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Brain Function and Writing with the Unaccustomed Left Hand

REFERENCE: Dawson, G. A., "Brain Function and Writing with the Unaccustomed Left Hand," *Journal of Forensic Sciences*, JFSCA, Vol. 30, No. 1, Jan. 1985, pp. 167-171.

ABSTRACT: Twenty right-handed subjects were asked to handprint a passage containing all the letters of the alphabet once with each hand. The purpose was to describe the changes a document examiner can expect to find in handprinting done with the unaccustomed left hand and to offer a hypothesis as to why these changes occur. It was found that many of the writers displayed persistent differences between their right- and left-hand writings. It is suggested that these differences were due to both a lack of manual dexterity when writing with the unaccustomed left hand and to the fact that different neurophysiological processes are involved.

KEYWORDS: questioned documents, handwriting, handedness, brain

From a very early age, people tend to be either left- or right-handed. Very few individuals are totally ambidextrous. People favor the use of one hand or the other and therefore become more practiced in that hand's use. From the age of four or five to mid-adolescence the individual develops handwriting skills that eventually lead to a mature handwriting style. It is through the countless repetitions of letter designs by the favored or accustomed hand that the patterns of writing motions become fixed habits.

What happens when a writer changes to his unaccustomed hand? What handwriting characteristics can a document examiner expect to find in writing done with the unaccustomed hand, and why do these characteristics occur?

To study these questions, right-handed writers were asked to handprint using their unaccustomed left hand. Right-handers were chosen because the majority of people are right-handed. It has been estimated that only 10% of the population is left-handed [1]. Handprinting was chosen because handprinted letters are isolated and lack connecting strokes and can be studied individually. Also, a review of the available literature on the subject of unaccustomed handprinting revealed no experiments involving the study of handprinting done with the unaccustomed hand.

In this study, 20 right-handers were asked to handprint the London letter, a passage that contains all the letters of the alphabet (Appendix A) once with the right hand and once with the left hand. They were to copy a typewritten script using capitals and lowercase letters where appropriate.

Though it was not the prime purpose of the study, the opportunity was taken to check whether any of the left-hand writings became so changed that they could not be matched with

Presented at the 36th Annual Meeting of the American Academy of Forensic Sciences, Anaheim, CA, 21-25 Feb. 1984. Received for publication 26 March 1984; revised manuscript received 14 June 1984; accepted for publication 27 June 1984.

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their corresponding right-hand writings. This was done by examining the right-hand writings for a combination of salient features that distinguished each of them. A search was then conducted of the unaccustomed writings for these same features until a match was found. These samples were then set aside and a second match was searched for. The process was repeated until the author was confident that all 20 right-hand writings were correctly matched with their left-hand counterparts. Another person coded the left-hand writings so that the author did not know who had written them.

Observations

Pictorially, the unaccustomed left-handed writing was quite different from the right-handed writing. The subtle, delicate writing movements found in the right handprinting were not reproduced in the left handprinting, and at no time was it found that a letter written with the left hand was more skillfully written or complex in design than the same letter written with the right hand. Skill of execution was the primary difference between the writings. The pictorial difference created by the obvious loss of pen control was enhanced by the fact that letters produced with the left hand were generally larger than their right-hand counterparts and had a pronounced shift in slope, usually leftward. The combination of loss of fluency, larger letters, and change in slope produced what appeared to cursory examination to be two quite different products.

Although the left-hand letters tended to be larger, the spacing between letters, words, and lines remained proportionally the same. Persons who wrote large letters with wide spacing with their right hands tended to write larger letters with proportionately wider spacing with their left hands.

