-sixteenths of an inch in diameter; a narrow glass tube; small tweezers and a stop watch were used. The child was seated with the box of beads, the tweezers/

tweezers and the glass tube in front of him.

Instructions: I want to find out how quickly you can put five of these little beads into the tube. Pick them up with these (indicating the tweezers), one at a time. Ready - Go.

This test was repeated with the other hand. A note was made of the hand used first, the time taken with each hand, and any undue clumsiness with either hand.

TEST 15. STOP WATCH (Earedness)

This test was to determine which was the preferred ear in a situation where a choice had to be made, but differed from Test 11 since there, the child was not permitted to touch the watch, while here, it was actually held in the hand. This was to discover the influence of the dominant hand on the choice. The child was seated with his hands behind his back, and a watch on the table in front of him. The watch was placed at an equal distance from each hand.

Instructions: When I say 'Go', pick up the watch with one hand, hold it to your ear, and count how many ticks you can hear before I say 'Stop'. Ready - Go.....(about fifteen seconds later) Stop. How many did you hear?

This test was repeated three times. Before each trial the watch was replaced in such a way that it favoured neither hand, and the child was instructed to start with his hands behind his back. A note was made of the ear to which the watch was placed at each of the four trials, and also of the hand used to lift the watch.

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TEST 16. ALTERNATING MOVEMENT. (Handedness)

This was a test of the relative ability of the left and right hand to carry out simultaneous rapid alternating movements. The child was seated with his arms in a bent position. A demonstration was given, the hands being rotated rapidly in opposite directions, movement being from the wrists.

Instructions: See for how long you can make both your hands move like this. Make them go opposite ways, as quickly as you can. Go on until I tell you to stop. Ready - Go.

Usually within a very short time one of the hands ceased to make the correct movement. The test was continued until some difference such as that was observed. A note was made of the relative ability of the two hands at the start and, where one tired more quickly, that was also noted. In one or two instances, the child found it impossible even to make both hands perform the task simultaneously.

TEST 17. HOPPING (Footedness)

Here the foot preferred for hopping was tested. The child stood with his back to the wall and his feet together.

Instructions: When I say 'Go', you will start hopping towards the end of the room. See how far you can get before I say 'Stop'.
Ready - Go.....Stop.

At each trial the time allowed was reduced and the child encouraged to attain greater speed. A note was made

of/

of the foot selected for hopping at each of four trials.

TEST 18. THROWING. (Handedness)

This test was to discover which hand the child selected when throwing. A small box was placed on a chair, and the child stood at several feet distance, holding a paper ball.

Instructions: Try and throw that ball into the box. You will have four chances, see how many times you can get it in the box.

No mention was made of the hand to be used, and after each attempt the ball was thrown back to the child who selected which hand he would use. When four trials had been made with the selected hand, the child was then given one trial with the non-preferred hand. A note was made of the hand selected, and also of his relative ability in throwing with the non-preferred hand.

WRITING TEST

In addition to the battery of eighteen tests of laterality characteristics just described, a writing test was given to all the subjects. After studying the various available writing tests it was decided that the American Handwriting Scale, full details of which are to be found in the manual,[1] was the most suitable for the purpose

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1. West, Op. cit.

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of/

of this investigation, since it was designed to measure quality and speed of writing and there were no such writing tests standardised on Scottish children. It seemed worth experimenting with this test in the absence of a better; since even if the quality scale provided with the test were found not to be fully applicable to these subjects, the test would at least give a quantity scale and possibly some indications of differences in writing between left-hand and right-handed subjects, and would provide a sample of the school writing of each of the subjects under similar conditions. In the light of findings on left-handed writing[1], it was felt that there

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1. Supra., Chapter x.

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would be some differences between right-and left-handed subjects in the type of writing they produced, their method of producing it, and also in their speed of writing. In view of the handicaps of the left-handed pupils and the lack of expert guidance on how to overcome these, it seemed probable that they would be incapable of achieving both the speed and quality of writing produced by their right-handed contemporaries. Though realising that only a small sample of left-handers would be found in the present study, it was felt that valuable guidance for future research on these lines, which would be of practical importance,/

importance,might be obtained. Further, the study would include most shades of hand-preference, and it was hoped this might make possible some analysis of the relative abilities in writing of the right-hand writers who had a greater or lesser degree of right-hand dominance. Obviously the best way to standardise the conditions under which the samples were obtained was to set a test such as the following.

DETAILS OF WRITING TEST AND METHOD OF APPLYING.

The American Handwriting Scale contains several sample sections of writing, with wording suited to the various ages of children. Each sample is divided into groups of twenty-five letters for ease in checking; and except for the first two samples each passage contains a total of one hundred letters. The sample used in this investigation was that designed for American Sixth Grade children. Copies of the passage were prepared on sheets of paper, one for each child. The passage read as follows:

Teacher gave us writing tests, and found quite a few very poor. Even lazy boys like the drills, and will improve the next time.

This test was administered to the subjects in groups,each class forming a group, and taking approximately one hour to test. The first stage was to make certain that every child in the class learnt the section by heart; since, as West pointed out, one cannot make a fair estimate of speed of writing when a child is copying, he must be concentrating/

concentrating only on the actual writing. Thus, the meaning of the passage was discussed with a class; the words were repeated several times; the first part was then copied three times, or until it was learnt; similarly with the second; then attempts were made to reproduce the whole passage. When it appeared that all the children knew the passage and would not waste time thinking of the correct words, a practice sheet of paper, pen and ink were issued to each child. Two preliminary attempts were made at the test, so that even the dullest children grasped the instructions, and also to give further practice in the passage without boring the subjects. The instructions used were a modified version of those used by West, as they had to be adapted to the language of British children. They were as follows:

> I want to see how quickly and how well you can write. Do not write so quickly that you spoil the writing, nor so slowly that you don't manage to write very much. Just write as you usually do, but do as well as you possibly can. You must only start writing when I say 'Go', and write until I say 'Stop'. If you have written all the story before I say 'Stop', then start and write it all over again. Remember as quickly and as well as you can.

The time allowed for writing the test was two minutes, which was timed exactly on a stop watch. Twenty seconds before time to start the children were warned to be ready, then care was taken to ascertain that they all started to write exactly on the word 'Go'. Some difficulties were found during the practice attempts. For example, some either/

either started too soon, or too late or stopped when they had completed one attempt, or in some other way did not follow the directions exactly. The final sample was written on a separate sheet of paper. Only the test passage was written on one side of the paper, details of the child's name, age, class and school being written on the opposite side to prevent these from affecting estimates of the writing. When absentees required to be tested after the main groups an attempt was made to keep the conditions comparable with those for the other subjects.

The battery of eighteen tests, the writing test described above, and the information gained from questioning each child on handedness and from the Promotion Schedule, completed the material gathered in the course of the investigation. The following chapters will be devoted to a report of the results of the study and discussion of the findings.

CHAPTER XVI

RESULTS OF THE THIRTEEN TESTS OF LATERALITY PREFERENCE.

I. TREATMENT OF RESULTS

Particulars of the tests were given in the preceding chapter, where it was stated that each subject was permitted four trials at each test, a note being made of his preference for right or left at each attempt. Details were obtained for each test of whether the subject showed right or left preference at all trials, or whether he varied in his preference from trial to trial. Record sheets were drawn up detailing the results on all tests for each subject, as 4 (right on all four trials); 3 (right on three trials and left on one); 2 (right on two trials and left on two); 1 (left on three trials and right on one); and 0 (left on all four trials). A total score for hand, foot, ear and eye preference was also obtained for each subject; those for hand, foot and ear ranging from 12 to 0, since there were three tests with four trials in each of these sections; while those for eyedness ranged from 16 to 0, there being four tests in that section. The scores for the individual tests enabled a comparison to/

to be made between both the relative amounts of left and right preference in the different tests, and the correlation between the various tests, or the relative position of the same subject on the different tests. The total scores for each laterality characteristic enabled the same types of comparisons to be made between characteristics as were made between tests.

In order to make a comparison of all the tests with each other it was found necessary to divide the scores into two classes, placing all those who showed right preference on all four trials in one class, and all those who had any other score, - 3,2,1 or 0 - that is, who showed any tendency other than complete right preference, in the other class. This yielded in each comparison a four fold table showing those who had complete right preference on the tests being compared, those who were not completely right on both tests, and those for whom the results of the two tests were different. This method of limiting the comparisons was made necessary by the disproportionate number gaining one score, namely that of complete right preference. Though not required in the initial comparisons between the tests, tables were also drawn up on a threefold classification - R(4), L(0), A(3,2 or 1) - to facilitate a comparison of those with intermediate scores on the tests, for which purpose it was necessary to distinguish those who used right and left on different/

different trials from those who were consistently left on all trials.

In the relevant sections of this chapter there are tables giving full details of the frequency with which each actual score was obtained . While it was impossible to give the actual score of each subject on all tests because of the numbers involved, it was felt that a combination of tables giving the frequency of each score on each test, and the correlations between the tests and between the laterality characteristics, would provide sufficiently detailed particulars of the results. Detailed discussion of the group of left-hand writers will be found in a later chapter[1]. Their results are at this stage included in the total group,as the concern in this

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1. Infra., Chapter XXI.

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chapter is the laterality characteristics of an unselected group. Mention of the results of the left-hand writers is, however, made in passing if they appear to bear on the matter under discussion.

This study of laterality characteristics resulted in some difficulty in finding an admissible statistical method of treating the material, a difficulty which was increased by the choice of a group unselected for hand preference. The inequality of the distribution into the various/

various scores, and in particular the extreme bias towards right in the handedness tests in particular, being in one test 93 per cent of the total, caused obvious difficulties, which even the testing of 330 subjects would not of course overcome. This, when combined with the inability to assume here a continuous variation in laterality characteristics, ruled out many of the better known methods of statistical treatment, since a normal distribution is usually assumed. The best method of treating the results seemed, for these reasons, to be by means of calculation of the phi-coefficient since, according to Guilford[1], this is the

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1. J.P.Guilford, Fundamental Statistics in Psychology and Education, p. 339. New York: McGraw-Hill Book Co. Inc.1950.

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most suitable method of comparing two distributions when other methods cannot be applied because of the dichotomous nature of the distributions. He also recommended that the significance of phi when calculated from a fourfold table be determined by a calculation of chi-square, since where it is significant, the corresponding phi is also significant. Unfortunately the maximum size of phi is limited under certain circumstances, circumstances which are present in this study; namely, when the marginal proportions for the two tests are not equal, or nearly so. Thus/

Thus the maximum phi which could be obtained in many of these tests was well below unity. When studying the underlying strength of the relationship of two tests by means of phi, it is necessary, therefore, to bear in mind the maximal phi possible with these existing marginal totals. As Guilford pointed out, however, when it is desired to make predictions from these to other categories, then the phi coefficient obtained is a more realistic figure. An approximation of the maximal phi can be ascertained by reading off from the graphic solution given by Guilford [1], which was done in this study, the

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1. Ibid, p.344.

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maximal phi being quoted beside the obtained value in each instance. In the comparisons given in the following part of this chapter, the chi-square values were calculated from fourfold tables, and phi coefficients were got from these by means of the formula $\left(\phi = \sqrt{\frac{\chi^2}{N}}\right)$.

The possibility of a sex difference in the frequency of the various laterality characteristics early became apparent, so the percentages of boys and girls who were right, left, and doubtful on each test were calculated. In most instances there was a higher percentage of boys than girls who showed left preference. The significance of these differences, both of those who showed complete left preference on all trials, and those who showed any left/

left tendency - that is, scored 3,2,1 or 0 on a test - was calculated in each instance.[1]

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1. H.E. Garrett, Statistics in Psychology and Education, pp. 218-220, New York: Longmans, Green and Co.,Inc., 1947.

The next part of this chapter contains the results of the preference tests grouped under the heading of the laterality characteristic they were designed to measure. The results of each test are detailed, the sex difference discussed, and a comparison made between the results of the various tests of that characteristic. A discussion on the connection between the various tests of one characteristic and those of the others and a series of tables summarising the results of the preference tests is to be found in the following chapter.

II. DISCUSSION ON THE RESULTS OF THE INDIVIDUAL PREFERENCE TESTS.

A. HANDEDNESS

1. SCREWING.

TABLE IV FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON SCREWING TEST

	Degree of Preference [a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	129	8	3	2	20	162
Girls	144	4	2	1	17	168
Total	273	12	5	3	37	330
	273		20		37	

a. Total Number of Trials 4

R - Right on all 4 L-Left on all 4.

R^L - Right on 3, left on 1 L^R Left on 3, right on 1.

RL - Right on 2, left on 2

As may be seen from Table IV, most subjects showed a consistent preference for the right hand in this test, the first of the battery to be given. Only 20 of the subjects (13 boys and 7 girls) changed their preference on subsequent trials, and in several instances this was actually a preference for one hand in unscrewing and the other in screwing. Though the higher frequency of R^L than L^R would be partly explained by the greater absolute amount of right-handedness and therefore possibly of those tending to it, it should also be noted that this test may favour right preference by the very nature of the screw, which is more easily unscrewed, at least, with the right hand. With a screw, as with many other implements which appear, on the surface, to be symmetrical, there is something in the nature of the design which makes them more adaptable to right hand usage; other examples of this being many kitchen utensils, scissors, and even the fastening on a brooch. The screw on a watch is a more extreme example of this, since its actual position on the watch necessitates the use of the right hand; though it may sometimes be found that a left-hander winds the watch by manipulating it and holding the head of the screw in position, instead of the reverse, a technique which is occasionally employed even when screwing and unscrewing a bottle, as in this test. Though the nature of the screw would probably not affect extreme left-handers/

left-handers much, the chances are that those in doubt would prefer the right on later trials. The definite left preference shown on this test represented 11.2 per cent of those tested, yet only 12 of the 18 left-hand writers (5 of 6 girls and 7 of 12 boys) were consistently left in their choice on this test, while 3 were consistently right, the remaining 3 using their right hand on the first three trials, and the left on the last trial.

A greater number of boys than girls showed complete left preference, and also a greater number showed doubtful preference on this test. The difference between the numbers of boys and girls showing complete left preference was 2.3 per cent, and between those not showing complete right preference the difference was 6.1 per cent. Neither of these differences was great enough to give any confidence in its significance, the critical ratios being .67 and 1. 47 respectively.

2. REACHING.

2. REACHING

TABLE V FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON REACHING TEST

	Degree of Preference [a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	129	3	8	3	19	162
Girls	145	7	8	0	8	168
Total	274	10	16	3	27	330
	274		29		27	

a. Total Number of Trials 4

R-Right on all 4 L-Left on all 4

R^L-Right on 3, left on 1. L^R-Left on 3, Right on 1.

RL - Right on 2, Left on 2.

The results of this test are to be found in Table V. Here again it may be seen that nearly all the subjects showed a consistent preference, in most instances for the right hand. The percentage showing consistent left preference was 8.2 per cent, while an almost equal number showed indecision (8.8 per cent).

The most noticeable difference between this test and the previous one was the larger number who were, here, equally divided between left and right (RL), 16 here against 5 in the Screwing Test. Since no skill or strength was required in the Reaching Test, nor was there anything particularly leading to right preference, as there was/

was in the previous test, those who were doubtful found nothing in the test to encourage them to come down on one side or the other. Only half of the left-hand writers used the left hand consistently in this test.

The same tendency for the boys to show more left preference than the girls was again evident in this test, complete left preference being shown by 11.7 per cent of the boys and 4.8 per cent of the girls; while the percentages of those who were doubtful on the test were almost identical for the two (8.7 and 8.9 per cent respectively). The difference between the percentage of boys and girls showing consistent left preference, 6.9 per cent, was large enough to be significant, with a critical ratio of 2.29 which is significant at the .05 level.

3. THROWING

TABLE VI FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON THROWING TEST

	Degree of Preference [a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	149	1	1	0	11	162
Girls	158	0	1	0	9	168
Total	307	1	2	0	20	330
	307		3		20	

a. As in Table IV

Details of the results of this test are to be seen/

seen in Table VI, from which it is apparent that few subjects were in any doubt as to their preferred hand for throwing, 3 only out of 330 showing any inconsistency in their scores on the four trials. A practised activity such as this, and one requiring a certain amount of skill and accuracy, seemed to divide the subjects almost entirely into two groups; their throwing hand having been determined years before. Since accuracy and the competitive element were stressed in this test, this would obviously not lead the subjects to indulge in any experimentation with the hand used. Left preference was shown by 6.1 per cent of the total group of subjects, and by all but three of the left-hand writers.

Left preference was again higher among the boys, the difference between the boys and girls being 1.5 per cent considering those with consistent left preference, and 2.1 per cent for those with any left tendency. Neither of these differences was, however, great enough to be significant, the critical ratios being .57 and 75 respectively.

4. CORRELATION BETWEEN THE TESTS OF HANDEDNESS

TABLE VII CORRELATION BETWEEN TESTS OF HAND PREFERENCE (330 SUBJECTS)

Tests	χ^2	ϕ	Maximum ϕ
Screwing Reaching	19.4	.24	.98
Reaching Throwing	33.9	.32	.57
Throwing Screwing	63.8	.44	.57

The values of chi-square and of phi obtained when a comparison was made between those showing complete right preference, and those showing any left preference on the three tests, may be seen in Table VII. All the chi-square results were well above P .01, revealing a high probability of a connection between the tests. The values of phi obtained, though limited by the nature of the distribution of the scores, the maximum phi under these circumstances being quoted in the table, were high enough to be significant. It may be seen that the Screwing and Throwing Tests had the highest measure of agreement (ϕ .44, maximum .57). Among the left-hand writers, 13 were 'not right' on both these tests, 1 was right on both, while in the remaining 4 instances, all boys, there was a disagreement in the results of the two tests.

B. FOOTEDNESS

1. KICKING.

TABLE VIII FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON KICKING TEST.

	Degree of Preference [a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	145	2	0	3	12	162
Girls	156	2	0	0	10	168
Total	301	4	0	3	22	330
	301		7		22	

a. As in Table IV

The results of this test are shown in Table VIII, and clearly reveal that most subjects were in no doubt regarding their preferred foot for kicking, 7 only showing any inconsistency, and that for most of the subjects the preferred foot was the right, for 91.2 per cent in fact. This activity, like throwing, is a much practised one, particularly by the boys, and for that reason one in which they would have established their preference long before the testing. The emphasis on skill in this test would prevent the subjects experimenting with the non-preferred foot; since, so far as they were aware, the aim of the test was to ascertain how many times they could kick the ball between the legs of a chair. As may be seen from the Table, none of the subjects used the right and left foot an equal number of times.

