MIRROR WRITING IN NORMAL ADULTS.

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(Received April 29, 1940.)

This subject has a moderately extensive literature and examples have been recorded by various authors for some years. Most of the cases, however, have been the subjects of some pathological lesion, either congenital or acquired. Perhaps the earliest authentic case is the one originally described by Rosinius Lentilius in 1698, and quoted by Critchley, of a female, presumably young, epileptic sinistrad. The sex is not as important as the other factors, but it is a pity that there is no reference to the intellectual capacity. It is, if nothing else, a pointer to the usual type of case studied. In the adults, hemiplegics seem to have proved the most fruitful source for those collecting examples of this phenomenon, although a full list of causes is well known.

There would, then, seem to be some excuse for examining instances of mirror-writing in normal adults if only to have some "yardstick," as it were, by which the frequencies and variants in the normal can be known. To this end 50 male and 50 female specimens have been obtained under conditions described more fully below.

Material.

The people who gave the specimens were mainly members of the staff of a hospital, holding varied positions from maids on the one hand to medical officers on the other. Each was asked for nine signatures as follows:

1. (*a*) Right hand. As in ordinary writing, i.e. on the upper surface of a piece of paper.

(*b*) Left hand. As in 1 (*a*).

(*c*) Both hands together. As in 1 (*a*).

2. A repetition of 1 except that this time it is done with the eyes shut.

3. A further repetition of the original, but this time the under surface of a piece of paper is used. It is obvious that under these circumstances the script is hidden from the writer's view, as in 2.

1 and 2 present no difficulties when the specimens are obtained, but there is a point that it is wise to observe when the last test is undertaken. Much trouble will be avoided when the writing is examined at leisure if the paper is labelled so that the edge nearest the performer is marked "bottom" and those

https://doi.org/10.1192/bjp.86.363.680 Published online by Cambridge University Press

on his right and left also noted. It will be seen that these are opposite from the examiner's. Unless this is done reversals either in the lateral or more probably in the vertical may be missed.

Results.

The classification of these is best done under the headings (*a*) frequency and (*b*) types of variants from normal writing. The former of these is shown in Table I, which is set out in two parts so that not only are the male and female results separated, but it also divides those obtained on the upper surface of the paper from those on the under surface and conveniently leaves apart the examples that were made with and without the visual aid. Table II deals only with the more unusual and, as a rule, minor variants of normal writing other than the common complete reversal.

Table I.

	Upper surface.					
	Eyes open.		Eyes shut.		Under surface.	
	Male.	Female.	Male.	Female.	Male.	Female.
Right hand	0	0	0	0	42	47
Left hand	0	0	0	1	41	45
Both together	0	0	0	0	40	46
Right only (both used)	0	0	0	0	1	1
Left only (both used)	1	0	1	1	0	1

The figures in this and the next table note the occurrence or absence of abnormal script.

In the whole series there will be 600 right- and 600 left-hand signatures, of which 100 are normal ordinary writing examples as practised daily. 800 are made on the upper and 400 on the under surface of the paper.

Firstly let the results on the upper surface be considered. Only on one occasion was mirror writing found when the eyes were open, and this in the left hand when both were used. When, however, the eyes are closed it occurred on three occasions, once in the left hand alone and twice in the left hand when both were used. Although such figures are not very great, yet it is rather extraordinary that such writing occurs three times more frequently with the eyes shut than when they are open and always in the left hand.

Let us now pay attention to the under surface of the paper. Of the 100 right-hand signatures 89 per cent. are written mirror-wise. 86 per cent. of left-hand signatures follow this rule and the same figure holds good when both hands were used together. Only 2 per cent. show it in the right hand alone if both were used, and only 1 per cent. of people in the left hand alone under the same circumstances. Roughly speaking, then, mirror writing is as usual

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on the under surface as ordinary left to right script is on the upper. Throughout it will be noted that females show a slightly higher reading than males.

Discussion.