Except where otherwise noted, the following characteristics of handprinting done with the unaccustomed left hand were observed in all writers:

1. The more rounded the letters were in design, the more jaggedly they were written. Letters such as "o," "s," and the rounded portions of "a," "d," and "g" were subject to abrupt directional changes.
2. (a) Most writers who normally connected the staffs of letters to the bodies generally did the same with the left hand. However, occasionally with the left hand these writers broke these letters up into their component parts, for example, *g, d*.
 (b) Only one person persistently connected the bodies of letters to the staffs regardless of the hand used.
 (c) Only one person persistently disconnected the bodies of letters from the staffs even though the connected form was used with the right hand.
3. (a) Tick marks and instances where the pen trailed were more prevalent with the unaccustomed hand.
 (b) Initial and trailing ticks were found with all writers using either hand, however, they were sometimes in different directions with the left hand. Also, with the left hand, these ticks were not always in the same direction in all instances of a particular symbol as they usually were with the right hand.
4. Letters containing strokes that are normally retraced were often found not to follow the line, for example, *m → m, h → h*. In the case of the "a," the following was observed to a certain extent for all writers: *a → a*.
5. The normal terminal upstroke of a letter such as on "a," "d," or "u" was often missing, for example, *a → a, u → u*.
 (a) In the case of the "a," 8 of the 20 writers who normally wrote a terminal upstroke did not write this stroke with the left hand. An additional five writers who normally wrote an upstroke with the right hand, intermittently wrote a terminal upstroke with the left hand. Four writers made no terminal upstroke with either hand. Two of the writers wrote an unusual type of "a," for example, *a*, and one wrote a capital "A."

- (b) In the case of the "u," 6 of the 20 writers who normally wrote a terminal upstroke with the right hand did not write it with the left hand. An additional four writers who normally wrote an upstroke with the right hand, intermittently wrote a terminal upstroke with the left hand. Four writers had no terminal upstroke with either hand. Two writers intermittently placed an upstroke on the "u" with each hand. Four writers did not put a downstroke on the "u" with either hand. However, one of these four occasionally put a terminal downstroke on the "u" with the left hand.
6. (a) Vertical and horizontal strokes used in the staffs and crossbars of letters like "b," "d," "f," "h," "l," and "t" were curved, straight, or wavy when written with the left hand, whereas these strokes were consistently straight with the right hand.
- (b) Most crossbars of the "t" by most writers were sloped haphazardly, for example, \uparrow , \uparrow , \uparrow with the left hand. These strokes were either straight across or sloped from lower left to upper right with the right hand.
- (c) It was not possible to determine the direction of most of the "t" crossings of all the writers. Where it was possible to make this determination, many made the crossbar in either direction with the left hand.
- (d) Where it could be positively determined, the crossbar was always written from left to right with the right hand.
7. One writer wrote the "f" with a completely different orientation, for example, $f \leftrightarrow \uparrow$. In one other instance, this writer also wrote the "s" reversed, thus: $S \leftrightarrow \mathcal{Z}$.
8. (a) Normally the "i" dots with the right hand were either directly above the body of the letter or slightly to the right of it. With the left hand they tended to be directly above the body of the letter and occasionally were slightly to the left of it. Some writers placed the "i" dots haphazardly either directly above, to the right, or to the left of the letter body when using their left hand, even though the dots of these same writers were placed more directly above the body when the right hand was used.
- (b) The shapes of the "i" dots with the left hand were often like commas or small vertical or horizontal slashes. Very few dots written with the right hand were of these unusual shapes.
- (c) If the "i" dots were generally not present in the right-hand writing, they were generally not present in the left-hand writing. If they were generally present in the right-hand writing they were generally present in the left-hand writing.

As mentioned above, another individual coded the left-hand writing so that it was not known to the author who had written the passages. It took approximately 2 h to correctly match the left-hand writing of the 20 subjects with their right-hand counterparts.

Discussion

Persistent, subtle, inconspicuous differences between two writings are standard criteria for concluding that they are the products of two separate individuals. It is possible, therefore, that a document examiner might conclude that writings exhibiting such characteristics are the products of two separate individuals were it not for the fact that one of the writings lacks the fluency of the other.

What accounts for this lack of fluency in handwriting done with the unaccustomed hand? Is it merely due to the lack of skill from lack of practice, or is there something else that complicates the process? What is the role of the brain in handwriting? Since the brain directs the hand, changing hands to write should require different neurological impulses. Can these different brain impulses be used to explain why the differences between accustomed and unaccustomed handwriting are at times so marked?

Knowledge of the brain's role in handwriting is important to the work of the document examiner. To explain properly the variations found in writing with the unaccustomed hand and

in disguised writing in general, it is necessary to know what is actually happening in the brain when we write.