Consistent left preference was slightly greater among the boys than the girls, as also was any degree of left preference, the differences being 1.4 and 3.3 per cent respectively. Neither difference was, however, great enough to be significant, the critical ratios being .51 and 1.06 respectively.

2 STEPPING

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2 STEPPING

TABLE IX FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON STEPPING TEST

	Degree of Preference [a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	65	26	15	17	39	162
Girls	100	22	13	11	22	168
Total	165	48	28	28	61	330
	165	104			61	

a. As in Table IV

The pattern of results on this test was completely different from that found on the previous tests, as can be seen on Table IX. The results here were much more evenly divided into the five categories, 104 subjects showing inconsistency, or almost half as many as were consistent on all four trials. The percentage of consistent left preference was also considerably higher on this test, representing 18.2 per cent of the total.

The boys again showed a greater incidence of consistent left preference on this test than did the girls, the difference being 10.4 per cent, and 18.8 per cent considering those showing any degree of left preference. These differences, with critical ratios of 2.46 and 3.48, may be considered significant, the former at the 2 per cent level and the latter at the 1 per cent level of significance./

Only 6 of 18 left-hand writers were consistently left on this test. This, when combined with the unusual distribution found in the total group, which was so different from that on any of the other tests, led to suspicions about the test, suspicions which were later confirmed when the test was compared with the other tests. Though the actual situation in this test was one which few of the subjects would have encountered previously, the training which they received in stepping off with a certain foot had, it seemed, caused a distortion of the distribution. The insistence in many situations that boys step with the left foot in marching and dancing for example, had, it was felt, also widened the gap between the two sexes, and was possibly the, or at least one, explanation for its greater significance in this test than in the other tests.

3. HOPPING

TABLE X FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON HOPPING TEST

	Degree of Preference [a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	130	4	3	3	22	162
Girls	117	6	4	6	35	168
Total	247	10	7	9	57	330
	247	26			57	

a. As in Table IV

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The results of this test, which are shown in Table X, reveal that in hopping the majority of subjects, boys and girls, had a consistent preference for the right foot. Consistent left preference was present in 17.3 per cent of the subjects. Though this percentage is comparable to that found in the Stepping Test, the percentage showing inconsistency is here much lower, being 7.9 per cent; while in the Stepping Test it was 31.5 per cent.

The sex difference on this test was the reverse of that found in the other tests. There was a greater percentage of girls than of boys showing left preference, both consistent and partial, the differences being 7.2 and 10.5 per cent respectively. The critical ratios were 1.74 and 2.22; the former cannot be regarded as significant, while the latter, P .05, may be regarded as barely significant.

4. CORRELATION BETWEEN THE TESTS OF FOOTEDNESS

TABLE XI CORRELATION BETWEEN TESTS OF FOOT PREFERENCE (330 SUBJECTS)

Tests	χ^2	ϕ	Maximum ϕ
Kicking Stepping	.94	.05	.31
Stepping Hopping	.14	.02	.58
Kicking Hopping	15.2	.22	.53

The/

The values of chi-square and of phi obtained from a comparison of the three tests of footedness may be seen in Table XI. The comparison was between those showing complete right preference and those showing any left preference on each of the tests. There appeared to be no connection between the Tests of Kicking and Stepping, and between those of Stepping and Hopping (χ^2 .94 and .14 respectively). The comparison between the tests of Kicking and Hopping indicated the probability of a connection between the two tests (χ^2 15.2, significant well above the 1 per cent level). Since the value of chi-square is significant, the corresponding value of phi is also significant (ϕ .22 max. ϕ .53), indicating a significant relationship between the foot used in hopping and that used for kicking.

Stepping appears to be the test in this group which disagrees with the results of the other tests. It was felt that this might result from the large number who were undecided on that test and who, in drawing up the fourfold tables were placed in the category with left preference, for that reason a further analysis was made of the test. Taking the Hopping and Stepping Tests and comparing them, since the numbers showing consistent left preference on these two tests were comparable (57 and 61 subjects respectively), it was found that 28 subjects were consistently right in stepping and consistently left in hopping; while/

while 46 were consistently left in stepping and consistently right in hopping. In only 12 of 330 subjects was there complete agreement on consistent left preference. It would appear, therefore, that calculating the correlation from a fourfold table was not covering up a relationship between the two tests. Further, chi-square was calculated separately for the girls' scores, in case the boys scores only were causing the disagreement. The value of chi-square was slightly increased for the Kicking and Stepping Tests - to χ^2 1.64, but reduced for the Stepping and Hopping Tests to χ^2 .04.

C. EAREDNESS

1. SOUND IN BOX

TABLE XII FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON SOUND IN BOX TEST

	Degree of Preference [a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	89	2	6	1	64	162
Girls	109	5	3	1	50	168
Total	198	7	9	2	114	330
	198	18			114	

a. As in Table IV

The results of this test may be seen in Table XII, indicating that about one-third of the subjects showed consistent/

consistent left preference in this test, most of the remainder being consistently right. The percentages were 34.5 and 60.0 per cent respectively. Though this was an unpractised activity, few changed their preference from one trial to the next, only 9 boys and 9 girls being undecided. It seems, therefore, that there must be a preferred ear even in a situation such as this where external circumstances favoured neither. The subject placed his ear down to the box to listen for the watch, without touching it, thus ruling out the possibility that the preferred hand might influence the results. In spite of these precautions, the tendency on this test, as in tests of handedness, was for the majority to show right preference. Here, however, the balance in favour of right preference was not so extreme being roughly 3:2 instead of 5:1 as in the Reaching Test which was probably the most comparable test of hand preference. The extent to which the results were determined or affected by the relative aural acuity of the two ears has not been estimated in this present study.

Left preference was shown by a greater number of the boys than girls again in this test, as in those of handedness. The difference between the boys and girls showing consistent left preference was 9.7 per cent, and between those showing any left preference, the difference was 9.9 per cent. The critical ratios of these differences were 1.87 and 1.84 respectively. Neither of these differences can/

can be considered significant.

2. STOP WATCH

TABLE XIII FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON STOP WATCH TEST

	Degree of Preference [a.]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	128	1	9	1	23	162
Girls	143	1	10	3	11	168
Total	271	2	19	4	34	330
	271		25		34	

a. As in Table IV

The results of this test shown in Table XIII, indicate that the majority of the subjects showed right preference on this test of earedness, the remainder being fairly evenly divided between mixed preference and consistent left preference (7.6 and 10. 3 per cent respectively). Most of those who were not consistently right or left appeared to be divided evenly between right and left, as may be seen from the fact that of 25 doubtful, 19 are in column RL in the Table. In this test the subjects held the watch to whichever ear they preferred, with whichever hand they pleased, in order that the effect of the dominant hand on the results might be ascertained. As may be seen from a comparison of this test and the previous test where handedness did not enter, the number/

number showing consistent left preference was reduced by more than two-thirds (from 34.5 per cent to 10.3 per cent). In most instances the watch was held to the ear with the corresponding hand, even when that was not the preferred hand in any of the preference tests of handedness. Even those who used the left ear twice and the right ear for the other two trials, still used the corresponding hand in each trial. Rarely was crossed preference shown. The emphasis on speed on this test may have reduced slightly the number showing crossed preference of hand and ear from the number who would use a different hand and ear in a real life situation, such as telephoning. Probably even in using the telephone the complicated distortions indulged in by some result from a third factor, namely finding it necessary to write with the hand which is already occupied in holding the telephone. Rarely under such circumstances does a person change the receiver to the other ear to suit the hand now being used. Thus, the crossed position there is probably derived through a series of circumstances and not the initial one.

A sex difference was also seen on this test, in favour of greater left preference on the part of the boys; 7.6 per cent more boys showing consistent left preference, and 6.1 per cent more boys showing any left preference. The critical ratios for these differences were 2.28 and 1.45 respectively./

respectively. Thus the difference between the percentage of boys and the percentage of girls showing consistent left preference on this test is significant at the 5 per cent level.

3. HEAD TURNING

TABLE XIV FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON HEAD TURNING TEST

	Degree of Preference [a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	109	0	2	5	46	162
Girls	121	2	2	1	42	168
Total	230	2	4	6	88	330
	230		12		88	

a. As in Table IV

From the results of this test, shown in Table XIV, it appears that most of the subjects had a consistent preference for one side or the other when turning their heads in response to a sound made immediately behind them, and that for the majority, the preference was for the right, 69.7 per cent preferring the right and 26.7 per cent showing consistent left preference. The amount of consistent left preference shown on this test, though greater than that shown in the Stop Watch Test (10.3 per cent); was not as great as that shown in the Sound in Box Test (34.5 per cent). Fewer/

Fewer were inconsistent on this test than on either of the other two tests of earedness.

The sex difference in this test was again in favour of greater left preference on the part of the boys than the girls, the differences being 3.4 per cent between those showing consistent left preference, and 4.7 per cent between those showing any left preference. Neither of these differences was great enough to be significant, the critical ratios being 0.7 and 0.93 respectively.

4. CORRELATION BETWEEN THE TESTS OF EAREDNESS

TABLE XV CORRELATION BETWEEN TESTS OF EAR PREFERENCE (330 SUBJECTS)

Tests	χ^2	ϕ	Maximum ϕ
Sound in Box Stop Watch	26.0	.28	.58
Sound in Box Head Turning	5.98	.14	.81
Stop Watch Head Turning	1.64	.07	.71

The values of chi-square and phi obtained when a comparison was made between the three tests of earedness may be found in Table XV. The improbability of a lack of connection between the Sound in Box Test and Stop Watch/

Watch Tests ($\chi^2$26.0) may be seen from the Table (P greatly exceeds .01). The correlation obtained on these two tests (ϕ.28 max.ϕ.58) is therefore also significant. The value of chi-square obtained on the Sound in Box and Head Turning Tests is significant at the 2 per cent level of significance; thus the corresponding value of phi (ϕ.14 max.ϕ .81) is also barely significant. The third comparison, that between the Stop Watch and Head Turning Tests ($\chi^2$1.64-P.20) fails to establish a connection between the tests.

There appears, from these results, to be a definite connection between the preference of the subjects on the two selected tests of earedness, Sound in Box and Stop Watch Tests. The Head Turning Test which involved turning round after a sound had been made, was not an instinctive reaction to the sound, but rather a deliberate act following it. This test appears to have little connection with the preferences found on the other tests of earedness. There was some slight connection between it and the Sound in Box Test, but none with the Stop Watch Test where handedness was also involved.

D. EYEDNESS

1. CONE TEST

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D. EYEDNESS

1. CONE TEST

TABLE XVI FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON CONE TEST

	Degree of Preference [a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	93	7	4	2	56	162
Girls	91	9	6	8	54	168
Total	184	16	10	10	110	330
	184		36		110	

a. As in Table IV

The results of the Cone Test of eyedness may be seen in Table XVI. The percentages of subjects showing consistent right and left preference on this test were 55.8 and 33.3 per cent respectively. Those showing inconsistency were fairly evenly divided into the three categories R^L, RL and L^R, the frequencies being 16, 10 and 10 respectively. The distribution of the scores of boys and girls was practically the same on this test.

Most subjects had a consistent preference for one eye or the other on this test (only 36 were not consistent), and for the majority the preference was for the right eye.

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2. HOLE IN CARD

TABLE XVII FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON HOLE IN CARD TEST

	Degree of Preference [a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	97	1	1	5	58	162
Girls	102	3	1	0	62	168
Total	199	4	2	5	120	330
	199		11		120	

a. As in Table IV

The results of this test of eyedness may be seen in Table XVII. In this test, as in the previous one, the subjects were unaware that a choice of eye was involved, as both eyes remained open. The distribution of scores on this test was similar to that on the Cone Test, except that slightly fewer subjects were inconsistent on this present test, resulting in a slight increase both in those with consistent right and with consistent left preference, the percentages here being 60.3 and 36.4 per cent respectively.

There was no significant sex difference on this test, the percentages of boys and girls showing consistent left preference being 35.8 and 36.9 per cent respectively.

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3. PEEP SHOW

TABLE XVIII FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON PEEP-SHOW TEST

	Degree of Preference.[a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	102	0	0	0	60	162
Girls	106	0	0	0	62	168
Total	208	0	0	0	122	330
	208		0		122	

a. As in Table IV.

The results of this test, which may be seen in Table XVIII, show that the subjects were clearly divided into two classes on this test, those showing consistent right preference and those showing consistent left preference, 63 and 37 per cent respectively. The percentages of boys and girls showing consistent left preference on this test were practically identical (37.0 and 36.9 per cent respectively).

The subjects were unaware that the eye selected in this test was being noted, and were under the impression that the task was to read the words written inside the box, yet they were consistent in their eye preference on all four trials.

4. CYLINDER TEST

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4 CYLINDER TEST

TABLE XIX FREQUENCY OF DIFFERENT DEGREES OF PREFERENCE FOR ALL SUBJECTS ON CYLINDER TEST

	Degree of Preference [a]					
Subjects	R	R^L	RL	L^R	L	Total
Boys	100	2	0	2	58	162
Girls	105	0	1	1	61	168
Total	205	2	1	3	119	330
	205		6		119	

a. As in Table IV

The results of this test may be seen in Table XIX. This test, like the previous one, involved a deliberate choice of one eye, and here as in that test, most subjects showed a consistent preference, only 6 subjects giving different results on repeated trials. Consistent right preference was shown by 62.1 per cent and consistent left preference by 36.1 per cent of the subjects, figures very similar to those obtained on the Peep Show Test. The scores obtained by boys and girls on this test were very similar, consistent left preference being shown by 35.8 per cent and 36.3 per cent respectively.

4. CORRELATION BETWEEN THE TESTS OF EYEDNESS

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4. CORRELATION BETWEEN THE TESTS OF EYEDNESS

TABLE XX CORRELATION BETWEEN TESTS OF EYE PREFERENCE (330 SUBJECTS)

Tests	χ^2	ϕ	Maximum ϕ
Cone Peep Show	160.4	.70	.86
Cone Cylinder	144.9	.66	.87
Hole in Card Cylinder	209.5	.80	.96
Cone Hole in Card	191.0	.76	.91
Hole in Card Peep Show	233.1	.84	.93
Peep Show Cylinder	261.7	.89	.97

The values of chi-square and phi obtained when a comparison was made between these tests may be seen in Table XX. Since all values of chi-square in the Table are significant well beyond the .01 level, the null hypothesis can be rejected with certainty in all instances. Since the chi-square values are significant, the corresponding values of phi are also significant. The more even distribution between left and right preference obtained in tests of eyedness resulted in higher maximum values of phi, and is one explanation of the higher correlations obtained on these tests than

on/

on any involving handedness. The correlations between all four tests of eyedness were very high, especially in view of the precautions which were taken to prevent one test influencing the subsequent tests. When one considers the high correlations obtained here between the tests of eyedness, and also the internal consistency of the tests, it seems impossible to deny that these appear to indicate the existence of eyedness as a laterality characteristic. Study of the results of all four tests of eyedness revealed that 246 subjects had consistent results on all four trials of all four tests, 160 being consistently right and 86 showing consistently left preference.

The percentage of boys showing consistent left preference on all four tests of eyedness was 25.9 and the percentage of girls 26.2 per cent: while 50.0 per cent of the boys and 53.0 per cent of the girls showed any left tendency. The critical ratio of the latter difference was .55. There was, therefore, no significant difference between the results of boys and girls on the tests of eyedness.

CHAPTER XVII

COMPARISON OF LATERALITY CHARACTERISTICS AS MEASURED BY PREFERENCE TESTS

The discussion in this chapter is concerned with the connection between the tests of the various laterality characteristics, both the relative percentages of the various preferences found and the actual correlations between the tests. Details of the percentage frequency of each type of preference in all thirteen tests may be seen in Table XXI.

TABLE XXI PERCENTAGES OF SUBJECTS SHOWING VARIOUS PREFERENCES ON THE PREFERENCE TESTS (330 SUBJECTS)

Tests		Percentage of Subjects [a]		
Type of Test	Name of Test	R	A	L
Hand	Screwing	82.7	6.1	11.2
	Reaching	83.0	8.8	8.2
	Throwing	93.0	.9	6.1
Foot	Kicking	91.2	2.1	6.7
	Stepping	50.3	31.5	18.2
	Hopping	74.8	7.9	17.3
Ear	Sound in Box	60.0	5.5	34.5
	Stop Watch	82.1	7.6	10.3
	Head Turning	69.7	3.6	26.7
Eye	Cone	55.8	10.9	33.3
	Hole in Card	60.3	3.3	36.4
	Peep Show	63.0	0	37.0
	Cylinder	62.1	1.8	36.1

a. R-Right on all 4 trials: L-Left on all 4 trials
A - all other scores

I HANDEDNESS AND FOOTEDNESS

Since the inter-correlations on the tests of footedness were not very high, it was decided to compare the tests individually with those of handedness instead of treating them as a single score. As was shown in the previous chapter, the Stepping Test did not appear to be a reliable test of footedness, and for that reason it is not considered further in this section. An examination of Table XXI shows that the relative percentages of subjects showing each type of preference in the Throwing and Kicking Tests bear a very close resemblance to each other. The results obtained from calculation of chi-square and phi on these tests may be seen in Table XXII.

TABLE XXII

CORRELATION BETWEEN KICKING AND HOPPING TESTS AND HANDEDNESS TESTS (330 SUBJECTS)

Tests	χ^2	ϕ	Maximum ϕ
Kicking Screwing	51.9	.40	.68
Kicking Reaching	17.7	.23	.68
Kicking Throwing	71.2	.46	.85
Hopping Screwing	6.7	.14	.78
Hopping Reaching	0.46	.04	.78
Hopping Throwing	12.9	.20	.46

When the Kicking Test of footedness compared with each test of handedness the value of chi-square was in each instance significant well beyond the .01 per cent level. Thus all three values of phi may be regarded as significant. The correlation obtained between the Kicking and Throwing Tests (ϕ .46 max.ϕ .85) compares favourably with the intercorrelations found on the handedness tests. Though the actual value of phi was slightly higher here than was obtained between the Screwing and Throwing Tests (ϕ .44 max.ϕ .57), it must be remembered that the maximum is considerably lower in this latter instance.

