The Pedagogical Seminary

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/vzps20>

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Published online: 18 Sep 2012.

To cite this article: M. Strack (1892) Mirror Writing and Left-Handedness, The Pedagogical Seminary, 2:2, 236-244, DOI: [10.1080/08919402.1982.10534019](https://doi.org/10.1080/08919402.1982.10534019)

To link to this article: <http://dx.doi.org/10.1080/08919402.1982.10534019>

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MIRROR WRITING AND LEFT-HANDEDNESS.

BY M. STRACK.

N. M. is a slender boy, now (July, 1892) fourteen years old, a little below the average stature and weight for the age, complexion somewhat sallow, dark hair, blue eyes which lack expression; he moves with moderation and slight unsteadiness of gait. He can do light work and plays at marbles and other childish games. The parents are of German birth, plain, laboring people, well built, strong and healthy. Their children are six boys and one girl. One older brother exhibited marked indistinctness of speech in childhood, which he has outgrown.

But in N. there is a combination of traits making him an extremely interesting subject, physiologically and psychologically. There is marked left-handedness which no other member of the family exhibits; he cannot pronounce a single word clearly, although the organs of voice are perfectly formed, and he makes sounds in his attempts to speak. There is total aphasia. He began school at the age of nine years. His progress was slow, but as hearing and sight were normal and active, it could not be doubted that the mind was unfolding. After a few months at school he began attempting to write at the blackboard and on paper. The left hand was used, being moved from right to left; each letter was reversed, and the letters placed in reverse order. Viewed in a mirror held before them, his early efforts were not more illegible than those of other children learning to write. With more exercise of the muscles the letters came to be well formed and fairly regular. If words he could spell were pronounced to him, they were put down in mirror writing; if required to copy written or printed words his copy was reversed. No effort was made by his teachers to induce direct writing, but he acquired it probably by imitation; at what time is not known. After being in school three years he wrote from dictation and from copy in direct hand such simple sentences as, *The man has a pen*. He also wrote the numerals from memory, but very laboriously, as if they were recalled with effort. They were not set down in their order and the 4, 5, 6 were plainly reversed. Words written in the reversed hand were shown him at that time; he tried to pronounce them and evidently understood their meaning.

Owing to timidity and ill health his attendance at school has been irregular. His present attainments are summed up in this: He recognizes at sight the words of Harper's First Reader, Part I., and can write most of them at dictation. His phonetic sense is so well developed that he distinguishes the most common vowel sounds and connects them with their marks for pronunciation; recently he wrote with his class ten words, as *horse*, *shells*, marking correctly the vowel sounds. Of numbers he seems to have no conception. His attempts at articulation are nearly as futile as at first, though his mother asserts that she understands them. At a test given him

last winter the printed words *red, yellow, blue* accompanying those colors were shown him. Upon request he tried to write them upon the board in direct order, but his letters were cramped and the words sloped at various angles. Finally he wrote in clear characters from right to left

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The following illustrations show his inability to originate ideas and to put them on paper. At request he wrote his own name reversed, misspelling it; he could not write his age. At the request to put down some numbers he wrote $2 \times 3 =$, $7 \times 5 =$, all being reversed. Shown a card of colors, such as makers of paints issue, red was pointed out, the name being covered, and he was asked to write the name; he could not do it, nor the name of any other color. At last he wrote with a pencil, imitating the type of the card,

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While he originates nothing on paper, he can do something more than follow the directions of others. He knows his rights in a game of marbles and will endeavor to assert them by the voice. He gives evidence in other ways of simple ratiocination. There is no hemiplegia nor paralysis, sensory or motor. The right hand and arm are as large as the left and capable of as strong a grasp; they are used somewhat, but the pen is always taken in the left hand, and no effort has ever been made to get the right hand used. It is to be regretted that no specimens of his drawing were taken early. Not long since he drew a cup placed on the table before the class; the outline was fairly done and the handle shown on the proper side.

