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Functionalities of the right and left hand in the context of handwriting expert opinion

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Handedness is only one type of the asymmetries present in people. Nearly every person has one dominant leg, as well as one eye and ear. Out of ten persons, nine are right-handed, eight have a dominant right leg, seven — a dominant right eye, and six — a dominant right ear[1].

It is an undeniable fact that nearly 90% of people use their right hand to write. However, there are persons who write with the left hand or with both hands. It should be stressed that a person is not born as left or right-handed. The dominance of one part is shaped along with the person's development, and it is influenced by various factors which will be discussed further on in this publication[2].

The secret of varied handedness has been studied for a long time. As it was claimed for a long time, a person who used the left hand to perform particular activities (including writing) is lazy, clumsy and incompetent. In the Polish language, the term "lefty" was and is still used

[1] A.D. Bragdon, D. Gamon, *Kiedy mózg pracuje inaczej*, Gdańsk 2003, p. 53.

[2] More about the dominance of brain hemispheres in: S. Konturek, *Fizjologia człowieka*, vol. 4. *Neurofizjologia*, Kraków 1998, p. 300 et seq.

to describe a person with such negative features. The pejorative meaning of left-handedness has never been confirmed by science, and it resulted more from the fear of otherness. It was so strong that as late as the 1970s efforts were taken to "unteach", mainly children, to write with the left hand. To do so, quite drastic methods were used which did more harm than good (such as learning and concentration difficulties, reduced manual capabilities, etc.). Fortunately, left-handedness is a normal thing today which occurs — it is just a slightly different form of human body functioning which is not combated, but is analysed to discover the factors which determine it. As a result of research, two groups of factors have been distinguished: internal and external. The external factors include the cultural and environmental impact, while the internal ones cover genetic conditions, influence of testosterone during foetal life which causes inhibition of growth in some areas of the left brain hemisphere — in this case, relevant areas of the right hemisphere develop better; the impact of brain damage during foetal life and labour, as well as stress during labour[3].

Scientific research on the functioning of the brain[4] has offered an opportunity to conclude that despite the symmetry in its structure, individual functions of the human body are divided between both of the brain's hemispheres. One of them is responsible for the speech and linguistic functions, i.e. reading and writing, while the other one determines spatial and motor skills, musical and artistic skills, emotions, etc. The above conclusions were drawn from clinical studies. As it was established, in 95% of right-handed people, speech and language (including reading and writing) is controlled by the left hemisphere, while in the remaining 5% by the right hemisphere. In 70% of left-handed people, the speech centre is located in the left hemisphere, in 15% of left-handed people in the right hemisphere, and in another 15% — in the left and right hemi-

[3] S.P. Springer, G. Deutsch, *Lewy mózg, prawy mózg. Z perspektywy neurobiologii poznawczej*, Warszawa 1998, pp. 128–134. The authors refer to the research from which an influence of the above reasons was concluded, none of which was recognised as dominant.

[4] See more in: M. Steuden, 'Struktura i funkcja mózgu', [in:] *Związek mózg–zachowanie w ujęciu neuropsychologii klinicznej*, ed. A. Herzyk, D. Kadzielawa, Lublin 2002, pp. 9–36.

sphere (bilateral speech control). In right-handed people, definite dominance (asymmetry) of the left hemisphere occurs more frequently than in left-handed people.

This means that if the speech centre is damaged, left-handed people have a greater chance of regaining speech function, which is taken over by the undamaged brain hemisphere[5].

The issue of so-called left-handedness has been for a long time, and still is, the object of interest as part of handwriting studies. It was analysed whether, based on handwriting, one can conclude if the writing was produced with the left or the right hand, and if the handwriting of one person produced with the right and the left hand demonstrates any convergent features which offer an opportunity to identify the person. Another issue which has been the object of scientific exploration is a theoretical possibility to conclude whether the writing person is right-handed, left-handed or ambidextrous[6].