The values of chi-square obtained when the Hopping Test was compared with the handedness tests were significant above the .01 level in two instances, with the Screwing and Throwing Tests (6.7 and 12.9 respectively). The value of chi-square found on the Reaching and Hopping Tests made it impossible in that instance to refute the null hypothesis. Since the values of chi-square between the Hopping Test and the Throwing and Screwing Tests were significant the corresponding values of phi were also significant (ϕ .20 and ϕ.14 respectively). These were, however, lower than those found when the Kicking Test was compared with the corresponding tests of handedness.

In short, the Kicking and Hopping Tests of footedness had a significant correlation with the handedness tests of Screwing and Throwing. The Reaching Test, whose/

whose correlation with the other tests of handedness was lower than theirs with each other, had a correspondingly lower correlation with the footedness tests, that with the Kicking Test still being significant, while that with the Hopping Test was not.

II HANDEDNESS AND EAREDNESS

A comparison between the percentage of left and right preference found on the handedness tests and those on the various earedness tests (see Table XXI) shows as would be expected that the percentages in the Stop Watch Test of earedness are closest to those of handedness. This test had also the highest correlation with the handedness tests, as is shown in Table XXIII.

TABLE XXIII

CORRELATION BETWEEN TESTS OF HAND AND EAR PREFERENCE (330 SUBJECTS)

Tests	χ^2	ϕ	Maximum ϕ
Handedness Sound in Box	1.9	.08	.78
Handedness Stop Watch	15.1	.21	.73
Handedness Head Turning	6.4	.14	.95

The values of chi-square found on a comparison of the results of the handedness tests with the Stop Watch Test

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Test ($\chi^2$15.1, P .01) and the Head Turning Test ($\chi^2$6.4 P.02) were significant and therefore the corresponding values of phi (ϕ .21 max.ϕ .73 and ϕ .14 max.ϕ·95 respectively) were also significant. The null hypothesis cannot be considered disproved by the chi-square obtained on comparing the handedness tests with the Sound in Box Test of Earedness.

The results of this study appear to indicate some connection between the ear selected for listening when an object is held in the hand, and the hand used in preference tests of handedness, and a low but significant correlation between the dominant hand and the direction in which the head is turned on hearing a sound. No significant connection was found between the ear preferred and the hand used in preference tests of handedness when the subject was not permitted to touch the watch.

III HANDEDNESS AND EYEDNESS

In all three tests of handedness and in all four tests of eyedness the majority of subjects showed right preference. The proportion of right to left preference was different on the two groups of tests. In the hand preference tests it was approximately 5:1; while in the eye preference tests it was approximately 3:2. Details of the relative position of subjects on the two groups of/

of tests may be seen in Table XXIV.

TABLE XXIV

COMPARISON BETWEEN PLACING OF SUBJECTS ON TESTS OF HAND AND EYE PREFERENCE.

Frequencies on Eye Tests.	Frequencies on Hand Tests.			
	Right (Score 12)	Doubtful (Score 11-1)	Left (Score 0)	Totals
Right (Score 16)	121	39	0	160
Doubtful (Score 15-1)	55	24	5	84
Left (Score 0)	60	23	3	86
Totals	236	86	8	330

The values of chi-square and phi calculated for these groups of tests from a fourfold table may be seen in Table XXV.

TABLE XXV

CORRELATION BETWEEN TESTS OF HAND AND EYE PREFERENCE (330) SUBJECTS)

Tests	χ^2	ϕ	Maximum ϕ
Handedness Eyedness (Consistently Right Not Right)	2.6	.09	.65
Handedness Eyedness (Consistent Not Consistent)	0.33	.03	.98

The values of chi-square obtained (χ^2 2.6) does not warrant dismissal of the null hypothesis. The correlation obtained between the tests of handedness and eyedness was therefore not significant.

A comparison was also made between those who were consistent and those who were not consistent on the two groups of tests, in order to ascertain whether there was a tendency for those who were doubtful on handedness tests also to be doubtful on eyedness tests. The chi-square value for this comparison is also shown in Table XXV, and indicates the absence of any connection between these two aspects (χ^2 0.33).

There was 122 of the total 330 subjects who were dominantly right or left on all trials of all tests of either hand or eye and doubtful on the other group of tests; while lack of consistency on both groups of tests was shown by 24 subjects. The actual scores obtained on both groups of tests may be seen in Table XXVI.

TABLE XXVI

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TABLE XXVI

COMPARISON OF DISTRIBUTION OF SCORES AND PREFERENCE TESTS OF HANDEDNESS AND EYEDNESS

Frequencies on Eye Tests		Frequencies on Hand Tests[a] L													
		0	1	2	3	4	5	6	7	8	9	10	11	12	Total
L	0	3		1	2	6		1	2	4	1	1	5	60	86
	1									1	1	1		5	8
	2													2	2
	3									1		1		4	6
	4					1					1		1	6	9
	5					1							1	1	3
	6	1												1	2
	7													2	2
	8									1			1	10	12
	9													1	1
	10														0
	11													2	2
	12	1								1	1	2		8	13
	13													5	5
	14	1										1	1	2	5
	15	2				1				2		2	1	6	14
R	16					3	2			16	2	9	7	121	160
Total		8	0	1	2	12	2	1	2	26	6	17	17	236	330

a. Handedness Scores 0-12:
0 - Left on all 4 trials of all 3 tests
12 - Right on all 4 trials of all 3 tests
Eyedness Scores 0-16:
0 - Left on all 4 trials of all 4 tests
16 - Right on all 4 trials of all 4 tests

It may also be seen from the Table that no subjects who were left on all tests of hand preference were right-eyed on all eyedness tests.

No connection between eyedness and handedness was found on the tests employed in this study; nor did it seem to follow that because a subject was inconsistent with regard to tests of either hand or eye, he was therefore necessarily more likely to be inconsistent on the other group of tests. In other words, inconsistency on one group of tests did not seem to be connected with inconsistency in the other.

An analysis of the Intelligence Quotients of the 24 subjects (8 girls and 16 boys) who gave inconsistent results on the tests of both eyedness and handedness revealed no tendency for them to be of less than average intelligence. The mean I.Q. of these subjects was 109.3 which was almost idential to that of the total group of right-handed subjects (109.3 for girls, 109.4 for boys) and further, only two of them had an I.Q. of under 100.

IV EYEDNESS AND EAREDNESS

The percentage of left and right dominance for eyedness and the Sound in Box of earedness were comparable as may be seen from Table XXI. When a comparison was made between the tests of eye and ear preference, the chi-square/

chi-square and phi values stated in Table XXVII were found.

TABLE XXVII

CORRELATION BETWEEN TESTS OF EAR AND EYE PREFERENCE (330 SUBJECTS)

Tests	χ^2	ϕ	Maximum ϕ
Eyedness Sound in Box	7.3	.15	.85
Eyedness Stop Watch	2.6	.09	.50
Eyedness Head Turning	0.36	.03	.67

The values of chi-square found between eyedness and the Stop Watch Test and eyedness and the Head Turning Test (χ^2 2.6 and 0.36 respectively) do not warrant dismissal of the null hypothesis. The value of chi-square obtained between the eyedness and the Sound in Box Test (χ^2 7.3 P.01), means that the corresponding values of phi is also significant (ϕ .15 max. ϕ .85), indicating a low, but positive connection between eyedness and the Sound in Box Test.

The correlations discussed in this and the preceding chapter are summarised in Table XXVIII. The correlations have been assumed to be significant where the corresponding value of chi-square was significant. Diagrammatic representation of the relative percentages of right, left and doubtful preference on all the preference tests may be seen in Figure 9.

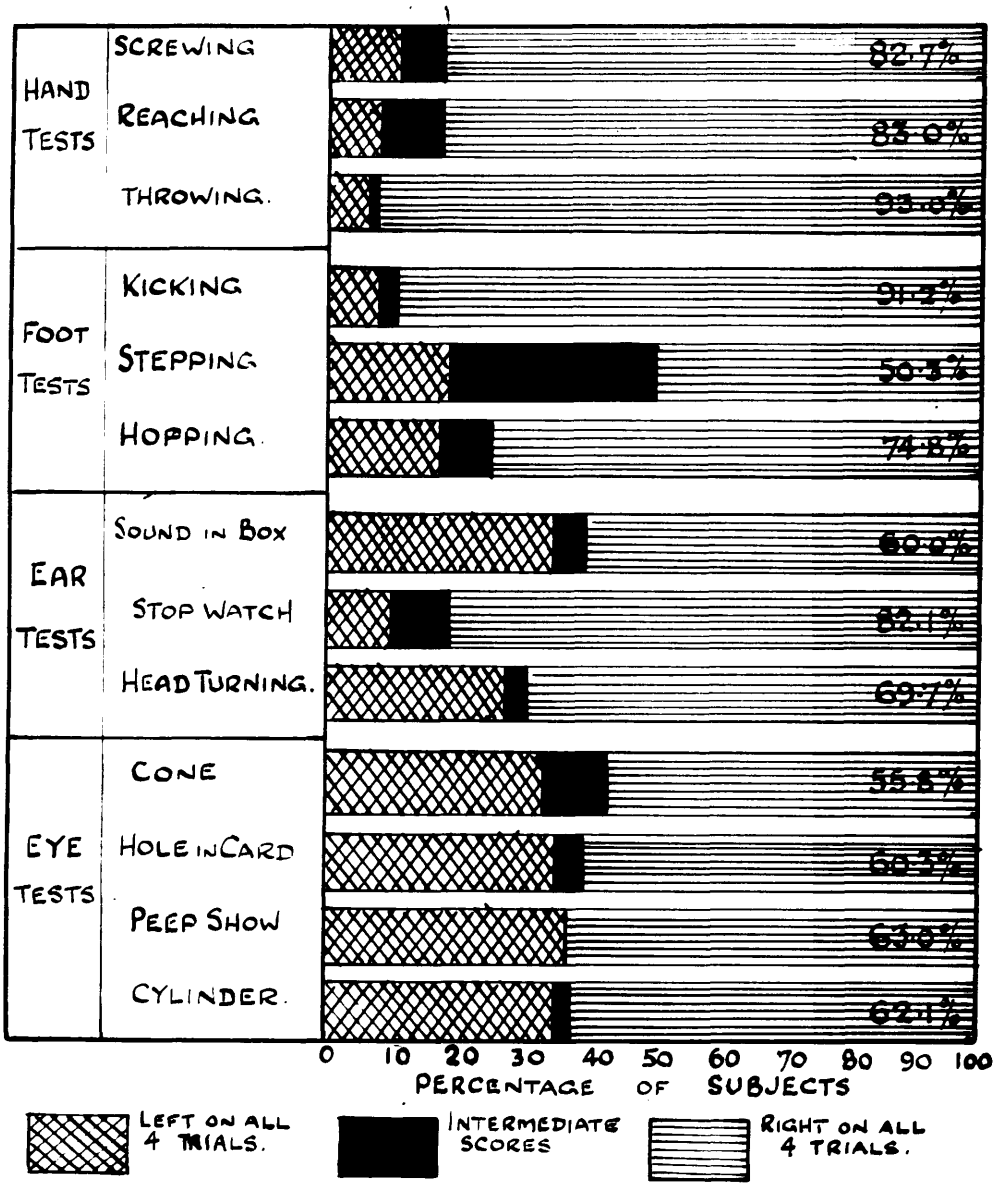

FIGURE 9. FREQUENCY DISTRIBUTION ON TESTS OF LATERALITY PREFERENCE (330 SUBJECTS)

TABLE XXVIII

CORRELATION BETWEEN PREFERENCE TESTS (330 SUBJECTS)[a]

Tests		Tests[b]												
		Hand			Foot			Ear			Eye			
		Sc	Re	Th	Ki	St	Ho	SB	SW	HT	Co	HC	PS	Cy
Hand	Sc		24	44	40		14							
	Re	98		32	23		04	08	21	14	09			
	Th	57	57		46		20							
Foot	Ki	68	68	85		05	22							
	St				31		02							
	Ho	78	78	46	53	58								
Ear	SB		78						28	14	15			
	SW		73					58		07	09			
	HT		95					81	71		03			
Eye	Co											76	70	66
	HC		65					85	50	67	91		84	80
	PS										86	93		89
	Cy										87	96	97	

a. Figures above diagonal are phi coefficients obtained; corresponding figures below diagonal are maximum phi coefficients Shaded sections are significant correlations.

b. Key to Test Names:
Hand: Sc-Screwing, Re-Reaching, Th-Throwing
Foot: Ki-Kicking, St-Stepping, Ho-Hopping
Ear: SB-Sound in Box, SW-Stop Watch, HT-Head Turning
Eye: Co-Cone, HC-Hole in Card, PS-Peep Show, Cy-Cylinder.

CHAPTER XVIII

RESULTS OF THE SPEED OF CROSSING TEST

I METHOD OF TREATING RESULTS

Details of the method of applying the Speed of Crossing Test, the ninth test to be administered, were set out in Chapter XV. The scores obtained took the form of the number of crosses drawn by each subject with right hand and left at the first and second trials. The writing hand was tested first in each instance, 18 out of 330 subjects (12 boys and 6 girls) having their first attempt with the left hand and second attempt with the right, in order to make the results comparable for all subjects with regard to writing and non-writing hand. For each subject the total score for the right and left hand was calculated. This enabled a comparison to be made between the absolute ability of different subjects with their writing hand, and particularly between the left- and right-hand writers. An Index of Handedness was then calculated for each subject based on the ratio of his score with right hand to his score with his left hand - thus right-handedness was represented by an index above unity, left-handedness by an index below unity, and ambidexterity by unity. A comparison could therefore be made of the relative ability of the two hands for different subjects.

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II COMPARISON OF SCORES OF RIGHT - AND LEFT-HANDERS

The average scores with right and left hand for the total group of subjects are given in Table XXIX, the averages for boys and girls calculated separately.

TABLE XXIX

AVERAGE SCORES OBTAINED BY THE TOTAL GROUP ON SPEED OF CROSSING TEST

	No. of Subjects	Average No. of Crosses	
		Right Hand	Left Hand
Boys	162	53.7	37.5
Girls	168	60.2	39.3

From the Table it may be seen that the scores obtained by the girls, both with right and left hand, were higher than those of the boys. In order to make a fairer analysis of the difference the scores of the left-hand writers were excluded from the calculation, since there were 12 boys and only 6 girls in this group, and these were considered separately.

TABLE XXX

TABLE XXX

FREQUENCY DISTRIBUTION OF SCORES WITH WRITING HAND ON SPEED OF CROSSING TEST

Scores	Frequencies				
	Right-Hand Writers		Left-Hand Writers		
	Boys	Girls	Boys	Girls	Total
75-79	-	3	-	-	3
70-74	3	17	-	-	20
65-69	12	38	-	1	51
60-64	26	40	1	3	70
55-59	46	32	2	2	82
50-54	28	17	5	-	50
45-49	19	11	2	-	32
40-44	11	4	2	-	17
35-39	5	-	-	-	5
Total	150	162	12	6	330

Table XXX shows the frequency distribution of the right-hand writers on this test when using their writing hand, and also the corresponding scores of the left-handers with their writing hand, the left. The standard deviation from the mean was the same for both the right-handed boys and girls (S.D., 7.75). A significant sex difference between the means of right-handed boys and girls was found on this test (Diff. 6.0, S.E. of Diff. 0.88). In view of this difference it seemed advisable to compare the scores obtained by the left-hand writers with those obtained by right-hand writers of the same sex with their writing hand. Such a comparison/

comparison showed that, of the left-handed girls, 4 obtained scores below, and 2 above the mean for right-handed girls (Mean 61.5); while among the left-handed boys, 10 had scores below and 2 above the mean for right-handed boys (Mean 55.5). Though the left-handed group here was, admittedly, small, it can at least be said that there was a tendency for the left-handers to make a poorer score with their left hand than did right-handers with their right.