Recently another case of mirror-writing has come under my observation. A girl, P. R., ten years of age, entered school September, 1891. She has a bright, pleasant face, and senses and speech are normal. I cannot learn of any congenital defect, or that she has ever suffered from serious disease. It is said that the father was at one time subject to fits, probably epileptic. It soon became apparent, however, that the girl was not tractable. She knew few words, had no comprehension of abstract numbers and wrote only a little. Being so backward she was placed in a class below her years; this aroused no sense of shame; she seemed quite regardless of the opinion of others. Commands were obeyed mechanically, to be entirely ignored in the next hour. Reproof was met by a stony stare or even a placid smile. Her attendance was irregular and the slightest indisposition sufficient cause for absence. The parents seemed to allow whatever she desired. She is also left-handed and her teacher noticed when she began to write that she wrote reversedly. She was at once required to trace a copy written for her. After a short time she wrote the direct hand nearly as well as the reverse, and at this time she writes both with about equal skill. In her exercise she now writes from left to right, and uses the reverse script only when requested to do so. There has also been increased pride in her work and general improvement in conduct. She never attempts to use the right hand in writing.

Before considering the rationale of this process, a few observations upon the use of the left hand by children in writing will be reported. It is believed these throw some light upon the more abnormal forms; and also that the mirror-writing will help to a better understanding of the difficulties in the way of ordinary left-hand penmanship.

In a large number of cases observed wherein children were learning to write with the left hand, in every case there was something unusual, either in the movement of the hand or its position on the paper.

M. M. is a bright boy of eight, left-handed. In writing he inverts the paper, the top of the sheet being nearest the body; the arm is then flexed so that the fingers point toward the top of the page; in this position the movement is from right to left, thus securing direct copy, legible but irregular. The movement is as difficult to understand as in mirror-writing. On the blackboard he wrote for me, with the left hand and the right, his name and the numerals, with other words from copy and dictation. The 3 and 5 were reversed when written at dictation with the right hand, the 5 only with the left, 10 with the left hand was 01, with the right correctly written. In copying there were no reversions.

Another case, B. W., a girl of seven, functions normal, using the left hand in writing, places the paper in the usual position and flexes the arm until the fingers point toward the body; the movement is then from left to right and strictly centrifugal, giving direct copy. What is normally the up-stroke is with her the down-stroke, and *vice versa*. The operation is extremely perplexing to an on-looker, and difficult to conceive of if not seen.

A young man of nineteen, who habitually writes with the left hand, can write back-hand only. That is, the arm movement is centripetal, but there is constant attempt at reversion in the right-to-left finger movements. He commonly reverses the numeral 8, finishing it with a horizontal movement to the left.

It is worth while to inquire carefully about the mental reaction in mirror-writing especially, and incidentally in all left-hand writing. Mirror-writing has been studied on the continent of Europe and in Britain, but scarcely at all in this country. We are indebted to certain German physicians and neurologists—Buchwald, Erlenmeyer and Peretti—and to Bianchi, an Italian physician, for accounts of many cases with learned opinions as to cause and significance. Its occurrence in connection with imbecility, dementia or paralysis led to its observation; and as might be expected from their profession, the observers have studied it in its relation to these diseases, attaching to it some pathological significance. The literature of the subject in English is extremely limited. I am aware of no translation of the works of the German writers. "Changes in hand-writing in relation to pathology"—A. Bianchi, was translated for the *Alienist and Neurologist* of October, 1883. I find no date earlier than 1879 assigned to reports of the phenomenon.

In "The Blot upon the Brain, Studies in History and Psychology," William W. Ireland, M. D., Edinburgh, 1885, are interesting papers on left-handedness and right-handedness, and on mirror-writing. In the latter article are references to the persons named above, and to a few other observers. Dr. Ireland has also published "On Mirror-writing and its Relation to Left-handedness and Cerebral Disease," in *Brain*, Vol. IV. To this I have not had access.

The Medical Record, New York, February 27, 1886, contains "Mirror-writing and Other Pathological Chirography of Nervous Origin," by Grace Peckham, M. D. The article is illustrated and gives numerous references to the investigators named. It is a careful résumé of facts and has some original conclusions, but treats at greater length of agraphia and the hand writing of cerebral and nervous disturbances.