Before going into the theories that have been advanced to explain this phenomenon it is perhaps as well to realize on what these results are founded. In each instance the subject was writing his or her name—one of the first things we are taught to write from childhood, if not the first, and, if we exclude the articles "the" and "a," the words that have been written most frequently by each of us. The result of this continued repetition is that one no longer, in adult life, spells one's name when putting it on paper, but draws a pattern in which particular letters may be quite indiscernible and the whole a mere shape, undecipherable and defying analysis except by those of the signatory's friends and acquaintances who are already aware of its peculiarities. These remarks are particularly true of the right hand, since this is the one mostly used, though not always for writing. When, however, a more unusual method of autographing is adopted the tendency to reproduce the usual right-hand pattern still persists, but there is also introduced an effort to spell the word, i.e. form a number of joined letters, where each is written as a separate entity, and in Table II this may account for the misspelling noted there.

It may be convenient at this stage to consider some of the theories that have been put forward to account for mirror writing. The following summary of causes is a modification of that given by Critchley :

(1) Dulling of the highest mental faculties.

(2) Post-hemiplegic cases, usually in left-sided cerebral lesions and associated with aphasia and apraxia.

(3) Normal left-handed children.

(4) Congenitally word-blind.

(5) Eyedness as well as handedness.

(1) *Dulling of the Highest Mental Faculties.*

Mirror writing has been observed on many occasions when the highest mental faculties are in abeyance, as in states of hypnosis and the cases described by Porot, Abély and Raircoule. This type can have no direct bearing on the present inquiry as, rather than a dulling of mental faculties, the attention of each subject was focused on the signatures he was making.

(2) *Post-hemiplegic Cases.*

This group leads at once to the relation between speech and writing, since a certain degree of aphasia and apraxia is usually present. In considering the laryngeal movements during speech Drennan has pointed out that those on one side of the body are a mirror image of those on the other. This is also

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true of movements of the hands and arms, as is readily seen in the clinical test for dysdiadokokinesia. Drennan further states that, in spite of the bilateral innervation of the larynx, one half of the brain is dominant and the side controlling the dominant hand also controls the larynx, i.e. the left hemisphere in right-handed persons. The movement predominant in the act of writing is abduction. When for any reason a right-sided hemiplegia occurs, the controlling half of the brain is removed functionally and the left hand, free from this influence, no longer writes from left to right, but reverts to the " natural " movement of abduction, thus producing mirror script. Does this unilateral cerebral dominance play any part in the first group of causes noted above ? There is no proof, but it is at least feasible to imagine that when the higher faculties are dulled the main stress falls on the dominant hemisphere.

(3) *Normal Left-handed Children.*

It has been shown that mirror writing is commoner in left-handed children than it is in the right-handed. From what has been said before this might be expected, since the left-handed child is usually taught to write with the right hand and consequently uses the subdominant cerebral hemisphere. The reversal is made with the left hand following the natural action of abduction which has already been learnt with the right. As Critchley has noted, such writing may be neater than the right-handed efforts and the child is often unconscious that he is writing mirror-wise with his left hand. Such writing, too, is read by such children quite easily.

(4) *and* (5) *Congenital Word-blindness and Eyedness.*

Critchley has suggested that the condition of word-blindness is not so rare as has been formerly supposed. He also says that when writing is first learnt kinaesthetic memory is more important than visual, the latter replacing the former as the child grows up. Presumably in these subjects there is no visual memory to replace the kinaesthetic, which will again be formed by the movement of abduction. The physiology of sight deserves some consideration at this point. In his interesting paper, Drennan points out that the images on the two retinae are identical, whereas those on the visual cortex are mirrors of each other. He does not, however, hold the usual view that these fuse, his reason being that it has been shown that people are as consistently right- or left-eyed as they are right- or left-handed. His explanation of mirror writing lies in the suppression of the normal or dominant image and the ascendency of the lesser images or " ghosts," through the association fibres to the auditory and motor paths. But it must, in fairness to him, be noted that dominance in one eye cannot be considered indicative of which hemisphere is dominant, since correlation between handedness and eyedness is not absolute. Hogben and Drennan have endeavoured to show that sinistrads are more often left- than

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right-eyed, and quote Elliot Smith's ape fissure in the left occipital cortex of dextrads as an anatomical support. There is an anatomical reason for the fact that handedness and eyedness do not correspond absolutely, namely, the simple one that both retinae are represented on both sides of the brain. Perhaps future research will show that it would be more correct to speak of people being right or left "retina-ed" than right or left-eyed.