The human brain is divided into right and left hemispheres that are connected by a large bundle of nerve tissues collectively called the corpus callosum. It is the function of the corpus callosum to integrate the operation of the two hemispheres [1]. In most persons, the left hemisphere of the brain controls the right side of the body and the right hemisphere controls the left side. Gross structural features of the right and left hemispheres are similar, but their functions are quite different [2]. This is reflected in the fact that most people are able to write better with one hand than with the other.

Since 95 to 99% of right-handers have speech centered in their left hemispheres, it is from this hemisphere that writing originates [3]. Also, right-handers receive motor signals (hand, arm, wrist, and so forth) and sensory signals (vision and touch) from this hemisphere. Thus the right hemisphere does not have an active part in the writing of the right-handed person.

Conversely, left-handers receive motor signals from the right hemisphere of the brain. In 60 to 70% of left-handers, language and speech are located in the left hemisphere [3]. It appears necessary therefore for the impulses to travel via the corpus callosum to the right hemisphere to relay the appropriate motor information to the left hand. This step is not necessary for those left-handers who have speech centered in their right hemispheres. There is even some evidence to suggest that a few left-handers have speech in both hemispheres. This may be the situation for ambidextrous writers [3,4].

Since the writing of left-handed persons is motor controlled by the right hemisphere, these persons may be undergoing an additional psychoneurological process when they write, that is, the corpus callosum is used to transfer the visual memory of the particular letter design to the right hemisphere from the left hemisphere. The net effect is that for left-handers, handwriting may be a more complex process than it is for right-handers. It may be that the normally left-handed person has to cope with simpler psychoneurological impulses when using the right hand than the right-handed person has to with the left hand.

This additional complexity may explain the loss of fluency described earlier. In addition to being unskilled at using the left hand, the brain has to transfer the visual memory of the letter design to the right hemisphere via the corpus callosum, a process that is not necessary when using the right hand. This transfer from the left hemisphere to the right hemisphere may be what caused one of the writers in this study to write the "f" and "s" facing backwards thus: f , s .

One of the reasons the matching of the left- and right-hand writings was readily accomplished was that no matter which hand was used, it was the same brain attempting to make the letter designs. The individual still attempted to make the same letter designs when using his left hand, but was unable to reproduce them with the same degree of skill. The letter construction must be modified to take into account the lack of skill with the left hand.

Conclusion

Writing habits are neurologically fixed in the brain in that a specific area of the cerebral cortex has become specialized for the production of writing. Handwriting habits that are ingrained with the accustomed right hand are not necessarily operative when the left hand is used because both hemispheres of the brain are not simultaneously and similarly specialized. Evidence of this lies in the fact that there were persistent differences between the left- and right-hand writings. One person persistently disconnected the bodies of letters from the staffs even though the connected form was used with the right hand. Many writers who normally had a terminal upstroke on letters did not write this stroke with the left hand. Crossbars on "t's" persistently written from left to right with the right hand were often made in either direction with the left hand. One writer wrote the "f" and "s" with a different orientation.

The differences in the ability to write with the unaccustomed hand may not be due only to

the lack of manual dexterity, but also to the fact that different neurophysiological processes are involved.

Understanding the brain's role in the writing process and its effect on handwriting by the unaccustomed hand will enhance the document examiner's ability to explain and interpret variations and differences. This in turn, will help him to arrive at correct conclusions.

Acknowledgments

The author gratefully acknowledges the assistance of Geoffrey W. K. Brohier and Douglas M. Lucas in the preparation of this manuscript.

APPENDIX A

London Letter

"Our London business is good, but Vienna and Berlin are quiet. Mr. D. Lloyd has gone to Switzerland and I hope for good news. He will be there for a week at 1496 Zermot St. and then goes to Turin and Rome and will join Col. Parry and arrive at Athens, Greece, Nov. 27th or Dec. 2d. Letters there should be addressed: King James Blvd. 3580. We expect Chas. E. Fuller Tuesday. Dr. L. McQuaid and Robt. Unger, Esq., left on the 'Y.X.' Express tonight."

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