The Germans gave the reversed copy the name *Spiegelschrift*, hence our mirror-writing. But the term levography better describes

the peculiar manuscript and is definite. The copy is of course negative with reference to our usual script, like the impression on blotting-paper; seen from the reverse side of thin paper or seen in a mirror, it assumes the left to right form of ordinary script.

A full investigation of the phenomenon involves consideration of the reason for our left-to-right script; of the whole subject of left-handedness; of brain and nerve physiology in health and disease, of the psychology of hand-writing and of the bearings of the manifestations described upon the work of education. It is the purpose of this article to call attention to this latter phase and incite observations, which will alike help to solve unsolved problems of mental physiology and to establish sound pedagogical principles.

It is very curious that a person should reverse the characters of a well-known word and then seriously consider the combination a proper representation of the idea; and still more curious that with the word before his eye he should deliberately perform the reversion and believe it a copy of the original. Of what low order must the intellection be that fails to distinguish *tac* from *cat*.

How does the subject see the word? Does the mind perceive the written word reversed and impel the hand to produce a correct copy of the mental image? Is the centre for the reception of written language sound or impaired? If there is reversion of words in the brain, is there reversion of other visual impressions? Or is the reversion of the written word external to the subject simply? The perception of form being dull and the memory of form weak, do the motor nerves impel in the direction of least difficulty, the inert intellect meantime accepting the result? Is the perceptive process disordered, or merely the motor?

A few principles in cerebral physiology are generally accepted by authorities as follows: Most of the nerve fibres which transmit motor impulses descend from the hemisphere of the brain and decussate in the medulla, those from the left side of the brain passing to the muscles of the right side of the body, and contrarywise. Movements of limbs are thus controlled by the opposite hemisphere.

According to the theory of localization of functions definite areas of brain tissue are assigned to the various mental operations. There are in the brain, centres of smell, of vision, of heard language, of spoken language and others. The centre of written language is placed in the second frontal convolution; and of spoken language in the third frontal convolution, both being in the left hemisphere. While these definite areas of gray matter have a dominant influence in certain sensations and motions, it is not held that they singly have exclusive control of functions. If a function be impaired or lost altogether, through lesion of brain tissue, it may reappear wholly or in part; the function has been taken up, it is supposed, by the corresponding area in the opposite hemisphere.

The eminent neurologist, M. Brown-Sequard, accepts none of these theories. He holds, in brief, that special cerebral functions reside in nerve cells specially endowed which are distributed throughout the brain tissue, not in groups or definite areas. And further, that each hemisphere is complete in itself, and sufficient for all mental operations; in fact, that we have two brains.

It is to be noted that according to the theory of special areas for special functions, the centres of spoken and written language are in the same lobe; and also that there are connecting nerve fibres which join each centre with adjacent and alternate centres, thus establishing communication between centres of the same hemisphere. There are various theories as to communication between corresponding areas in the opposite hemisphere. The most gen-

erally accepted theory is that of connecting nerve fibres through the corpus callosum, direct correspondence being thus established between special areas for the same function.

And it is also to be observed that the sensory tracts are obscure. While it may be determined that a motor impulse has its origin in a definite group of cells or kind of cells, it is not determined that the sensation which precedes that impulse exists in the same group or kind of cells. It can be judged whether or not sensations are normal only after they have called forth nervous impulses which are transformed into muscular contractions.

The explanations of aphasia are in accord with the theories above stated. The centres controlling the expression of thought by language are near those which control skillful manual operations; and as most people are right-handed, the seat of spoken and written language is commonly in the left hemisphere with the seat of right-hand movements. Loss of speech, therefore, is referred to injury of cells in the third frontal convolution of the left hemisphere in right-handed subjects, and of the right hemisphere in left-handed. If there is recovery of speech the corresponding centre of the opposite hemisphere is said to have assumed the function.