III INDEX OF HANDEDNESS

TABLE XXXI

FREQUENCY DISTRIBUTION OF RATIO OF WRITING HAND TO NON-WRITING HAND ON SPEED OF CROSSING TEST

Index	Frequencies				
	Right-Hand Writers		Left-Hand Writers		
	Boys	Girls	Boys	Girls	Total
2.5 - 2.59	1	1			2
2.4 - 2.49	-	-			0
2.3 - 2.39	-	-			0
2.2 - 2.29	-	1			1
2.1 - 2.19	-	1			1
2.0 - 2.09	6	7			13
1.9 - 1.99	4	8			12
1.8 - 1.89	6	12			18
1.7 - 1.79	8	19	-	-	27
1.6 - 1.69	17	22		1	40
1.5 - 1.59	37	32		-	69
1.4 - 1.49	35	31	2	1	69
1.3 - 1.39	19	18	3	3	43
1.2 - 1.29	5	8	5	1	19
1.1 - 1.19	11	2	1	-	14
1.0 - 1.09	-	-	1	-	1
0.9 - 0.99	1	-			1
Total	150	162	12	6	330

Details of the range of indices found among the right-hand writers given in Table XXXI show that there was a slight tendency for the girls to score a higher index than the boys - indicating a greater ability with the right hand relative to the left. The mean index for the right-handed girls was 1.6 (S.D. .23), and for the right-handed boys it was 1.52 (S.D. .23). The difference between these means was great enough to be significant well above the .01 level of significance (C.R. 3.07). In order to make a comparison between the strength of these indices and those of the left-hand writers, it was decided in this latter instance also to calculate an index of ratio of writing hand to non-writing hand. A comparison of the relative ability of the writing hand to the other with regard to right- and left-handers was felt to be necessary in view of the suggestion made by many that in left-handers the superiority of the left hand over the right is not as great as the superiority of right over left in right-handers. If the indices of handedness of the left-handers calculated as $\frac{R}{L}$ had been employed, with a possible range of only unity to zero, these would not have been readily comparable with those of the right-handers, having as they did, a theoretical range of from unity to infinity. The new index of writing hand to non-writing hand, which necessitated a re-calculation only/

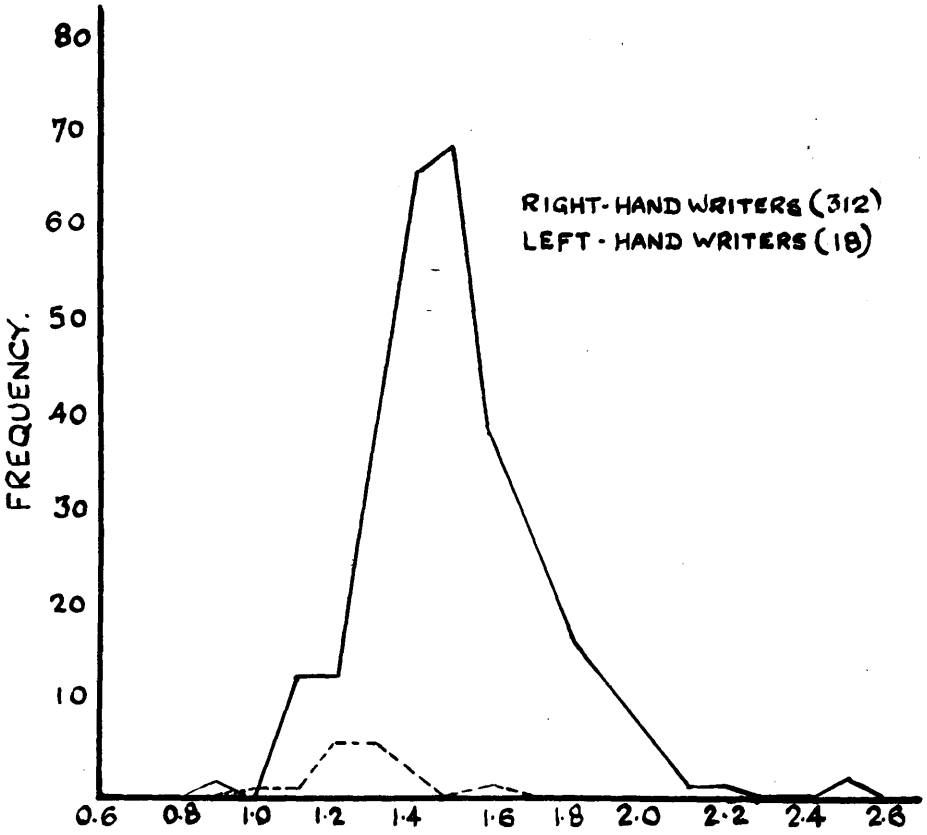


FIGURE 10. RATIO OF WRITING HAND TO NON-WRITING HAND FOR RIGHT-AND LEFT-HAND WRITERS ON THE SPEED OF CROSSING TEST.

only for left-handers, was then directly comparable for the two groups therefore serving the purpose of this section, having, however, no longer anything to distinguish left- from right-handedness, except where a right-hand writer scored less than unity, as did happen in one instance, which of course showed that he was better with his left hand in spite of the writing practice which the right received. It may be seen from Table XXXI where these indices are set out that the ratios tended to be smaller in the left-handed group. In fact, not one of the group of left-hand writers had a ratio of writing hand to non-writing hand larger than the mean for right-handers of the same sex. The highest ratio for a left-hander was that of a girl with 1.6, the next highest was 1.46, while the lowest was 1.0. A comparison of these results is facilitated by a study of Figure 10, where the distribution of ratios for the left-handers (writing to non-writing hand) is illustrated on the same scale as the similar indices for the right-handers.

It would appear, therefore, that there is some truth in the view that the degree of dominance with regard to speed, or the distance from ambidexterity, is on the average greater in right-handed persons than in left-handers. Though superficially this may seem surprising, a little consideration reveals the explanation./

explanation. In a right-handed world there are occasions on which even the extreme left-hander finds it necessary to employ the right hand, while the reverse is seldom true for right-handers. Further, practically without exception, left-handers are at some time forced into actually attempting to write with the right hand for a period, which thus results in a narrower margin between the performance of the two hands in comparison with that of right-handers.

In view of the lack of incentive to right-handers to utilise the left hand for writing at any time, it is surprising to find so many right-handers with a low index of handedness, or who are, in other words, almost as good or as bad with both hands. Table XXXI reveals that 12 right-handed boys and 2 right-handed girls had an index of less than 1.2, one boy actually scoring better with his left hand. It should be borne in mind that a low index does not necessarily mean a low score, indicating only comparable scores with both hands, which may be low, high or intermediate. If a right-handed person is extremely good with both hands he is, however, less likely to attempt to use his left hand than is someone who is poor with the right. On consideration of these 14 subjects scoring an index of less than 1.2, it was found that only two, one boy and one girl, were left-handed, the girl in everything but writing and the boy/

boy even at times in writing; while the remainder had never, so far as they could remember, written with the left hand. When the score obtained with the right hand by these 14 subjects was considered it was found that all but three (two being those mentioned above) had a score below the mean for the group of their own sex. Thus the low index was not to be explained by two exceptionally good hands. It must either be assumed that the transfer had, for them, been considerable from right to left hand, or that little profit had accrued to the right hand from all the practice it had received. Possibly the increase in left-hand writers appearing as the attitude to left-handedness becomes more tolerant, involves children in a comparable position to this group discussed here, who would then use the left hand for writing, especially if this narrow margin between the two hands is combined with a preference for the left.

IV COMPARISON OF SPEED OF CROSSING AND HAND PREFERENCE TESTS.

A comparison of the Index of Handedness on the Speed of Crossing Test and the degree of preference on the tests of Hand Preference (Screwing, Reaching and Throwing), was difficult because the distribution of subjects was so different on the two aspects, relative ability and preference. The great majority of right-hand writers showed right preference on all three tests, and only a few/

few on two tests or one - the figures being 235, 61 and 16 showing right preference on all trials of all three tests, on two tests, and on one or no test, respectively. On the Speed of Crossing Test the indices of the right-hand writers were more normally distributed (see Figure 10).

TABLE XXXII

COMPARISON OF RESULTS OF PREFERENCE TESTS AND INDEX OF HANDEDNESS ON SPEED OF CROSSING TEST (RIGHT-HAND WRITERS)

Crossing Test Index of Handedness	Preference Test Result: Right on 0 or 1 Test	Right on 2 Tests	Right on 3 Tests	Total
← 1.39	10	18	36	64
1.40 - 1.49	2	12	52	66
1.50 - 1.59	0	15	54	69
1.60 - 1.69	1	6	32	39
1.70 →	3	10	61	74
Total	16	61	235	312

Table XXXII gives a comparison of the position of right-hand writers with regard to the strength of their index of right-handedness and their score on the preference tests. A study of all those who did not score complete right-handedness/

right-handedness on the preference tests (77 subjects) reveals that they tended to score lower indices of handedness than those who were right on all the preference tests (235 subjects). In the group showing some left preference there were twice as many with an index near to left-handedness as there were at the other extreme; in contrast, in the other group showing no left preference there were almost twice as many with a high index as there were with a low index. A direct comparison was difficult because of the discrepancy in numbers, but a study of the percentages of subjects at the extremes with regard to index (below 1.4 and above 1.7), as shown in Table XXXIII, reveals their relative position on the preference tests.

TABLE XXXIII

COMPARISON OF PREFERENCE TEST RESULTS OF SUBJECTS WITH HIGH OR LOW INDICES ON SPEED OF CROSSING TEST (AS PERCENTAGES)

	Preference Test Result	
Speed of Crossing	Right on all Tests	Not Right on all Tests
Index Below 1.4	15.3 per cent	36.4 per cent
Index Above 1.7	26.0 per cent	16.9 per cent
Total Number of Subjects	235	77

The difference in the percentages in the two preference groups/

groups with regard to their index, shows that there was a difference of 21.1 per cent between those with a low index. This difference was great enough to be significant (S.E. of Diff. 6.0). The percentage of those with a high degree of preference who scored a high index was larger than that of those who showed any left preference. Here, however, the difference was not so large (9.1 per cent, C.R. 1.77).

One explanation of the absence of a more exact connection between these two aspects, and of the existence of as many as 36 subjects with an index of less than 1.4 who still used their right hand on all preference tests, is the fact already mentioned that some of these, having a high ability with both hands, have in a right-handed world no particular urge to utilise the latent ability of the left hand. An analysis of those who, though right-hand writers, showed a preference for the left on two or more of the tests and an Index of Handedness of less than 1.4 (10 subjects, 5 boys and 5 girls) shows that four of them, three girls and one boy, had actually been left-hand writers at some time and had changed or been changed to the right hand, retaining their preference for the left in other activities and the close margin between scores with the left and right hand in a speed test.

This test gives a clearer picture of the relative

speed of right-and left-handers than can be obtained from a writing test in the usual sense of the word, where the relative emphasis placed by the child on quality acts as a complicating factor. A comparison between the scores obtained on this test of Speed of Crossing and on speed in the Writing Test will be presented in Chapter XX.

CHAPTER XIX

RESULTS OF THE SIMULTANEOUS WRITING AND VAN RIPER TESTS

The Simultaneous Writing Test and the testing on the Van Riper Critical Angle Board, both involving bimanual drawing, had sufficient in common to justify their consideration within the same chapter. The Simultaneous Writing Test involved writing a series of numerals with both hands at the same time, and with visual cues removed, thus enabling a study to be made of the instances in which mirroring of the numerals resulted, and with which hand this was performed. This test was a simplified and somewhat cruder approach to the problem than that on the Van Riper Apparatus, where a further distraction was introduced, one whose influence was gradually increased. The writing was, on this latter test, done in a vertical position by copying a diagram, but still without visual cues as to direction since the subject, though he had not his eyes shut in this test, was not permitted to look at the paper on which he was drawing. The difficulty was increased as the vertical boards were rotated back thirty degrees between each attempt. Thus it was not only possible here to determine whether mirroring took place, if so, with which hand and with which diagram there was a greater amount, but also, to consider the point at which the mirroring took place - with regard to the angle of the vertical boards.

The /

The results of the two tests will be discussed separately, this will be followed by a comparison of these, and finally an evaluation of them in the light of the other information gained in the course of the study.

I. SIMULTANEOUS WRITING TEST

Two attempts were made at this test by each subject, the seven numerals being written at each attempt. Only asymmetrical figures were included, hence the exclusion of 0, 1 and 8. The remaining seven were repeated quickly to the subject who, with eyes closed, wrote them down with both hands at the same time. It was possible to note at the time whether any numeral was mirrored and also to go back and check the results at a later date. The order in which the numbers were written down was that normal to the subject, viz:- 2,3,4,5,6, 7,9. Speed was emphasised in order to prevent sensation of an error from resulting in its correction. Any suggestion of mirroring was counted, even when corrected, since that was taken to indicate its presence. The total amount of mirroring found in the whole group is shown in Table XXXIV. The

TABLE XXXIV /

TABLE XXXIV

FREQUENCY OF MIRRORING OF NUMERALS IN SIMULTANEOUS WRITING TEST

	No. of Times Mirror-Image was Written.					
	With Left Hand			With Right Hand		
Numeral	Boys	Girls	Total	Boys	Girls	Total
2	43	42	85	5	10	15
3	63	71	134	1	7	8
4	21	42	63	4	15	19
5	59	62	121	7	10	17
6	41	36	77	9	20	29
7	42	51	93	2	12	14
9	58	56	114	22	9	31
Totals	327	360	687	50	83	133

anticipated result for a right-handed subject was mirroring with the left hand, while a left-handed subject was expected to mirror with the right hand. It may be seen from the table that in spite of the existence of only 18 left-hand writers in the group there was a considerable amount of mirroring with the right hand - approximately one-sixth of that with the left hand. An analysis of the sex difference is not discussed at this stage since these results contain 12 left-handed boys and only

6 /

6 left-handed girls, and the table does not reveal how many subjects in the group were responsible for these totals. For that it is necessary to study Table XXXV, where details are

TABLE XXXV

NUMBER OF SUBJECTS PRODUCING MIRROR-IMAGE IN SIMULTANEOUS WRITING TEST

	Number of Subjects Mirroring				
	Left Hand Only	Right Hand Only	Both	Neither	Total
Right-Hand Writers					
Boys	83	4	17	46	150
Girls	77	4	26	55	162
Total	160	8	43	101	312
Left-Hand Writers					
Boys	-	5	2	5	12
Girls	-	4	-	2	6
Total	-	9	2	7	18

given of the actual numbers of subjects mirroring with the left hand, right hand, both hands either together or at different points in the test, and the total who mirrored with neither. One-third of the subjects contributed no mirroring to the results, while 45 subjects mirrored with both hands.

Considering /

Considering the left-handed subjects first, it may be seen from the table that nine of them mirrored with the right hand only, and seven with neither, both results which might have been expected. However, the remaining two mirrored with both hands. On studying their results it was found that one had mirrored once with each hand, the same number at the same time; while the other mirrored with the left twice in the first trial and once in the second, and once with the right in the second, not at the same time. This latter subject's result was of interest in view of his score on the Speed of Crossing Test where he had an Index of Handedness of unity, indicating equal skill with both hands.

A study of the eight right-handed subjects who mirrored with the right hand revealed that only one of them mirrored more than one numeral, while one of the girls was actually left-handed in all but writing. The record sheets of the 17 boys who mirrored with both hands revealed that ten mirrored only once with the right hand and the rest of the time with the left, and four mirrored only twice with the right, which is only an average of once per trial. A consideration of the remaining three whose mirroring in the right and left was 4,12; 5,6; and 4,1 respectively, showed that the first (score 4,12) was actually a changed left-hander, having been forced to use his right hand in school. The boy scoring 5,6 actually mirrored with both hands at the same time (with one additional /

additional mirroring with the left only); while the third (4,1) was actually left-handed in his preference on the Screwing Test. An analysis of the results of the 26 girls who mirrored with both showed that 17 mirrored twice or less with the right hand. Of the remaining nine, two had been left-hand writers, and another was left-handed in screwing. It seemed advisable to make a comparison between these results and those on the Van Riper Test before any final conclusions were drawn.

It is clear that even in children of the age here tested, eleven plus, when the visual clues were removed there was a tendency to mirror with the non-writing hand. Among the right-hand writers (312) there were 51 who mirrored with either the right hand or both hands at some time during the test, including five subjects who had strong left tendencies, all but one having written with the left hand at some time. It should be noted that not one of the left-hand writers produced a mirror-image with the left hand only, and only two with the left hand at all, indicating that even with the visual cues removed they had still sufficient control over the direction of movement of the left hand to prevent it from mirroring. Possibly some mirroring with the left hand might have been found in younger left-handed subjects with, as in this test, the removal of visual cues to direction.

II THE VAN RIPER TEST

A GENERAL DISCUSSION

Four diagrams were used in this test[1], the first being a very simple visual pattern; the second, the number 'three' presented as an auditory stimulus; while the third and fourth patterns were a more complicated design presented in two different positions. The results noted were, for each diagram, and at each angle, whether there was any mirroring, and if so, whether with the right or left hand. Details of the total mirroring in the group of 330 subjects are given in Table XXXVI.

1. See Figure 8 page 229 for illustration of the diagrams.

TABLE XXXVI

AMOUNT OF MIRRORING ON THE VAN RIPER TEST ON DIFFERENT DIAGRAMS AND AT DIFFERENT ANGLES (ALL SUBJECTS)

	Frequency of Mirroring[a]							
	With Left Hand Diagrams				With Right Hand Diagrams			
Angles	1	2	3	4	1	2	3	4
Boys: 0°	3	30	14	21	1	1	7	9
30°	16	46	23	37	7	5	25	10
60°	44	79	62	80	37	18	42	29
90°	61	88	69	99	87	45	79	53
Total	124	243	168	237	132	69	153	101
Girls: 0°	9	26	16	25	2	2	10	10
30°	21	49	41	35	6	4	12	16
60°	51	76	63	83	22	16	30	28
90°	83	103	80	123	69	40	72	36
Total	164	254	200	266	99	62	124	90

No. of boys in group 162
No. of girls in group 168

The /

The results indicate that, with each diagram, as the angle boards were rotated back from zero to 180 degrees the amount of mirroring increased. Further, it was found that the total mirroring with the two hands (R + L) of both boys and girls increased with each diagram; while the proportion of right to left mirroring was greatest for Diagram 2, the auditory diagram, which, because of the method of presentation, had to be a pattern with which the writing-hand was already familiar. The group of 168 girls contained 6 left-hand writers, while the group of 162 boys included 12 left-hand writers, thus the totals for mirroring of boys and girls shown in Table XXXVI are not directly comparable. There was no sex difference in the total amount of mirroring, but appeared to be some difference in the relative mirroring with right and left hand. A further analysis was necessary to ascertain whether or not this was entirely the result of the excess of left-hand writers among the boys.

In Van Riper's original method of using the test he continued only until an angle was reached where mirroring took place plus one stage further to make certain of its consistency. The first angle at which the mirroring took place was then taken as the 'Critical Angle', and the hand mirroring as the non-dominant hand. In this present study, following the example of Smith[1], each subject was tested through four angles in order to

1. L.C.Smith, 'A Study of Laterality Characteristics of Retarded Readers and Reading Achievers', Journal of Experimental Education, vol.XVIII, 1950, pp.321-329.

ascertain the consistency of the first results. The results stated in Table XXXVII were calculated on the basis of the

TABLE XXXVII

DOMINANT HANDEDNESS AS MEASURED BY TOTAL MIRRORING ON THE VAN RIPER TEST (ALL SUBJECTS)

	Number of Subjects[a]			
	Right Dominance	Left Dominance	Ambi	Total
Right-Hand Writers:				
Boys	95	37	18	150
Girls	113	40	9	162
Total	208	77	27	312
Left-Hand Writers:				
Boys	3	9	0	12
Girls	3	3	0	6
Total	6	12	0	18

a. The total mirroring at all angles on all four diagrams was used to calculate these frequencies, all whose total was less with the right hand being ranked as right dominant, whose total was less with the left hand as left dominant, and equal as 'Ambi'.

total mirroring at all angles and on all four diagrams. From that table it may be seen that even on that rough criterion not all left-hand writers, who may be assumed to be the more extreme left-handers, were differentiated, only two-thirds of them /

them mirroring with the right hand more than the left. A more rigid criterion was set up and dominance then determined by the hand mirroring consistently on all diagrams, and at all angles at which mirroring actually took place. The results of that calculation are set out in Table XXXVIII where details are

TABLE XXXVIII

DETAILS OF CONSISTENCY OF MIRRORING ON VAN RIPER TEST WITH FOUR DIAGRAMS (ALL SUBJECTS)

	No. of Subjects Mirroring						
	With Right Hand		With Left Hand		With Neither Hand	With Both Hands	Total
	Only	First	Only	First			
Right-Hand Writers:							
Boys	6	4	32	13	3	92	150
Girls	8	4	47	20	1	82	162
Total	22		116			174	312
Left-Hand Writers:							
Boys	5	1	-	1	-	5	12
Girls	1	-	-		-	5	6
Total	7		1			10	18

also given of the subjects who were consistent on all four diagrams on Van Riper's criterion, namely, those who mirrored first with the same hand on each diagram. It may be seen that 116 of the right-handed subjects gained the results expected, namely, /

namely, left-hand mirroring, or in 4 instances no mirroring with either hand; while 7 left-handers gained the expected result of right-hand mirroring. Only one left-handed subject appeared with consistently left mirroring, while 22 right-handers mirrored with the right hand. Since the Van Riper Test is claimed to show up right-hand writers who are really left dominant, such a result might be understandable. However, the discovery of 174 right-handed and 10 left-handed subjects who mirrored with a different hand on different diagrams, more than half the total group in each instance, is more difficult to explain, since, even should the indications of left tendencies in the 22 subjects mirroring with the right hand be accurate, the test is severely limited in its application if it cannot differentiate at all in half the cases.