From these various explanations it will be seen that certain facts stand out and may be summarized under the following heads:

(*a*) Normal movement of writing is abduction.

(*b*) Unilateral cerebral dominance including eyedness and handedness.

(*c*) Primary kinaesthetic and secondary visual memory.

It must now be seen what relation these hold to the results here obtained.

Firstly, let us take the results from the under surface of the paper. When the right hand alone is used no less than 89 per cent. of the subjects wrote mirror-wise, 86 per cent. with the left hand alone and 86 per cent. with both hands together. When both hands are used together we note that only 2 per cent. showed mirror writing in the right hand alone and only 1 per cent. in the left hand alone. It would thus seem that this form of script is the common result on the under surface of the paper. It will likewise be obvious that to produce it the person is using the normal movement of abduction. During this they experience the usual kinaesthetic sensations that accompany this action, and although they will say that it feels strange to write in this way when further questioned, they will also say that in order to make their signature they form a mental picture of what they are writing. Another point is that they rarely know that they are not writing in the usual way because of the strength of the kinaesthetic impressions experienced. In other words they actually try to sign their names in the usual way. What then accounts for those occasions when mirror writing was not shown? As has been noted, when a person tries to re-orientate himself to write on the under surface he forms a visual image of his effort, and it is here suggested that this is in excess of or overrules the abnormal kinaesthetic sensation of adduction that must accompany such an effort. It is difficult to interpret this by any other means with the data that are known to influence this phenomenon.

Now for the signatures on the upper surface of the paper. It will at once be observed that here mirror writing is a rarity; in fact it is only found four times in 800 autographs. Of these four times, no less than three occur when the eyes are closed. This fact alone must indicate the importance of visual aid in signing. The next fact is that in all these four the left hand was at fault and never the right. But it can also be seen that three of these four are to be found only when both hands are used together. Can these figures be explained in the same way as were the under-surface ones? The increase of mirror-writing when sight is removed leaves the person with only a visual memory or image and the kinaesthetic memory of his previous effort. It can

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be fairly argued that since the kinaesthetic element is the same if the eyes are closed or open, it is not surprising that we occasionally find the left hand reverts to its original abduction pattern and so produces mirror script, especially as it is so much commoner when both hands are used together. A further point of interest here is that the one female case showing this example in the left hand with the eyes shut, although a dextrad herself, said that she came from a left-handed family.

Since these results are, however, the exception rather than the rule, it must be assumed that in most circumstances the visual memory is in itself sufficient to produce normal left to right caligraphy, and takes precedence over the kinaesthetic memory.

So far the results have been interpreted mainly from the consideration of kinaesthetic and visual memories and their relation to the normal abductive movement in writing, but what of the question of unilateral cerebral dominance? With the figures at our disposal here it is best considered by studying the effects of one hand on the other. It does not greatly matter if this be on the upper or under side of the paper.

It will be noted at once that when both hands are used together, on the upper surface, mirroring occurred only on the three occasions referred to above. On the under surface of the paper the occasions when the two hands differed number only three again. So that in three hundred occasions when both hands were used together we find only six examples of one hand not following the other. It is also shown that this difference is distributed equally between the upper and under surfaces of the paper. Surely this must mean that the factor causing it is independent of either sight or visual imagery. Why is it, also, that almost consistently the two hands follow each other so happily? It would seem that the dominant hand has a strong guiding influence on the other. To put it another way, the right hand acting as an aid to the left overrides the original tendency for them both to abduct, and this in spite of the adductive kinaesthetic impulses that must be received from the left in this act. The fact that the divergence from the usual remains the same even when visual help is removed is also important. As has been said, the kinaesthetic imagery is in abeyance, and so one can only attribute this to the dominance that one half of the brain is able to exert over the other side since visual aid made no difference.

TABLE II.

	Male.	Female.
Fragmentary reversals (parts of letters)	1	0
Individual letters only	1	2
Misspelling	1	2
Vertical transposition :		
(*a*) Incomplete	1	0
(*b*) Complete	4	2

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The results in this table are of more interest from the point of view of the clinician, and show some of the rarer variations in calligraphy that can occur.