In every act of writing there are two distinct mental operations: *First*, that effort of the intellect which brings into the mind the form of the letter. In early efforts this is given attention to the copy placed before the eye, that its image may be transferred to the mind; later it is simply recalling the mental image of letters already formed. *Second*, the mental effort which impels and guides the muscles in the production of characters. In the child and the person of feeble intellect, each process will be slow and laborious; in the skilled penman they will be so rapid as to seem instantaneous and merged into one. There are, however, always two distinct phases of the mind. The impression of the motions for the formation of characters follows the impression of the image of the characters in every act of writing.¹

In the ordinary act of writing, the muscles used are those of the right side which move the hand from left to right. In writing with the left hand, then, the exercise of corresponding muscles of the left side will require movement from right to left, and there will result the levographic copy. There is necessary in the mind not only the image of the characters to be formed but also the impression of the muscular motions involved in the production of the characters; in an attempt to write with the left hand the muscles of the left side which are brought into play will naturally move the hand to the left. In the usual exercise of mental faculties, however, the image is the dominant factor and the muscles will be impelled to a reproduction of the normal image, even in opposition to the muscular tendency. The right-handed person will find difficulty in grasping the pen and executing the movements of writing with the left hand. But let some freedom of movement be gained; then to reverse each letter and move the hand from right to left is not a difficult task. The reason is to be sought in the physiology of nerves and muscles. The natural direction for forceful and often repeated movements of the limbs is away from the nerve centres, as in throwing, kicking, planing, sawing, sewing and writing. Whenever we exert muscular energy to the best effect, and whenever the exertion must be long continued, the movement will be in a direction centrifugal to

¹Dr. Bianchi, quoted by Ireland, "Blot on the Brain," p. 306.

the body.¹ This principle may account for our left-to-right written language, though to assert so much would be to assert a different physiological principle or psychological development for Mongols and Arabs.

Ireland says: "We have only to suppose that in mirror-writing with the left hand, the writer obeyed the acquired tendency to a given muscular adjustment." He is not willing, however, to allow this for all cases, and adds: "But in some of our instances children unconsciously produce mirror-writing as a correct copy of ordinary writing, from which it may be concluded that the image in their minds from which they wrote was also inverted." He then goes on to ask if the "image or impression or change in the brain tissue from which the image is formed in the mind" is also reversed, and suggests that the images in the two hemispheres lie in reversed order to each other.

Bianchi as quoted by Ireland believes that in hemiplegia of the right side the reversed writing will result, "because of the preserved remembrance of the muscular combination associated with the image of the word."

Whether these authorities hold that in all cases of levographic writing there is brain lesion in the left hemisphere, thus compelling the use of the left hand, is not clear. Certainly they do not refer cases of levographic writing to the muscular tendency simply, or to a perverted sense impression.

Dr. Peckham attempts to distinguish between "cerebral mirror-writing and mirror-writing from mechanical causes alone." She cites no case which has come under her own observation, but concludes an examination of twenty-five cases reported by others, by referring all to mechanical causes. "The person writing with the left hand could do so more easily in a centrifugal than a centripetal direction, the former association of ideas and muscular action making this so." She admits the possibility of cases "where there is a true reversal of the impression of the hand-writing due to the false perception of the psychical centres," and proposes as a test for such cases the ability to read mirror-writing. The suggestion seems to be founded upon the remark of Ireland about an imbecile girl, "that she can write from right to left with about as much ease as from left to right, but cannot now read it so well." She could evidently read both and write both. Would anyone suppose that there was now false perception, and now true? Or that when she wrote reversed hand the image in the brain was reversed, and the contrary when she wrote direct?

Dr. Ireland gravely remarks that among imbecile children frequent inversions occur in learning to read; they call *no on* and *was saw*. But every primary teacher knows that these are mistakes of common occurrence and liable to be made by all children. Nor is it necessary to suppose a graver defect than a weak sense impression, which miscarries somewhere in the motor tract. It would be to the point to observe if such mistakes are more frequently made by left-handed children.