A comparison was made of the distribution of mirroring in boys and girls in the group of right-hand writers. It may be seen from Table XXXVIII that 102 boys and 94 girls mirrored with either the right hand or both hands, while 48 boys and 68 girls mirrored with the left hand or neither hand. The difference between the percentage of boys and girls mirroring with the writing hand was 10 per cent. (S.E. of diff. 5.4). This sex difference in distribution among the right-hand writers was significant at the .05 level of significance, indicating a greater tendency among boys than among girls to mirror with the writing hand.

B. /

B. ANALYSIS OF INCONSISTENT RESULTS

A further analysis was made of the right-handed subjects whose results were inconsistent on the four diagrams in order to ascertain whether this inconsistency resulted from one diagram in particular or whether it was distributed throughout the diagrams, in other words, to determine whether the exclusion of any one of the diagrams would have increased the consistency of the results. Table XXXIX shows the results of

TABLE XXXIX

ANALYSIS OF RESULTS OF SUBJECTS SHOWING INCONSISTENT MIRRORING ON THE VAN RIPER TEST USING FOUR DIAGRAMS.

	No. of Subjects Mirroring						
	Consistently in three Diagrams and inconsistently in one. Inconsistent Diagram.				Consistently in two pairs of tests.	In two tests only.	Total
	1	2	3	4			
Boys	15	11	13	17	23	3	82
Girls	25	13	10	14	27	3	92
Total	40	24	23	31	50	6	174

this analysis, revealing that in 50 of the subjects the inconsistency did not depend on only one of the tests. The results of 6 of the subjects were excluded from the further analysis because they had mirrored in only two of the four diagrams. The remainder of the 174 subjects were consistent in their mirroring on three of the diagrams. The greatest inconsistency /

inconsistency resulted from Diagrams 1 and 4, while the remaining two diagrams, Diagram 2 and 3, were almost equal in the amount of inconsistency they contributed. It was necessary to conclude that the exclusion of any one of the diagrams would not have greatly increased the consistency of the results. Details of the actual mirroring on all four diagrams are set out in Table XL from which it is apparent that Diagram 3 was

TABLE XL

COMPARISON OF MIRRORING ON THE VAN RIPER TEST WITH DIFFERENT DIAGRAMS (ALL SUBJECTS)

	No. of Subjects Mirroring with -				
	Right Hand only	Left Hand only	Both	Neither	Total
Right-Hand Writers					
Diagram 1	128	134	27	23	312
2	37	185	55	35	312
3	89	142	58	23	312
4	59	190	48	15	312
Left-Hand Writers					
Diagram 1	11	5	1	1	18
2	8	4	5	-	18
3	15	-	3	-	18
4	7	7	3	-	18

most accurate in indicating the dominance of the left-handed subjects, where 15 mirrored with the right hand and three with different hands at different angles. Considering the right-hand subjects, almost equal numbers mirrored with the right and left hand on Diagram 1 (128 and 134 respectively). This diagram, /

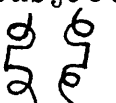
diagram, one used by Smith, which was included because it was simple in design and yet asymmetrical, appears to have favoured right mirroring. One explanation of this may well be its resemblance to the numeral 'four' in reverse, a resemblance which seemed to strike, and possibly confuse, some of the subjects when attempting to draw it, several referring to it as 'the four'. This tendency to associate a diagram with some known symbol possibly operates in any test such as this, and it is probably impossible to devise any simple pattern which is asymmetrical and therefore serves the purposes of this test, and which yet does not bear a resemblance to some letter or numeral, either written normally or in reverse. The second diagram, the auditory stimulus 'three', also used by Smith, revealed a greater proportion of left- to right-hand mirroring than the other diagrams (185:37), which might be expected, since the bias in favour of the writing hand would be considerable in such a situation. Diagram 3 was one used by Van Riper, while Diagram 4 was the same figure in reverse. These were both included because it was felt that there might be something in the shape of the figure favouring the right or left hand. A few subjects were found with a tendency to draw the same double image  throughout the testing no matter which was the stimulus, with the result that they were mirroring with the right hand in the first part and the left hand in the second. It might have been better, however, if these two diagrams had been separated in the testing, as in one or two instances there was a carry-over from

Diagram /

Diagram 3 to the first attempt at Diagram 4, resulting in an appearance of inconsistency. It seems, nevertheless, that there is the possibility of a tendency, even with more complicated patterns, to prefer one double image to the other, or rather for one to be easier to perform with both hands at the same time, which may well be another complicating factor.

C. DOMINANCE AS MEASURED BY THE VAN RIPER TEST

Any value which the Van Riper Test may have will depend on its ability to pick out left-handers who cannot be adequately differentiated by any other means. Thus the first step in analysing its effectiveness as a measure of dominance would seem to be a study of the results on the test of known left-handers, followed by a study of other aspects of those who, though not in fact left hand writers, appear as left dominant on the basis of the Van Riper Test. In other words, do left-handers mirror with the right hand consistently on this test, and does consistent mirroring with the right hand in right-hand writers in fact indicate left dominance? Unless at least the first of these questions is answered in the affirmative, it is not justifiable to place any value on the test as a measure of laterality as generally considered, nor to place any significance on right-hand mirroring of other right-hand writers. In Table XLI the results of left-hand writers on each diagram are

TABLE XLI

COMPARISON OF RESULTS OF TWO GROUPS OF LEFT-HANDERS ON THE VAN RIPER TEST

Mirrored with	No. of Subjects Mirroring[a]							
	Diagram 1		Diagram 2		Diagram 3		Diagram 4	
	L H	l h	L H	l h	L H	l h	L H	l h
Right Hand only	11	5	8	1	15	7	6	3
first	-	2	2	-	1	1	2	3
Neither	1	1	1	2	-	2	1	1
Left Hand only	5	5	4	8	-	2	8	6
first	1	1	3	3	2	2	1	1
Total	18	14	18	14	18	14	18	14

[a] L H - Left-hand writers.
l h - Right-hand writers, either changed from left or with preference for left in other activities.

set out together with those of 14 right-hand writers who were found in the course of the rest of the study to have either had a preference for writing with the left hand, but to have been changed over to the right, or who preferred the left hand in most other activities except writing. Left-hand writers would be expected to give more extreme results than the other left-handers, which was in fact the case. The contrast between the two groups was most pronounced in Diagram 2 which involved writing a figure for which the second group were accustomed to use the right hand. The results of Diagram 3 are interesting since /

since in this diagram, which was less connected with previous writing experiences than Diagram 2, the frequency of mirroring with the right hand was increased in the second group from one to eight out of fourteen subjects. There was therefore a tendency for left-handers, whether left-hand writers or changed left-handers, to mirror with the right hand rather than the left. Though this was by no means absolute, it was clearest in Diagram 3.

It may be seen from Table XXXVIII that 22 right-hand writers showed left dominance as measured by the criterion of the Van Riper Test, namely, mirroring in all diagrams with the right hand. The results of these subjects on the other tests were analysed. The Simultaneous Writing Test, that most closely parallel to the Van Riper Test, showed eight subjects mirroring with the right hand only. Not one of these subjects mirrored with the right only in the Van Riper Test. Of the 22 subjects already mentioned as mirroring with the right, nine mirrored with the left only on the Simultaneous Writing Test, nine mirrored with neither, and four with both hands. One of the 22 was left-handed in all else but writing; three subjects showed some left preference in screwing, one in reaching, and two in throwing. In no other case was there any evidence of left preference. The indices of handedness obtained by this group on the Speed of Crossing Test ranged from 1.15 to 1.75, four scoring below 1.39, and a total of fourteen below, and six above the mean index for all /

all right-hand writers of their own sex. The conclusion must be drawn that consistent right mirroring on the Van Riper Test did not have much connection either with a tendency to prefer the left hand or a narrow margin of ability between the two hands. In short there was little evidence of other left tendencies in those right-hand writers who consistently mirrored with the right hand on the Van Riper Test.

D. COMPARISON WITH THE SIMULTANEOUS WRITING TEST

A comparison of the results obtained on the Van Riper Test and the Simultaneous Writing Test discussed earlier in the chapter, is set out in Table XLII. It may be seen from the

TABLE XLII

COMPARISON OF FREQUENCY DISTRIBUTION ON VAN RIPER AND SIMULTANEOUS WRITING TESTS (RIGHT-HAND WRITERS)

	No. of Subjects Mirroring on Simultaneous Writing Test.				
No. of Subjects Mirroring on Van Riper Test[a]	With R.H.	With L.H.	With Both	With Neither	Total
With Right Hand	-	9	4	9	22
With Left Hand	1	66	13	32	112
With Both Hands	7	85	26	56	174
With Neither	-	-	-	4	4
Total	8	160	43	101	312

[a] Right mirroring includes all subjects mirroring with right consistently on all four diagrams and also all mirroring first with the right on each diagram - similarly with left. 'Both' - indicates inconsistency on different diagrams.

table /

table that there was no exact connection between the results of the two tests. More mirroring was, of course, apparent on the Van Riper Test where the task was more difficult and the distraction such as would increase the amount of mirroring. In the Simultaneous Writing Test there were 101 subjects who did not mirror with either hand, while on the other test there were only 4 subjects who mirrored with neither hand, these four who had no mirroring on the Van Riper Test had no mirroring on the Simultaneous Writing Test either. However, omitting those who did not mirror on the Simultaneous Writing Test from the comparison (101 subjects), the results of the two tests agreed in less than half of the remaining cases (92 out of 211 subjects). Of the 160 subjects who mirrored with the left hand only on the Simultaneous Writing Test, 66 mirrored with the left hand only and 94 with the right hand or both hands on the Van Riper Test; while of the 51 subjects who mirrored with the right or both on the Simultaneous Writing Test 37 subjects mirrored with the right hand or both on the Van Riper Test and 14 with the left hand. In short, mirroring with the writing hand on the simpler test did not necessarily mean a subject would mirror with that hand on the other test, and even less did mirroring with the non-writing hand on the simpler test mean that a subject would not mirror with the writing hand when the distraction was increased. A comparison was made between the Simultaneous Writing Test and the Van Riper Test, excluding those who mirrored /

mirrored with neither hand on the former test. On the basis of a fourfold table contrasting those who mirrored with the non-writing hand only and those who mirrored with the right hand or both hands, that is with the writing hand, little connection between the two tests was found (χ^2 3.18, ϕ .22 max. ϕ .7).

E. INTELLIGENCE AND TOTAL MIRRORING

The whole basis for the use of the Critical Angle Board as a measure of laterality, rather than two vertical boards placed back to back, is the view of Van Riper that thereby it may be possible to use the angle at which mirroring takes place as a measure of degree of dominance. Van Riper dismissed the question of intelligence as unimportant; in fact, unless it is unimportant, the whole basis of use of a certain angle as any measure of dominance is defeated. During the course of the present testing, it seemed that, even among subjects who were of approximately the same chronological age, and capable of drawing the more elaborate diagram fairly accurately, variations in intelligence were having some effect on the quantity of mirroring produced. No matter at what speed the subjects were required to perform the task. A highly intelligent subject appeared to be able to prevent or delay mirroring, whereas mirroring seemed more frequent with the duller or more naive subject. In order to study the truth of this impression and examine /

examine the extent of distortion of the results from such causes, a comparison was made between the intelligence of the subjects and the total mirroring they produced in the course of this test on all diagrams and at all angles irrespective of the hand with which the mirroring was produced. The Intelligence Quotient used for the comparison was that secured in the course of the testing for the Primary Promotion Scheme, and was based on a written group Intelligence Test. The details of the comparison are set out in Table XLIII, where the range in

TABLE XLIII /

TABLE XLIII

SCATTERGRAM SHOWING RELATIONSHIP BETWEEN INTELLIGENCE AND AMOUNT OF MIRRORING ON THE VAN RIPER TEST (RIGHT-HANDED SUBJECTS)

TOTAL MIRRORING ON VAN RIPER TEST	INTELLIGENCE QUOTIENT[a]															
	70- 74	75- 79	80- 84	85- 89	90- 94	95- 99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135-139	140-144	Total
16	1				1	-	1	-	2	2						7
15			1	2	-	1	-	1	-	1						6
14						2	2	-	1							5
13	1	-	1	1	2	4	2	-	2	2	1					16
12			1	1	1	-	6	3	-	-	1					13
11			1	-	1	2	3	4	-	1						12
10		1	1	-		3	1	4	2	2	2	-	2			18
9					5	5	9	4	5	2	1	1	1	1	1	35
8			1	-	-	-	2	3	6	2	2	3	1	2	1	23
7				7	1	7	2	4	5	8	3	2	-	1		40
6		1	-	2	1	4	9	7	6	3	3	-	1	-	1	38
5				1	2	2	5	7	4	3	7	7	-	2		40
4				2	-	3	4	2	5	3	2	1	2	-	1	25
3		1	-	-	-	-	1	1	2	2	3	1	2	1		14
2						1	-	-	2	3	3	-	3	-	1	13
1										1						1
0								1	-	-	1	-	1	1		4
Total	2	3	6	16	14	34	47	41	42	35	29	15	13	8	5	310

[a] I.Q. was not available for two of the subjects who were therefore omitted from the table - hence 310 instead of 312 subjects.

mirroring is from 0 to 16, zero indicating no mirroring on any diagram, and 16 standing for mirroring on all diagrams at all angles. It is at once apparent from the table that there is some connection between the two factors, since no subject with

an /

an I.Q. of over 125 mirrored more than ten times, and at the other extreme, no subject with an I.Q. of less than 95 mirrored less than three times and only three less than five times. A calculation was made of the product-moment correlation between the two factors, which gave a correlation between level of I.Q. and quantity of mirroring of such a size as to indicate the probability of some connection between the two aspects ($r = .38$, $S E_r .049$). This showed that the higher a subject's I.Q. the less mirroring he was likely to produce, a finding which makes the results unreliable as a measure of degree of dominance, and which would seem to indicate that as much might be discovered by the use of a simpler apparatus of two fixed vertical boards.

F. CRITICISMS

The following criticisms of the Van Riper Test are based on the experience gained in this present study of 330 children:-

1. Individual testing is necessary and a thorough testing as detailed by Van Riper is lengthy and very tiring for both subject and tester.

2. A single diagram is not sufficient for testing different subjects, since, if the diagram is too easy no mirroring will take place resulting in the subject being classed as ambidextrous, and if the diagram is too difficult the actual reproduction may be so distorted that the mirroring is not distinguishable.

3. /

3. The actual scoring of the test is somewhat subjective. It is not always easy to determine whether a certain performance should be termed mirroring or not. Partial mirroring may take place very early, or the first mistake may be complete reversal. This complication becomes progressively apparent as the diagrams increase in difficulty.

4. The maturity of the subject affects the stage at which mirroring takes place. Van Riper pointed out that some factor other than intelligence and attention was responsible for mirroring at a certain angle. It is clear, nevertheless, that intelligence does have some effect. Working the experiment in the reverse direction (i.e. from mirroring to non-mirroring), Van Riper found gave great inconsistency to the results and did not differentiate between the various laterality groups; this indicates that intelligence was probably a factor in the performance on the Critical Angle Board from the difficult position, where it would aid in the determination of the stage at which awareness of mirroring would take place, and hence its prevention. The effect of intelligence on the performance is probably reduced when the test is started from the easier position, but it is certainly not eliminated. Further, its effect may vary with different degrees of laterality preference. A more intelligent subject may realise that, for example, the left hand is mirroring, and in concentrating on that hand at the next trial in an attempt to prevent that may well mirror with the right hand. This alternative mirroring does take place with /

with some subjects, and conscious or subconscious awareness of the mirroring is the most likely explanation, suggesting that the testing is more effective with the more naive subjects. Further, Van Riper himself found that the critical angle does not remain constant even for one individual, but increases on retest, in other words, test sophistication results in an apparent increase in the strength of a subject's hand dominance.

5. Such factors as the position of the experimenter may have some influence on the results. If, for example, he stands to the right, this may make the subject attend to that hand and hence mirror with the left. Van Riper tried control tests on a group of right- and left-handed subjects to determine the effect of such factors as attention, position of the hands and type of pattern. He found that the dominant hand mirrored in only four of thirty-one subjects. This number is too high, however, to entitle one to neglect such factors altogether.

6. The results of the present study confirm those of Smith[1] who found a considerable amount of right mirroring among

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1. Loc.cit.

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right-handed subjects and that many of her subjects were not consistent on later angles. Since she was concerned with a comparison of the results obtained by a group of retarded readers and a group of reading achievers, and since, further, all her subjects were boys, it was not possible to make a full comparison /

comparison with her study. She did not actually estimate laterality from the test, but made a comparison of the significance of the differences in results in the two groups. Her results do reveal, however, that an estimation of laterality with any certainty would have been as difficult in her study as it was in the present study.