The solitary case in which a fragmentary reversal of part of a letter occurred is that of a male who, although he describes himself as being right-handed, is actually ambidextrous, for when playing cricket he bats left-handed. The fault was to make the convexity of the curve of a capital R go to the left instead of the right in a left-handed signature with the eyes shut.

The next column deals with three cases in which individual letters alone were reversed, two of these being female cases. In the case of the man one of the initials of his signature was mirrored when the left hand alone was used on the upper surface of the paper, and again when both hands were used and the eyes shut. On the under surface of the paper a different initial was mirrored by the right hand. In the female cases one mirrored a capital P at the beginning of her name when both hands were used with eyes both shut and open in the left-hand signature. In the last case it was the final letter of the name that was at fault, an "h," when both hands were used together with the eyes shut. This case also showed vertical transposition with each hand used separately on the under surface of the paper.

The third heading deals with misspellings, once in a man and twice in women. The man was the case of a fragmentary reversal already noted, and he reduplicated an "e" at the end of his name when the right hand was used and the eyes shut. One of the female cases is somewhat similar, a "b" erroneously being repeated in the middle of the name when both eyes were shut, but the last case differs from the others in that a letter was omitted when both hands were used on the under surface.

The last item is the incidence of vertical as opposed to lateral transposition. It is as common as all the other variants in this table put together and is twice as common in men as in women. It is usually complete, only one incomplete specimen happening. In no less than four of these six cases it replaced lateral transposition.

Nearly all the points noted in this table can be explained in the same way as those in the first table.

So far we have considered the occurrence of this phenomenon in bulk as it were and have not applied the theories noted above to any individual case. The figures in the tables denote only the presence or absence of transposed script and do not show what may happen in any particular instance. It may be said at once that no case necessarily shows a complete consistency in performance. Let us illustrate this. A male mirror-wrote on the following occasions during his test: with the left hand when both were used together on the upper surface of the paper with the eyes shut and open, and also with the right hand only when both were used together on the under surface Or the case of a woman whose only lateral transposition occurred when both hands

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were used together on the under surface, but each hand separately, underneath the paper, gave vertical alteration; and finally the case of a woman whose mirror writing followed the usual course except that in the right hand under the paper part of a letter, i.e. the tail of a final "y," was not mirrored.

Can such apparent inconsistencies be explained by the factors put forward above, namely, the balance between the visual and kinaesthetic elements, whilst bearing in mind that there is a dominant or controlling hemisphere exerting a guiding influence on both hands? These factors would appear to be sufficient if it is admitted that they do not act with unvarying force continuously, i.e. if visual imagery is the main factor in any given case moments may occur when it fails, and then a temporary reversion to the primitive movement of abduction may result, giving the fragmentary and minor alterations in the writing that have been seen to occur at times; or if the kinaesthetic influence is the greater it can, for a longer or shorter period, be replaced by a visual dominance.

There is still one final point to be considered. We have no satisfactory explanation for the disorientation that produces vertical transposition. That it occurs with or replaces the more usual form of mirror writing is clear. The six names actually so written were the following: Hamilton, Higgins, Ridpath, Winter, Smith and Stark. All these have in the written script a fair sprinkling of vertical as opposed to round letters, and consequently in forming their visual images the vertical rather than the horizontal becomes relatively important, as may the to-and-fro kinaesthetic sense experienced in writing them, but such an explanation is not entirely satisfactory, as many others with similar spellings do not show this abnormality.

Summary and Conclusions.

From the above the following points of interest emerge:

(1) 100 normal adults have been examined for mirror-writing.

(2) The frequency of this type of writing has been shown, under stated conditions, in both males and females, together with the minor variants.

(3) The causation has been discussed and in the light of present knowledge accounted for by the balance between visual and kinaesthetic elements under the guiding influence of the dominant cerebral hemisphere, although there are still some points not fully explained.

Finally I should like to thank Dr. Wootton for letting me get specimens from the members of his staff, and also those who so kindly gave me samples of their writing.

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