Levographic copy would be read with difficulty at first by one unaccustomed to it; but it is inconceivable that one who should write it, from whatever cause, could not also comprehend it. Teachers and others have been greatly puzzled by the appearance of such writing and were unable to read it until the trick of it was acquired, when it presented no greater difficulty than any cipher

¹"Blot upon the Brain," p. 303. "The Intra-Cerebral Tract," M. Allen Starr, M. D., in *Medical Record*, Feb. 13, 1886.

would. The photographer readily detects faults in his negative, and the type-setter reads the copy in his stick or form easily enough.

We have in the correlation of mental image and muscular movement and in the law of centrifugal action a sufficient explanation for many reversions in writing. Instances of reversion of single letters or numerals by children are common; the 3 gets the form of a script E, the 5, the 8 and the capital S are turned about. The cause is purely physiological; weak memory of form in the child affords a sufficient explanation for such errors. In experiments which I have made, seventy-five children just learning to write were requested to take the pencil in the left hand; they then copied a few words from the board and wrote their own names. Only two wrote to the left, one of these both name and copy, the other, name only. This last one could not copy with the left hand. The two mentioned are, however, awkward in the use of their hands. Both read simple sentences in the levographic script without hesitation. Ireland cites experiments with young school children in left-hand writing. The results were various. Nearly all the left-handed children wrote from right to left, and no others did so. It seems to be a fact that learning to write presents considerable difficulty to the left-handed more than to the right-handed. Young children, the feeble-minded and unlettered persons are most apt to fall into the levographic writing. Persons attacked with right hemiplegia sometimes do so upon recovery in learning to use the left hand.

The cases which I have seen and reported above are believed to be typical cases of left-handed writing in children, and representative of all causes except hemiplegia, hypnotism and known injury to the brain. They also present a gradation of symptoms. In the girl B. W. the correct idea of writing is maintained and the muscular movement conforms to the image in the mind, although accomplished at great pains, it would seem, to a normal writer. In the case of the boy M. M. no claim of brain lesion would likely be made. His letters and words, as they flow from the pen, are vertically inverted; and such inversion is quite as perplexing as lateral inversion. It cannot be doubted that the boy cognizes what he sets down as proper representation of ideas; the eye and hand co-ordinate; the clear image in his mind determines that the characters must stand in left-to-right order and to preserve this idea the sense of vision accommodates itself to the muscles, which take such position as to accomplish the result with least difficulty. In both these cases the sense impression of correct copy dominates in the act of writing; had sense impressions been feebler the muscular sense might have determined the form of copy and levography resulted. Passing on to a consideration of the children who used the mirror-writing altogether in their early efforts, there seems no strong line of demarkation separating them from the others. M. M. after two years in school still reverses some characters. We are not warranted in holding that in P. R. and N. M. there is reversion of sense impressions on account of the reversed copy. It is not proven that all who use the reversed copy somewhat persistently are feeble-minded. Dr. Ireland instances a boy who wrote that form secretly. He was described as "a thin, pale boy of thirteen, who used his left hand out of school, rather intelligent, and getting on well with his lessons."

In both P. R. and N. M. there are perverted ideas besides the ideas of written language. Inherited tendencies, or malnutrition of gray matter may explain them all. There is inherited ignorance through a long line of ancestors. There are no books in the home

except the few school-books of the children. There is the constant grind of hard labor for the sole purpose of accumulation of property. Intellectual pursuits find no place. Is it surprising that the feeble body should have a feeble brain; that debility of the system should be most marked in the cerebral and nervous regions; that feeble action of mental faculties should result from scanty nutrition of those regions?