7. There was considerable disagreement in the results on the different diagrams, and this disagreement could not be traced to any one diagram. It would be difficult to discover any diagram which would not in some way predispose to either left- or right-hand mirroring, since to serve the purpose of the experiment the diagram must be asymmetrical.

8. Those subjects who were right-hand writers and yet showed consistent right mirroring on all the diagrams, when their results were analysed and other information about them considered, were found to show little in the way of other left-tendencies.

9. The results of the Van Riper Test were not in complete agreement with the simpler but similar Simultaneous Writing Test where the writing was also bimanual but horizontal.

It must be concluded that the Van Riper Test in its present form does not justify consideration as a single test or even inclusion in a battery of tests for diagnosing hand dominance, because of its unwieldiness, the difficulty of marking and interpreting /

interpreting the results, and the insufficient evidence that mirroring with one hand or the other has a precise connection with hand dominance. It does appear, nevertheless, that there is a tendency for left-handers to exhibit mirroring with the right hand, and for right-handers, though to a less degree, to show a tendency to mirror with the left hand. Though agreeing with Van Riper that attention and intelligence are not sufficient to account for mirroring with a certain hand and at a certain angle, it may yet be concluded that this mirroring has not a direct connection with hand dominance as generally interpreted. It is significant that though many clinics both in Britain and America have among their stock of apparatus a Critical Angle Board, few use it, and that, further, since his early studies in 1933 and 1934 Van Riper appears to have abandoned the apparatus in spite of his claims for its possibilities. In his Speech Clinic he apparently uses a modified vertical board, and not a Critical Angle Board[1]. It

1. C.Van Riper. Speech Correction, pp.292-4. New York: Prentice-Hall, Inc., 1947.

may be that the use of the boards at only the most difficult position may reduce the influence of intelligence on the results as the subjects will then have less time in which to become aware of what is actually happening. It seems, therefore, that further research might most profitably be directed to ascertaining whether any reliable information may be /

be obtained from a simpler form of apparatus, without the added complication of the moveable boards. In order to be of value such a test would require first to pick out all left-hand writers, (a few exceptions might be accounted for on the grounds of a person having developed left-hand usage though not left dominance because of, say, an accident or perversity). Further it would have to be shown that it could pick out accurately those with left tendencies among right-hand writers. Only then could a test on these lines be considered of other than academic interest as a measure of laterality preference. It is possible, however, that extensive mirroring with the writing hand when found in children above a certain age, and especially in those not of low intelligence, may have some educational significance. There still remain many unanswered questions on the meaning of mirroring found on a test such as this, when even in designs unconnected with writing there should be a tendency for the non-writing hand to mirror; what explains the sex difference in the mirroring with the writing hand; and why, as Smith found, poorer readers tend to mirror more frequently with the writing hand. All these and many other problems will have to await further research for their solution.

CHAPTER XX

RESULTS OF THE WRITING TEST

I. GENERAL DISCUSSION

The Writing Test performed by each subject was given as a group test, the passage to be written being learnt beforehand, then written as quickly and as well as possible for the two minutes of the test. Two practice attempts were given which were not scored, then a final scored trial. The preliminary attempts were found necessary since instructions, no matter how simple, are never followed exactly by a complete class of over forty children, and failure to do so would upset the results. The most common error was for a child to stop writing when he had completed the passage once, instead of writing it again and again until the two minutes were over. This sort of mistake was, however, easily corrected during the practice trials. The testing of each class was made as nearly identical as possible; while absentees were tested individually or in groups under similar conditions.

The material to be written was learnt before the test so that the child might concentrate on the writing, and in order that speed might be measured without the distraction present when material is copied. The aim of the Paul West Test used in this study was to make possible the measurement of both speed and quality at the same time. Possibly it is difficult, or /

or even impossible, to measure both these factors adequately within the bounds of one test. However, from the limited point of view of the present study, where the concern is the effect of left-handedness on writing rather than a study of writing per se, this test seemed suitable, especially since it was particularly desired to study the effects of left-handedness under conditions as near to normal as possible.

The test papers revealed that speed could be measured without much difficulty but that quality would be very difficult to estimate, particularly since the Paul West norms for American children were not suitable for use on Scottish children who have a totally different style of writing. A preliminary study of the scripts revealed that the greatest factor in determining the quality of writing appeared to be the teacher or teachers under whom the children had studied, the stamp of the individual teacher appearing in the eight groups of scripts. Writing is, of course, a subject where the range of interest of teachers is considerable, and therefore the time and attention devoted to that subject will vary considerably, even within the bounds of apparently similar curricula. Since only one, or sometimes two, left-handers customarily appear in any one class, the dangers of comparing a group of left-handers with right-handers, unless they are from the same class, are apparent. Further, since boys are usually recognised as on the average poorer writers than girls, and there are more boys than /

than girls who write with the left hand, it is further necessary to ensure that the left-handers are compared with right-handers of the same sex. The aim here was to estimate not the absolute ability of left-handers in writing but rather the effect on writing of performing it with the left rather than the right hand, and more particularly to ascertain how true it is that left-hand writers are slower and, or, poorer writers than those who use the right hand; while the other main aim was to ascertain the position in the group of others who, though right-hand writers, had left-hand tendencies and to compare them with right-hand writers who had not such tendencies.

The speed scores in the Writing Test will be discussed first, then will be compared with the results on the Speed of Crossing Test, and finally the quality of writing will be discussed.

II. SPEED OF WRITING

Speed of writing was calculated from the number of letters written in two minutes. Incomplete letters were counted if they were recognisable. The results obtained here were considerably below the speeds given in the norms supplied by West for American children. However, it is generally recognised that the writing of British children is in fact slower than that of American children, since the emphasis there /

there appears to be on speed rather than quality, whereas in Britain the tendency is to sacrifice speed to quality. The results of the right-handed subjects on the Writing Test are shown in Table XLIV. The main score for the girls was slightly higher than that for the boys (107.9, 104.8) and the

TABLE XLIV

SPEED SCORES OF RIGHT-HANDED BOYS AND GIRLS ON WRITING TEST

	Boys	Girls
Number of Subjects	150	162
Mean of Speed Scores	104.8	107.9
Average No. of Letters per minute.	52.4	54
Range of Scores.	50-176	54-192
Standard Deviation.	25.4	28.4
Difference between Means	3.1	
Standard Error of Difference.	3.1	

standard deviation slightly greater (28.4, 25.4). The difference between the means was not, however, great enough to be significant. Of the eighteen left-hand writers eight boys and one girl scored above the mean for right-hand writers of their own sex, while four boys and five girls scored below the corresponding /

corresponding mean for right-handers. Since the left-hand writers were not evenly distributed in the eight classes used in the testing, and since there were considerable differences in speed of writing in the different classes, the actual scores of the left-hand writers are set out in Table XLV, along with

TABLE XLV

POSITION OF SPEED SCORES OF LEFT-HAND WRITERS ON WRITING TEST RELATIVE TO RIGHT-HAND WRITERS IN OWN CLASS

School	Right-Hand Writers			Left-Hand Writers	
	No.	Mean Score	Range of Scores	No.	Actual Scores
A1	38	119	77-192	3	119,128,138
A2	46	102.7	55-151	1	69
B1	38	117.8	69-172	1	124
B2	46	101.7	54-175	2	93,107
B3	38	112.8	50-155	1	136
B4	38	90.6	61-137	2	80,95
C1	35	118.1	58-176	3	51,75,101
C2	33	112.8	70-162	5	88,89,113, 113,120.

the mean and range in the class to which they belonged.

An attempt at a more precise study of the left-hand writers as compared with right-hand writers was made, and to that end, each left-hander was paired with a right-hand writer in the same class, of the same sex, and with the same Intelligence Quotient. A similar paired group was established of fourteen right-hand writers /

writers who were either changed left-handers or had strong left-hand tendencies, paired for sex, class and I.Q. with right-hand writers with no apparent left-hand tendencies. In both paired groups it was possible in nearly all instances to find a mate for each left-hand writer or subject with left-hand tendencies whose Intelligence Quotient was almost identical to his. The mean I.Q. of the left-hand writers was 108.7 and of the paired right-handers 109, and the greatest single difference between the I.Q.s of any pair was nine points. The mean I.Q. for the right-hand writers with left-hand tendencies was 106.5 and of the paired right-handers it was 107.6, and the greatest single difference was ten points in I.Q. In the few instances where there were two right-handed subjects with the same I.Q. as the left-hander, in the same class and of the same sex, then the first on the alphabetical list of subjects was selected; this occurrence was, however, rare.

The results of the comparison of speed of writing in these two paired groups are shown in Table XLVI, where it may be seen

TABLE XLVI /

TABLE XLVI

PAIRED COMPARISON OF LEFT- AND RIGHT-HANDERS ON SPEED OF WRITING

	Left-Hand Writers		Subjects with Left-Hand Tendencies.	
	Left-Handers	Paired Right-Handers	Left-Handers	Paired Right-Handers.
No. of Subjects	18	18	14	14
Mean Speed	102.2	108.7	104.4	115.1
Standard Deviation of Scores	23.4	17.3	29.8	23.8
Difference Between the Means	6.5		10.7	
Standard Error of the Difference	5.6		9.3	

that the means for both the left-hand writers and for those with left-hand tendencies are lower than the corresponding means for the paired right-handers, and that in both groups the standard deviation is greater in the left-handed group. A study was made of the differences between the means, the differences being 6.5 and 10.7 respectively for the left-hand writers and those with left-hand tendencies. The correlations in the two paired groups of scores were calculated in order to correct the standard /

standard errors of the differences for paired samples. The Standard Errors of the differences were 5.6 and 9.3 respectively, thus neither of the differences was significant. The results of this study do not, therefore, justify the assumption that left-handers are slower writers than right-handers of the same sex and intelligence, and taught in the same class. Though the small numbers used in this test would prevent one from asserting that this is always the position with all left-handers, it does at least indicate the absence in this group of a difference which many assume to exist, and on which they even base their attempts to change left-hand writers and make them employ the right-hand for writing.

III. COMPARISON OF SPEED ON THE WRITING AND CROSSING TESTS

The results of the Speed of Crossing Test are set out in detail in Chapter XVIII. A comparison was made between the results of that test where speed only was emphasised and the task was to draw a series of crosses as quickly as possible and this present writing test where words had to be written and quality and speed were both emphasised. The emphasis on quality in the Writing Test reduced the average quantity produced. Whereas in the Writing Test the average numbers of letters per minute were 52.4 and 54 for boys and girls respectively, the average numbers of crosses per minute were 83.4 amd 92.4 respectively. Thus, the actual amount produced was reduced in the Writing Test, and also the ratio of the girls' /

girls' scores to those of the boys. Though the girls still scored slightly better than the boys in the Writing Test, the difference between the means was not significant in that test, whereas in the Crossing Test it was. The implication would seem to be that the absolute ability of the girls in a task such as this is better than the boys as far as speed only is concerned, but that the necessity to concentrate also on quality reduces that superiority over the boys. In Table XLVII the comparative

TABLE XLVII

SCATTERGRAM OF SPEED SCORES FOR ALL SUBJECTS ON WRITING AND CROSSING TESTS

Writing Test. Scores	Crossing Test 35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	Totals
190-199								1		1
180-189										0
170-179					1	-	2	-	1	4
160-169			1	-	-	-	-	1	1	3
150-159				3	2	4	6	2		17
140-149					2	6	7			15
130-139		1	-	1	3	5	6	2		18
120-129		2	2	6	11	13	4	2		40
110-119			2	5	12	8	3	6		36
100-109		2	7	15	18	14	7	2		65
90-99	2	2	5	6	9	7	9	1		41
80-89		2	4	7	11	4	4	1	1	34
70-79		3	4	3	7	6	2			25
60-69	2	4	5	3	4	3	1	1		23
50-59	1	1	2	1	2	-	-	1		8
Totals	5	17	32	50	82	70	51	20	3	330

results of the total group on the Speed of Crossing and the Writing Test are set out - the trend of scores indicating that there is some connection between ability on the two tests. The correlations between the scores of the right-handed subjects on the two tests were calculated for boys and girls separately, and indicated some relationship between the two tests. The correlation between the boys' scores on the two tests was slightly higher than that between the girls' scores (r .35, S.E. .07 for the girls and r .46, S.E. .06 for the boys). The Z test of differences between the two correlations was applied, and indicated that the difference between the two correlations was not significant. The actual scores of the left-hand writers and those with left-hand tendencies were compared with the mean on each test of the right-handers of the same sex. The results are shown in Table XLVIII, eight left-

TABLE XLVIII /

TABLE XLVIII

COMPARISON OF LEFT-HANDERS WITH MEAN OF RIGHT-HANDERS OF THE SAME SEX ON WRITING AND SPEED OF CROSSING TEST

			Crossing Test				
			Boys		Girls		
			Above Mean	Below Mean	Above Mean	Below Mean	Total
Writing Test.	Group L H	Above Mean	2	6	1	0	9
		Below Mean	0	4	1	4	9
		Total	2	10	2	4	18
	Group l h	Above Mean	1	0	3	3	7
		Below Mean	1	3	0	3	7
		Total	2	3	3	6	14

L H Left-Hand Writers.
l h Right-Hand Writers with Left-Hand Tendencies.

hand writers and six with left-hand tendencies scoring below the mean on both tests, while three and four respectively scored above the mean on both tests, most of the others were above the mean on the Writing Test but below in the Crossing Test.

IV. /

IV. QUALITY OF WRITING

In view of the considerable disagreement between observers generally in any estimates of quality of handwriting, and in particular the lack of consistency when, in the present study, observers were asked to rank the eighteen scripts from the left-hand writers, it seemed a formidable task to attempt to get all 330 scripts marked for quality of handwriting with anything approaching consistency in marking. Since it was felt that little extra reliable information pertinent to the aspect of handwriting here under consideration was to be gained from a study of the quality of writing in the total group, attention was confined to the paired groups discussed in an earlier section of the chapter. The writing scripts belonging to the eighteen paired left- and right-handers, and the fourteen pairs of subjects with and without left-hand tendencies, were singled out. The actual sample of writing was on one side of the paper, and the name of the pupil, his school and class were on the back, leaving no distinguishing mark evident to the observers which would differentiate the two scripts of each pair. Thus the pairs of subjects were matched for class, sex and intelligence, while one of each pair had either left-hand tendencies or wrote with the left hand, the other writing with the right hand. Each pair of scripts was given a key letter, the first group being numbered from 'A' to 'R', and the second group (containing those with left-hand tendencies) from 'a' to 'n'. /

'n'. Each pair of scripts was shown in turn to a series of seven observers who were asked to decide which of the two scripts was the better writing - on their criterion. The seven observers studied all the scripts in this way, not aware that one of each pair in the first set had been written with the left hand. From these estimates a table was then drawn up showing whether the left-hander of each pair was considered better or worse than the right-hander. Finally, the first eighteen pairs of scripts, where one was actually written with the left hand and one with the right, were again shown to the observers who were this time told that one of each pair was left-handed and were asked to determine which of the pair it was.

Considerable consistency was found between the estimates of quality between the seven observers when the method described here was employed, and it was possible in most instances to determine which of each pair of scripts was generally considered the better writing. If five or more observers were agreed that the writing was better or worse, then that decision was accepted, if there was less agreement than that, it was assumed that there was little difference in quality between the two samples in the pair, and they were therefore classed as 'doubtful'. Seven left-hand writers were judged worse than the right-handers, nine were judged better and two 'doubtful', while the parallel results for those with left-hand tendencies as /

as compared with the right-handers were five worse, four better and five 'doubtful'. Thus, though there were left-handers better or worse than the right-handers there was no apparent tendency for the left-handers generally to be either worse or better than the right-handers so far as was indicated by the results of this study.

The ability of the seven observers to recognise the writing of the left-handers was then studied in order to determine whether they tended to rate as worse writing which was easily distinguished as having been written with the left hand. The ability to recognise the writing of the left-handers ranged from 15 out of 18 for one observer (himself left-handed) to 6 out of 18. Table XLIX shows, for the seven

TABLE XLIX

COMPARISON BETWEEN ABILITY TO RECOGNISE LEFT-HAND WRITING AND ESTIMATE OF ITS QUALITY (SEVEN JUDGES)

	No. of Scripts of Left-Handers.			
	Judged Worse		Judged Better	
Judges	Total	Recognised as L H	Total	Recognised as L H
1	12	6	6	-
2	8	7	10	8
3	11	7	7	6
4	10	9	8	4
5	8	7	10	7
6	9	5	9	7
7	9	6	9	4
Total	67	47	59	36
Mean	9.6	6.7	8.4	5.1

observers, details of their judgments on the writing of the left-handers as compared with the right-handers, and also their ability to distinguish the writing which had been performed with the left hand. The results show that 70.1 per cent of those judged as worse were recognised as left-handed and 61.0 per cent of those judged as better were recognised. The ease with which the writing was recognised as left-hand writing seemed to bear little relation to the observers' judgments as to its relative quality, except possibly in the case of the first observer who recognised only six of the scripts of left-handers, less than chance expectation, and all six scripts were ones which he had already judged as poorer.

V. COMPARISON BETWEEN QUALITY AND SPEED OF WRITING

The placing of the left-hand writers compared with their right-handed partners on a combination of speed and quality is shown in Table L. It may be seen that while four of the

TABLE L /

TABLE L

PAIRED COMPARISON OF LEFT-HAND WRITERS WITH RIGHT-HAND WRITERS FOR SPEED AND QUALITY OF WRITING (18 pairs)[a]

		Speed of Writing.			
		Quicker	Slower	Equal	Total
Quality of Writing	Better	4	5	-	9
	Worse	3	3	1	7
	Doubtful	-	2	-	2
	Total	7	10	1	18

[a] The comparison is in each instance in terms of the Left-Hander

left-handers were both quicker and better in writing, three were slower and worse. From the table it would appear that the left-handers did not, more than the right-handers, sacrifice quality to speed or speed to quality.