The evidence of numerous examinations in known cases of diseased brains point to injury of brain tissue as the cause of aphasia in N. M. He recovers slowly from the injury. Loss of the use of oral language is often accompanied by partial or total loss of the power to write. And naturally, since destruction or impairment of the speaking centre may readily involve, through the connecting nerve fibres, the writing centre also, in varying degrees. Cases of uncomplicated agraphia are rare, and this fact is important in our consideration of mirror-writing. Impairment of one function through injury of its centre may amount to complete obliteration without impairment of any other function, especially in adults. Impairment of the speech centre would likely be more far-reaching in its effects than of the writing centre. When we write we try to think "how it will sound." The impression of written language seeks re-enforcement and confirmation from the impression of spoken language; but the impression of spoken language, in general, needs no such confirmation from the writing centre. Moreover, the power to write is of later development than the power to speak, involves more complex physical apparatus, and disturbance of the function is less likely to be dependent upon structural changes, and more likely upon physiological ones. It would seem from this that the reversion of written language is not always an indication of brain disease. There are varieties of aphasia, and there are irregularities of speech amounting many times to grave defects which need not be referred to brain lesions. Such are the inversions of words by children in reading, and the more serious substitutions or forgetfulness of terms. Such perverted mental products stand in a descending series from perfect speech through casual slips of the tongue, substitution of one name for another, total forgetfulness of certain terms, the incoherent mouthings of inebriety to complete aphasia. So in written language we descend from the regular forms of the expert penman through the hurried hand of the busy man, the irregular writing of the illiterate, the careless writing of the child, the labored attempts of the left-handed child, the occasional reversion of a 3 or a 5, the complete reversion of levography, to total agraphia. Manifestations in the former series have been pretty carefully studied and each form referred to some appropriate cause more or less dependent upon material conditions; the latter series has received little attention, and the phenomena of hand writing offer a wide and interesting field for psychic investigation.

A. Geissler and R. Uhlitzsch in Heft, 1 and 2, Vol. XXXIV. of the *Zeitschrift des Königlich-sächsischen statistischen Bureaus*, make a valuable contribution to the anthropology of school children, in four sections as follows:

Section 1, which is general, treats of previous anthropological investigations, noticing the labors of Quetelet (in Belgium), Bowditch (in Boston), Roberts (in England), Pagliani (in Italy), Erisman (in Russia), Koller and Spiess (in Germany). The investigations of Geissler and Uhlitzsch were undertaken in accordance with an order of Schulrat Lohse of Freiberg, who, in 1886 determined upon having the school-children in his district

measured. The measurements (taken, wherever possible, without shoes, and with proper attention to the arrangement of the hair in the case of girls) were made in the following December. The measurement cards contained place, class, name, birthday, year of birth, and height in centimeters.

Section 2 treats of the material obtained and the results. In all 21,173 children were measured, of whom 10,343 were boys and 10,830 girls. The ages of the children extended from 6 1-2 years to over 14, half of them being contained in the series between 6 1-2 and 7 years and over 14. The differences in stature are remarkable: The range was from 38 cm. (6 1-2 to 7 yrs.) to 79 cm. (over 14). For boys and from 35 cm. (6 1-2 to 7 yrs.) to 65 cm. (13 to 14). The smallest boy (7 yrs.) measured 88 cm. The two smallest girls (7 to 8 yrs.) measured 85 cm. The tallest boy (over 14) measured 176 cm. The tallest girl (over 14) measured 167 cm.

These cases, of course, are quite exceptional. The greatest number of the boys are to be found between numbers which have a variation of from 8 to 11 cm., and the girls, where the variation is from 7 to 13 cm.

Section 3 is devoted to the consideration of the average, which is obtained by use of Gauss' law of errors.

Section 4 consists of comparisons with the results obtained by other observers, and tables containing the results of Quetelet, Bowditch and Erisman are given.

The principal results of the investigations of Geissler and Uhlitzsch may be stated as follows:

1. The children of the Freiberg school are shorter than in the rest of Saxony. 2. Up to the 11th years the boys are taller than the girls, then they are exceeded by the latter until the 16th year, when the boys again become taller. But it would appear that at the age 12-13 years both sexes are about the same (averaging 135.5 cm.). These results are in general accord with those of Bowditch and Erisman. 3. The miners' children are on an average shorter, and the children of the Bürgerschulen taller than the generality of the school children. 4. The arithmetical averages do not adapt themselves for use in anthropological investigations.