Similar results for the right-hand writers with left-hand tendencies are shown in Table LI, where it may be seen that only

TABLE LI

PAIRED COMPARISON OF SUBJECTS WITH LEFT-HAND TENDENCIES WITH RIGHT-HANDERS FOR SPEED AND QUALITY OF WRITING (14 pairs)[a]

		Speed of Writing.			
		Quicker	Slower	Equal	Total
Quality of Writing	Better	1	3	-	4
	Worse	4	1	-	5
	Doubtful	1	4	-	5
	Total	6	8	-	14

[a] The comparison is in each instance in terms of the subject with Left-Hand Tendencies.

one of this group was better and quicker than the right-handed partner, and only one was slower and worse, while three were slower but better and four worse but quicker. There seemed in this group a slight tendency to be either worse or slower, though not both. Unfortunately this group which was already small, having only fourteen pairs, was further reduced from the point of view of comparison by the fact that the judges were in disagreement with regard to quality in more instances here. Possibly the very fact that the two members of each pair in the other group wrote with different hands in some way facilitated the /

the comparisons of quality, making them more uniform. The greater than chance accuracy with which the observers could recognise the writing of the left-handers would indicate that in many cases it did have some distinguishing mark.

The left-handers and those with left-hand tendencies were in this test of writing distributed evenly above and below the mean for right-handers of the same sex. When a further study was made of matched groups it was found that there was no tendency for the left-handers to be poorer than the right-handers of the same sex, class and intelligence, either with regard to speed or quality of writing.

CHAPTER XXI

ANALYSIS OF THE RESULTS OF THE LEFT-HANDED SUBJECTS

In the preceding chapters attention has been concentrated on the findings on the total group of subjects, though reference has been made incidentally to the left-hand writers. This present chapter will, however, be devoted to a more detailed analysis of the left-handed subjects, both those writing with the left hand, and those who showed left-hand tendencies. Their results in the battery of tests of the various laterality characteristics will be discussed and a comparison made between their achievement marks in the Qualifying Tests and those of their right-handed fellows.

I. ANALYSIS OF THE PREFERENCE TEST RESULTS

The group of eighteen left-hand writers in the present study might justifiably be assumed to be extreme left-handers, since they use that hand for writing, yet it was found in this present study as previous investigators have suggested, that they were not, in fact, as complete in their left-hand preferences as were some of the right-handed subjects in their preference for their right hand. The detailed results of the left-hand writers are set out in Table LII, where a score of

TABLE LII

PREFERENCE TEST RESULTS FOR LEFT-HAND WRITERS

	Scores on Tests[a]												
	Hand			Foot			Ear			Eye			
Subjects	Sc	Re	Th	Ki	St	Ho	SB	SW	HT	Co	HC	PS	Cy
Girls:													
A	3	4	0	0	4	1	3	0	0	0	0	0	0
B	0	0	0	0	0	0	4	4	4	3	4	4	4
C	0	4	0	4	4	4	0	4	4	0	0	0	0
D	0	0	0	0	4	0	4	4	4	3	4	4	4
E	0	0	0	0	0	4	4	2	0	0	0	0	0
F	0	4	0	0	0	0	4	4	4	4	4	4	4
Boys:													
G	0	4	0	4	0	4	0	4	0	3	4	4	4
H	4	1	0	0	3	0	2	4	4	4	4	4	4
I	4	4	4	4	4	4	0	0	4	2	1	0	0
J	3	0	0	4	1	4	0	0	1	0	0	0	0
K	3	4	4	0	4	0	0	4	4	0	0	0	0
L	0	0	0	0	1	0	0	0	0	0	0	0	0
M	4	0	0	0	4	4	0	0	4	0	0	0	0
N	0	4	4	4	3	4	0	4	4	4	4	4	4
O	0	0	0	4	2	0	0	0	4	2	4	4	4
P	0	0	0	4	0	4	0	1	4	4	2	0	0
Q	0	4	0	0	0	4	0	0	0	0	0	0	0
R	0	0	0	0	3	1	0	0	4	0	0	0	0

a. Key to Test Names:
Hand: Sc - Screwing, Re-Reaching, Th - Throwing
Foot: Ki - Kicking, St - Stepping, Ho - Hopping
Ear: SB - Sound in Box, SW - Stop Watch, HT - Head Turning.
Eye: Co - Cone, HC - Hole in Card, PS - Peep Show, Cy - Cylinder.

Scores:
4 - Right on all 4 trials: 3 - Right on 3 Left on 1:
2 - Right on 2, Left on 2: 1 - Right on 1 Left on 3:
0 - Left on all 4 trials.

'zero' means left preference on all four trials, and a score of 'four' means right preference on all four trials of a test. It may be seen that even in the tests of hand preference, only seven of the left-hand writers showed left preference on each trial of each test, three of the boys even showing preference for the right hand in throwing. In the tests of eye preference nine subjects showed left preference on all trials of all four tests, for six subjects there was not agreement on all the tests, while the remaining three were right-eyed in all four tests, a result in contrast to that found in the total group of 330 subjects, where the frequencies were 48.5 per cent right-eyed, 25.5 per cent doubtful, and 26 per cent left-eyed.

Table LIII shows the parallel results for the fourteen

TABLE - LIII /

TABLE LIII

PREFERENCE TESTS RESULTS FOR RIGHT-HAND WRITERS WITH LEFT-HAND TENDENCIES

	Scores on Tests[a]												
	Hand			Foot			Ear			Eye			
Subjects	Sc	Re	Th	Ki	St	Ho	SB	SW	HT	Co	HC	PS	Cy
Girls:													
a	4	4	4	4	2	1	2	4	4	4	4	4	4
b	0	4	0	0	0	0	4	4	4	0	0	0	0
c	4	4	4	0	2	4	0	4	0	0	0	0	0
d	0	3	4	0	0	0	0	0	4	0	0	0	0
e	4	2	2	4	4	1	4	2	2	4	4	4	4
f	3	4	4	4	1	0	0	0	4	4	4	4	4
g	0	4	0	3	4	0	4	4	0	4	4	4	4
h	4	4	4	4	4	4	4	4	0	4	4	4	4
i	4	4	4	4	4	4	0	4	4	4	4	4	4
Boys:													
j	0	0	4	0	0	0	0	0	0	4	0	0	0
k	0	0	4	0	0	4	4	2	4	4	4	4	4
l	0	4	4	0	4	4	0	4	0	4	4	4	4
m	0	2	0	0	4	3	2	4	0	0	0	0	0
n	4	4	4	4	3	4	0	4	0	4	4	4	4

a. See footnote to Table LII.

subjects with left-hand tendencies. While five of them showed right preference on all three trials of the tests of hand preference, the remaining nine showed disagreement on /

on the tests, in other words, showed some left tendency. It is worth noting that of the five who showed right preference in all three tests, four were right-eyed on all four tests of eyedness. The subject designated 'a' on the table only claimed to deal cards with the left hand, the other three who were right-eyed and right-handed on the preference tests had actually been left-hand writers at some time, but had changed or been changed to the right hand. It would appear that in these instances the change had been complete. A further point of interest is the finding that of the total group of fourteen with left-hand tendencies, only four now use the left hand for anything actually connected with writing - 'b', 'c' and 'd' for drawing and ruling lines, while 'm' writes with either, but usually the right - and these are the only four left-eyed on all four tests of eyedness. Though final conclusions on this matter cannot be drawn from so small a group, it does, nevertheless, indicate various lines for possible research - to ascertain whether transfer to right-handedness is only complete or more likely to be complete in those not left-eyed, whether subjects who are both left-handed and left-eyed are more extreme cases of left laterality, or as a third alternative, whether a change of eye dominance may in fact take place in those who change over completely to right-handedness.

A further point to be noted is the contrast between eyedness /

eyedness in these two groups. Whereas among the left-hand writers there were three right-eyed, nine left-eyed and six inconsistent, in the group with only left-hand tendencies there were nine right-eyed, four left-eyed and one inconsistent.

II. FINE MOVEMENT AND ALTERNATING MOVEMENT TESTS

These tests which formed part of the battery have not yet been discussed, as it was decided in the course of the testing that the results obtained were not sufficiently objective to warrant inclusion as an important part of the study. Difficulties soon became apparent as they were being applied, since, however, they only took a minute or two to apply it was decided to retain them in the battery, as there was the chance that they might reveal some interesting material in individual instances. With regard to the Fine Movement Test, it was found that, in order to utilise such a method, a more elaborate experimental set-up would be required. In the present study, the child was asked to transfer a series of metal balls from a box into a small tube by means of a pair of tweezers, and a note was made of the hand used at the first attempt, and the time taken to perform the task, which was then repeated with the other hand. Difficulties, such as the child dropping one of /

of the balls, made effective timing of the action impossible; however, it was possible to make a subjective estimate of the relative ability of the two hands. In the Alternating Movement Test it was found that some of the subjects were incapable of making their two hands rotate in alternating directions at the same time; while others though capable of making the movement showed poor co-ordination with one hand; while still others could make both hands function fairly well to start with, but one hand tired long before the other. An analysis of the results of the left-handers on this test revealed the following points of interest. In the Alternating Movement Test in the group of left-hand writers, eight were much the same with both hands, five were poorer with the right, four were very poor with both hands, while the remaining subject could not do the test. In the group with left-hand tendencies, four were more or less the same with both hands, three were poor with both hands, while five and two respectively were poorer with the right and left hand.. In the Fine Movement Test all the left-hand writers except two, used the left hand first in the test, while five of those with left-hand tendencies used the left hand first, the remaining nine used the right first.

III. /

III. ACHIEVEMENT TEST RESULTS AND LEFT-HANDEDNESS

The achievement test results of the total group of 330 subjects will not be discussed in any great detail, since they did not form part of the actual testing carried out in the course of the present study. However, it is necessary to mention several points in connection with them preparatory to a comparison of left- and right-handers on these tests.

Both the group Intelligence Test and the Achievement Test marks used in the study were those obtained in the course of the testing for allocation to secondary schools by the Glasgow Education Committee. The Achievement Test mark used here was the sum of the scores on the Arithmetic and English Tests. The correlation between the results of the Intelligence Test and the Achievement Test marks was calculated by means of the Pearson product-moment correlation, yielding a correlation of r .77, $S.E._r$.03 for the right-handed boys and r .74, $S.E._r$.04 for the right-handed girls. The results of one boy and one girl had to be omitted as they were not on the schedule for the class, though they were in the class at the time this study took place. The mean I.Q. of the right-handed boys was 109.4 (S.D. 14.2) and of the right-handed girls 109.3 (S.D. 13.7); while the mean Achievement scores were 111.2 (S.D. 22.2) and 113.2 (S.D. 21.3) respectively.

The /

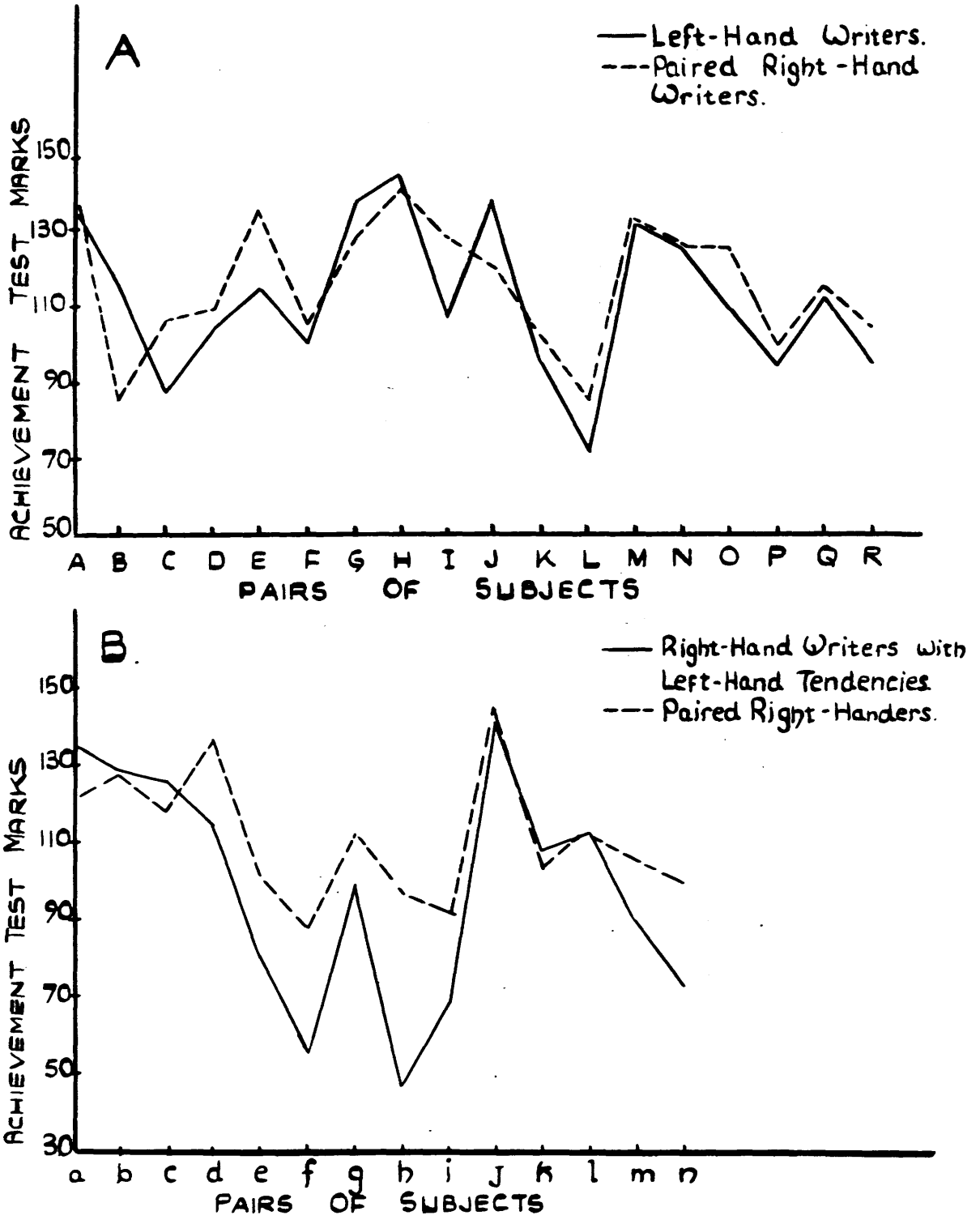

FIGURE 11. PAIRED COMPARISON OF ACHIEVEMENT TEST RESULTS OF LEFT- AND RIGHT-HANDERS

The paired groups used in earlier sections of the study were used again here to compare the left-hand writers with right-hand writers matched for sex, class and I.Q., and to compare the right-hand writers with left-hand tendencies with right-hand writers without such tendencies. The mean Achievement mark of the left-hand writers was 111.6 (S.D. 19.8), and the corresponding mean for the paired right-handers was 115.6 (S.D. 17.0). The standard error of the difference was calculated, corrected for correlated samples, and found to be 3.3, thus the difference between the two means, 4.0, was not great enough to be significant. Thus the left-hand writers did not as a group score significantly lower than right-handers on the Achievement Tests. In Figure 11A are shown the corresponding Achievement marks of the pairs of left- and right-hand writers, indicating that between some of the pairs there was a considerable difference in achievement. The mean Achievement mark of the right-handers with left-hand tendencies was found to be 97.5 (S.D. 30.2) and the corresponding mean for the paired right-handers was 110.3 (S.D. 16.0). The standard error of the difference between the two means, corrected for correlated samples, was 5.2, thus the difference between the means (12.8) was significant at the .05 level of significance (t 2.46). The mean Achievement Score of the right-hand writers with left-hand tendencies /

tendencies was, in other words, significantly poorer than that of right-handers matched for sex, class and intelligence, but having no apparent left-hand tendencies. In Figure 11B are shown the corresponding Achievement Marks of each matched pair in this group. Those who were actual changed left-hand writers are those numbered e, f, h, i and n, all of whom scored more than twenty points below the paired right-hander, and one as much as fifty points below. It would be unjustifiable to draw any final conclusion from these small groups on the effects of left-handedness on achievement in school, or on the relative placing of those writing with the left hand and those who have been changed to right-handedness. As far as this study is concerned, it has been shown that whereas the left-hand writers were not poorer than the right-handers of the same sex, class and intelligence, those with left-hand tendencies were inclined to be so, and that the most glaring examples of this were in those who had actually been forced to use the right hand, even though all five of them were right-eyed. If these subjects were penalised in tests where little writing was involved, they may be even more so in other aspects of studies, since the use of an achievement test does so far as is possible remove the influence of speed and style of writing.

No /

No further discussion of the other tests in the battery will be given here as the results of the left-handers on these were discussed in some detail in the relevant chapters. The following section of this chapter will be devoted to a discussion of the information gained from the left-handers during talks in the course of the testing.

IV. INFORMATION ON LEFT-HANDEDNESS GAINED FROM THE LEFT-HANDED SUBJECTS

Most of the left-hand writers stated that they had at some time been encouraged or forced to attempt to write with the right hand - usually about the age of eight years. In several instances this occurred when the child changed to a different school - indicating that though the official policy is to permit left-handers to write with the left hand, there are teachers and whole schools who do not follow this. It is interesting to note that subject 'B', who was left-handed in all the preference tests, had never been made to try with her right hand, she said, because her mother had instructed the teacher to allow her to use the left hand, her mother being left-handed herself in most things except writing. Subject 'D' said that her mother had tried to change her before she started school, as she thought she was 'just putting it on' - it is worth noting that there was no instance of left-handedness among her close relatives.

Subject /

Subject 'F' stated that attempts were made to check her in the infant room at school, but that she could not use the right hand. More recently she has been reprimanded because her writing with her left hand had different slants. On being asked whether she had tried sloping the paper, she replied that she had, but had been told by the teacher to keep it straight. Subject 'I' was rather interesting because, when his position was discussed with the teacher, he claimed that the boy was not left-handed but only trying to be different. The fact that his preference results showed right preference in all the tests, where he did not realise that handedness was being tested, would lend support to this view. He admitted that when he broke his left arm he wrote with the right hand for a time, but when the left healed he returned to it. Apparently his parents had also attempted to force him to use the right hand, without success. It was observed that when he wrote in class, he turned the paper right round so that he wrote in towards the body, and rather seemed to like being reprimanded for that.

Subject 'L' said that when he was six years old he was made to use his right hand and to put his left hand behind his back, but was so poor with his right hand that he was permitted to return to the left. He confessed that he had great difficulty in writing, and that the fine nib used in school caused the ink to spurt and blot the writing, with the result /

result that he was frequently punished for bad writing. Further, his hand was inclined to go numb when he did much writing, This was probably the result of the clenched position of his hand when writing, which meant that he was straining the hand all the time. Subject 'M' said his mother had tried to change him, but never any of the teachers, but one teacher had said that she did not like left-handers.

In the group with left-hand tendencies, there was one subject, 'm' who was still writing with the left hand occasionally, while several used the left hand for drawing and ruling lines (b, c and d). Several of the subjects who had at one time written with the left hand and been changed over to the right were content to write with the right hand and use the left for other activities. One girl, 'f', said she used her left for a few years but changed to the right hand because she was not very good with the left; while another girl, 'h' admitted that when she had used the left she had been corrected repeatedly for bad writing and was the only left-hander in the class, so her mother had suggested that she should practice with the right hand - which she now uses for everything. One of the boys 'n' said that when he started school he used the left hand, but was forced to use the right. He was taken away from that school because they had forced him to change to the right hand; however he still uses the right hand for writing, and is quite efficient with that /

that hand.

These extracts from the information gained by questioning the left-handed subjects reveal the diversity of treatment to which they were subjected, not only varying from individual to individual, but in one child as between home and school, or with different teachers.

V. SEX DIFFERENCE IN HANDEDNESS

The sex difference in handedness as far as writing is concerned has already been discussed in connection with the inheritance of handedness[1]. It was there suggested that

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1. Supra, pp.34-35

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the sex difference might result from temperamental factors rather than any actual difference in degree of native dominance. The finding in the present study of only six girls writing with the left hand and twelve boys using that hand for writing suggests a similar trend to that found by previous investigators, while the reverse trend was in fact noted in those with left-hand tendencies but not writing with the left hand, the numbers there being nine girls and five boys with left-hand tendencies, making the total numbers with any left tendencies more or less the same for the two sexes. In an attempt to estimate more accurately the actual percentages of boys and girls writing with the left hand, a

form was sent to each teacher in the eight schools in which the testing took place, asking for information of the total number of boys and girls on the roll, the total number now using the left hand only for writing, and also particulars of any other children who had at some time used the left hand, and if they had been changed to the right hand, by whom. It was realised that this latter part of the form would certainly be an under-estimation of the numbers involved, but it seemed worth enquiring for that information at the same time as that concerning present left-handers. The results of that investigation are shown in Table LIV, where the figures obtained in the individual schools are listed

TABLE LIV

TOTAL NUMBERS OF LEFT-HAND WRITERS IN EACH OF THE EIGHT PRIMARY SCHOOLS USED FOR TESTING

School	No. on Roll		No. of Left-hand Writers.		Total on Roll	Total of Left-Hand Writers.
	Boys	Girls	Boys	Girls		
A 1	471	478	40	24	949	64
A 2	415	409	41	30	824	71
B 1	447	434	37	27	881	64
B 2	249	236	25	19	485	44
B 3	411	380	19	21	791	40
B 4	450	412	35	18	862	53
C 1	233	246	13	12	479	25
C 2	269	250	26	18	519	44
A-Above Average	886	887	81	54	1773	135
B-Average	1557	1462	116	85	3019	201
C-Below Average	502	496	39	30	998	69
Totals	2945	2845	236	169	5790	405

separately. The percentage of left-handedness found in the three grades of school were 7.6, 6.7 and 6.9 per cent for above average, average and below average schools respectively. The differences between these percentages are not significant. The percentages of left-hand writers in the eight schools were 8 per cent of boys and 5.9 per cent of girls. The difference between these percentages was significant, indicating a greater proportion of boys than girls using the left hand for writing, as was found in previous studies. In addition to the percentage found using the left hand only, another 1.2 per cent were reported as having used the left hand for writing at some time, and the majority of these were reported to have been changed at home rather than at school. Even if this is an accurate picture of the reason for changing, this does not necessarily mean that the school had no part in making the parent feel it would be better for the child to use the right rather than the left hand. The figure for left-handedness found here, approximately seven per cent., using the left hand in writing, indicates a considerable increase in recent years in the amount of apparent left-handedness. Whether this is only an increase in the <u>apparent</u> left-handedness, resulting from the more tolerant attitude, is hard to say. Further how representative these figures, obtained from almost six thousand children under the age of twelve, are for the rest of /

of Scotland, and how they would compare with present-day figures from other countries cannot at present be determined. A further line of study would be an attempt to ascertain whether the incidence of left-handedness varies greatly in different districts, and whether it is constant in different age groups.

In the course of the present study information was obtained from the subjects on left-handedness and twinning among their immediate relatives. Though lack of positive information could not be accepted as absence of any left-handedness in the family, it was fair to assume that the instances reported were accurate. However, in view of the difficulty of gaining full information on the more distant relatives, the figures were calculated from only the siblings of the subjects who were tested. The results of that information may be seen in Table LV. Since information on

TABLE LV

LEFT-HANDEDNESS AMONG SIBLINGS OF SUBJECTS TESTED[a]

Siblings.	L.H.[b]	R.H.	Total	Percentage Left-Handed
Boys	22	287	309	7.1
Girls	14	264	278	5.0
Total	36	551	587	6.1

a. Only siblings of school age or over are included, i.e. who have reached the age of five years.
b. All those reported as left-handed are included.

children /

children of school age and over was likely to be more accurate than that on younger children, the data on children under five years of age was treated separately. A sex difference was again apparent in these results, and the total percentage of left-handers, 6.1, was slightly lower than that found for children between five and twelve, which could be accounted for by the presence in the group of siblings of some over school age. Another 10 out of 116 siblings under the age of five years were reported as showing left-handed tendencies, but without actually seeing the children it was impossible to estimate what strength these tendencies had, as some parents would notice slight attempts to use the left hand, while others might remain unaware of even more pronounced attempts until the child attempted to use the left hand for writing.

Finally a study was made of the left-handedness and twinning among the relatives of the left-handed subjects. A summary of that may be seen in Table LVI. It is worth

TABLE LVI /

TABLE LVI

DETAILS OF KNOWN LEFT-HANDEDNESS AND TWINNING AMONG THE RELATIVES OF LEFT-HANDERS.

No. of Subjects with	Left-Hand Writers	Subjects with Left-Hand Tendencies.
Left-Handedness and Twinning among relatives.	0	2
Left-Handedness only	10	6
Twinning only.	2	1
Neither.	6	5
Total	18	14

noting that four of the left-hand writers, and one of those with left-hand tendencies ('b', who actually draws with the left hand) stated that their mother was left-handed, while none in either group had a left-handed father. This is particularly noteworthy in view of the finding that in the total group of 330 subjects approximately equal numbers had left-handed fathers or mothers (16 and 17 respectively). There was little evidence of twinning in the left-handed groups, but the two instances which did occur among the left-hand writers were both cases of twins among the siblings. It /

It would be presumptious to attempt an analysis of the hereditary mechanism at work in the transmission of hand dominance, on the basis of the information supplied by the children tested in this study, particularly in view of the difficulties which have been encountered by geneticists in their attempts to account for the phenomenon. The information was gathered here with the aim, rather, of studying the family background of left-handedness as one factor affecting the attitude to the individual left-hander.

CHAPTER XXII

SUMMARY AND CONCLUSIONS

I. SUMMARY

The first part of the present study was devoted to a critical analysis of the main investigations which have been performed on the more important aspects of laterality characteristics; while the second part contained an original research into the laterality characteristics of a group of 330 school children of about eleven years of age. The children (162 boys and 168 girls) were subjected to a battery of eighteen tests of the various aspects of lateral asymmetry and to a writing test. In addition, the marks obtained by the subjects on the Group Intelligence Test and the Achievement Tests, which are administered to all children in the schools under the Glasgow Education Committee at the completion of the Primary Stage of their education, were utilised in the present study. The following are the main findings of the experimental section of the study:

A. PREFERENCE TESTS

Thirteen preference tests were performed by the subjects, three tests each of hand, foot and ear preferences, and four tests measuring eye preference.

1. Right preference predominated in all tests of preference, the greatest percentage of right preference being /

being evident in the tests of handedness.

2. In the tests of hand preference, screwing and throwing were the two activities with the greatest connection; reaching, though positively correlated with the other two, showed more undecided subjects. The percentages for right, left and doubtful preference on all three tests were 71.5, 2.4 and 26.1 per cent respectively, taking all those not consistent on all twelve trials as 'doubtful'.

3. The foot preference tests of kicking and hopping were positively correlated, but there was no significant connection between the foot used in stepping off and the foot used in the other two activities.

4. The two ear preference tests, Sound in Box and the Stop Watch Test, gave connected results, while the results of the Head Turning Test were connected with the former but not the latter test.

5. There was a close connection between the results of all four tests of eyedness, the Cone, Hole in Card, Peep Show and Cylinder Tests. The percentages for right, left and doubtful preference were 48.5, 26 and 25.5 per cent. respectively, taking all those who were not consistent on all sixteen trials as 'doubtful'.

6. A significant correlation was found between each of the three tests of hand preference and the Kicking Test of footedness, /

footedness, and also between the Hopping Test and both the Screwing and Throwing Tests of handedness.

7. The ear preferred in the Stop Watch Test of earedness, where the subject was permitted to hold the watch, had some connection with the hand preferred in the hand preference tests, as also had the direction in which the head was turned at a sound; while the Sound in Box Test of earedness, where the direct influence of handedness was removed, was connected with the preferred eye.

8. There was no connection between the preferred hand in the tests of hand preference and the preferred eye.

9. No connection was evident between those who were non-dominant or changeable in the tests of handedness and those who were doubtful on the tests of eyedness.

10. The boys showed a greater tendency than the girls towards left preference in all tests of hand, foot and ear preference (except the Hopping Test). However, only in reaching, stepping and the Stop Watch Test were the differences great enough to be significant.

B. SPEED OF CROSSING TEST

The Speed of Crossing Test measured the relative ability of the writing and non-writing hand in drawing crosses at a high speed.

1. A sex difference was found in ability to perform the test, /

test, girls being on the average quicker than boys.

2. There was a tendency for the left-hand writers to be slower than right-handers of the same sex in performing the task with the writing hand.

3. The ratio of ability with the writing hand to ability with the non-writing hand was calculated, and showed that in the left-hand writers there was a tendency for the two hands to be closer in ability than were those of the right-hand writers.

4. A significantly smaller ratio of writing hand to non-writing hand was found among the right-handed boys than among the right-handed girls, in other words, the superiority of the right hand over the left hand was greater among the girls.

5. A significantly greater percentage of those with a low index of handedness on this test showed some left tendencies on the preference tests than showed no such tendencies; while a greater percentage of those with a high index of handedness showed right preference on all the tests than showed any left tendency.

C. SIMULTANEOUS WRITING TEST

1. When visual cues to direction were removed, as in this test, there was a tendency for the non-writing hand to mirror in bimanual writing; there was, however, some mirroring /

mirroring with the hand accustomed to writing. In the total group of subjects, the mirroring with the right hand was approximately one-sixth as frequent as mirroring with the left hand.

2. There was no evidence of mirroring in one-third of the subjects, while 45 subjects mirrored with both hands. All but eight of the remaining subjects mirrored with the writing hand only.

D. THE VAN RIPER TEST

Simultaneous drawing with both hands was carried out in this test, at four different angles, and on four different diagrams.

1. There was a greater tendency to mirror with the left hand than the right hand under these circumstances.

2. The amount of mirroring increased as the angle was increased.

3. The amount of mirroring varied with different diagrams and so also did the ratio of left- to right-hand mirroring.

4. A significantly greater percentage of boys than girls mirrored with the writing hand.

5. Inconsistency in the hand with which mirroring was performed as between different diagrams was shown by a considerable group of the subjects - 184 out of 330.

6. /

6. Inconsistency in the hand with which mirroring was performed as between different angles on the same diagram was shown by an additional 43 subjects.

7. Of the total group of subjects, 123 out of 330 mirrored with neither hand or the non-writing hand first on each diagram. Of the remaining 207 subjects, 23 mirrored first with the writing hand. An analysis of their results on the other tests revealed little evidence of other left-hand tendencies in them.

8. Left-hand writers did, however, show a tendency to mirror with the right rather than the left hand, particularly in Diagram 3.

9. An analysis of subjects giving inconsistent results indicated that no single diagram was causing the inconsistency.

10. A comparison between this test and the Simultaneous Writing Test showed that there was much more mirroring with the writing hand on the Van Riper Test, where the distraction was greater, and that there was no indication that those who mirrored with the writing hand on the one test would tend to do so on the other.

11. A negative correlation was obtained between the total amount of mirroring produced with either hand and the intelligence of the subject, indicating that intelligence was influencing to some extent the angle at which mirroring would take place.

E. /

E. THE WRITING TEST

1. No significant sex difference was found between the speed of writing of the right-handed boys and girls.

2. A low, but significant, correlation was obtained between speed on the Writing Test where both speed and quality were emphasised and speed on the Speed of Crossing Test.

3. There was no apparent tendency for the left-hand writers or those with left-hand tendencies to score below the mean of right-handers of the same sex.

4. The group of eighteen left-hand writers and of fourteen subjects with left-hand tendencies, when matched for sex, class and intelligence with right-handers, did not differ significantly in mean speed of writing from the paired right-handers.

5. Approximately equal numbers of the left-hand writers were judged better or worse than the paired right-handers, nine better, seven worse and two doubtful; while of those with left-hand tendencies, four were better than, and five worse than the paired right-handers - in the remaining five instances the observers were not agreed.

6. When both quality and speed were considered, four of the left-hand writers were better and quicker than the paired right-handers and three worse and slower; while one with left-hand tendencies was better and quicker than the paired /

paired right-hander and one worse and slower. Thus there was no tendency for the left-handers as a group to be poorer or slower than right-handers of the same sex, class and intelligence.

F. RESULTS OF THE LEFT-HANDERS

1. The preference test results of the group of left-hand writers showed that they were not so complete in their preference for the left hand as were many right-handers in their preference for the right hand.

2. There was a greater tendency towards left-eyedness among the left-hand writers than right-hand writers, only 3 out of 18 left-hand writers were right-eyed on all tests of eyedness.

3. In the group with left-hand tendencies, all five subjects who had been changed to the right hand for writing were also right-eyed; while in contrast, the four subjects who still used the left hand in drawing and ruling lines were all left-eyed.

4. The Alternating Movement Test revealed a tendency in both groups of left-handers to be better with the left hand; while in the Fine Movement Test all the left-hand writers except two preferred the left hand, and five of those with left-hand tendencies preferred that hand.

5. /

5. A paired comparison of left-hand writers and right-hand writers matched for sex, class and intelligence showed no significant difference between the mean Achievement Test result of the two groups.

6. The mean Achievement Test mark of the group of subjects with left-hand tendencies was significantly lower than that of right-handers with no such tendency when they were matched for sex, class and intelligence. The five subjects who had actually been changed to the right hand for writing were all more than twenty points below the paired right-handers in score on the Achievement Test.

G. SEX DIFFERENCE IN HANDEDNESS

1. A study of the writing hand of all the children attending the eight Primary Schools used in the present study gave the number of children writing with the left hand only as seven per cent (based on almost six thousand children aged between five and twelve years of age).

2. The percentage of left-hand writers was significantly higher among boys than among girls (8 and 5.9 per cent respectively).

3. In the total group of 330 subjects, 16 had left-handed fathers and 17 had left-handed mothers, yet of the left-hand writers and those with strong left-hand tendencies, five /

five had a left-handed mother and none had a left-handed father.

II. CONCLUSIONS

1. Right-handedness is not a single factor existing in almost the entire human race with only one or two exceptions termed left-handed; nor can hand dominance be adequately described in terms of a dichotomous classification of right- and left-handedness appearing in unequal proportions. In short, differences in the proportion of right- and left dominance are apparent not only in the total population, but also in the same person for different activities, the preponderance of right preference being greatest in those activities most connected with school writing. The number of persons showing consistent preference for one hand or the other appears also to vary for different activities and to be greatest in the more skilled and more often practised tasks. These results lead to the conclusion that no single test of hand dominance will give an adequate picture of handedness, and that, though the results of different tests are positively correlated, a battery of tests is necessary for a study of even the more important aspects.

2. Lateral asymmetry is a feature not only of use of the hand, but also of foot, ear and eye. The presence of

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a connection between the preference of foot and hand should be noted, and the lack of connection between those of hand and eye. The association found here, between the ear preferred in listening and the preferred eye, when the subjects were unaware that either of these aspects was being tested, is also worth noting. However, since visual and aural acuity were not tested it may be that, in the subjects showing such a connection, acuity was in some way involved, an aspect which may warrant further investigation.

3. The inclusion of the Van Riper Critical Angle Board as a diagnostic instrument for measuring left-handedness has not been justified by the findings of this study because of the inconsistency of the results on different diagrams and at different angles, and the connection of the total mirroring with intelligence. Since no reliability can be placed on the critical angle as a measure of degree of dominance, it would seem that future research might profitably be confined to the ninety degree or 'back to back' position of the boards where mirroring most often occurs.

4. The study of writing difficulties of left-handers and the analysis of their writing as compared with that of right-handers is the aspect of most practical importance. The absence of a difference between the speed or quality of writing of the left-handers and right-handers in this study reveals /

reveals only the absence of a group connection. Though showing clearly that left-hand writers are not inevitably slower or poorer than right-hand writers as a result only of using the left hand, the conclusion should not be drawn that there are no left-handers whose writing is suffering either in speed or in quality. Some valuable information might be secured by an investigation of the relative scores of older left- and right-handers on such single aspects as speed, legibility, quality, pressure, and, possibly most important of all, fatigue from long periods of writing.

5. Left-hand writers, as this study has shown, represent only a fraction of those with left-hand tendencies. Some have been changed to the right hand, others have transferred of their own volition after commencing writing lessons, while still others have been changed even before entering school. The percentage of children using the left hand for writing seems to be increasing; however, a more extensive survey of the present incidence in different districts and among different age groups is required.

6. It is not desired to over-stress the findings on the achievement scores obtained in the present study because of both the limited numbers involved and the fact that the tests were not personally administered. They do seem, nevertheless, to suggest a most important line for future research to ascertain the truth of the indication that, though left-hand writers are not poorer in scholastic achievement /

achievement than right-handers, right-hand writers with left-hand tendencies may be, and to ascertain, further, if this is so, where in fact the greatest difficulties lie.

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