It must be admitted that undoubtedly the studies of texts produced with the hand other than the one used by the writing person on a day-to-day basis, are difficult. It is often a method of disguising handwriting or a way to write a text in circumstances when the author is unable to write with the hand accustomed to writing because of injury. The difficulty of these studies arises from the lack of certain and constant symptoms or features which could irrefutably prove right-handed or left-handed writing, as well as the changes caused by writing with the other hand. In some manuscripts, it is possible to determine the features which may signify left-handedness and such features of left-handed writing which are also present in right-handed writings. Nevertheless, even in these circumstances the quantity and quality of the features is insufficient to entitle one to identify the author, even within specified probability. On the con-

[5] Sally P. Springer, op. cit., pp. 28–32. The authors refer to clinical research conducted using direct electrical stimulation of brain hemispheres in persons suffering from epilepsy, and the amytal test (the so-called Wada test). A. Kędzia, 'Struktura i funkcje ośrodkowego układu nerwowego', [in:] *Neuropatologia*, ed. J. Dywecki, J. Kulczycki, Wrocław 2005, p. 5 et seq.; E. Szeląg, 'Mózgowe mechanizmy mowy', [in:] T. Gorska, A. Grabowska, J. Zagrodzka, *Mózg a zachowanie*, Warszawa 2005, p. 489 et seq.

[6] T. Widła, 'Znamiona grafizmu leworęcznego', [in:] *Problematyka dowodu z ekspertyzy dokumentów*, vol. I, ed. Z. Kegel, Wrocław 2002, pp. 311–312.

trary, such features cannot be identified in other writings. Once again, the basic assumption of handwriting studies concerning the individual character of every person's handwriting is confirmed.

Similar features are present in left-handed handwriting because the person, while writing a particular text, uses the same pattern of graphic signs encoded and retained in their memory. Therefore, they attempt to write the way they do on a day-to-day basis. On the other hand, the differences which appear in the general picture of the handwriting and the individual features follow from the lack of handwriting ability in the unaccustomed hand, which means a decreased motor ability in the writing apparatus. This ability can be certainly acquired by means of regular exercises. Persons who write fluently with the accustomed hand go through the learning process more easily. In this case, more distinct common features may appear. One can even encounter an opinion that the more a given hand becomes accustomed to writing, the greater the chance that a declining tendency in the features typical of left-handed writing will occur[7].

Research on so-called left-handed writing (such research has been conducted so far although research on right-handed writing in persons who write with the left hand could be conducted) regards primarily two issues. The first one is the possibility to determine whether a text was produced with the left or right hand. Their objective is to identify the features typical of both these handwritings. The other issue is the possibility to compare right and left-handed writing, and to identify relevant quantity and quality of convergent features.

The first issue was the object of interest of J.V.P. Conwey, W.R. Harrison, T. Widła, as well as T. Tomaszewski and T. Dziedzic.

Both J.V.P. Conwey and W. R. Harrison offered an opinion that faultless identification of features which would confirm that a text was produced with the left hand is not possible. This regards cases when the writing person fluently uses the left hand. Nevertheless, J.V.P. Conwey identified features which may be recognised as relevant to left-handedness. They comprise: drawing a horizontal stroke in the letter t, ł and dia-

[7] W. Wójcik, 'Z zagadnień identyfikacji pisma leworęcznego', *Problemy Kryminalistyki* 1959, No. 22, pp. 751–754.

critical marks from the right to the left, as well as marks left by the hand when moving across the text in the appropriate direction of writing some elements in graphic signs[8].

T. Widła carried out a noteworthy experiment which concerned amongst others identification of features "strongly and significantly related to left-handedness". The experiment consisted in identifying 206 handwriting features in the analysed material produced by 40 people (20 right- and 20 left-handed) and indicating which of these features are significant for the writings produced with the left hand by left-handed people, and which of them are typical of writings produced with the right hand by right-handed people. Based on the experiment, the author distinguished 29 features which meet the criteria necessary to classify them as typical (i.e. strong and significant) for a particular type of graphism. He determined fourteen of these features as symptomatic of writings produced with the left hand, and another fourteen as typical of handwritings produced with the right hand. He presented their detailed list and thus proved that it is possible to establish whether a text was produced with the right or the left hand, however — as the author emphasises himself — the accuracy of the method (its diagnostic value) does not exceed 80%[9].

As part of that experiment, T. Widła undertook an attempt to analyse another problem, which is the frequency of occurrence of left-handed and right-handed graphism features in left-handed persons. As it appears, in writings produced with the left hand by left-handed persons, between 4 and 12 features of left-handed graphism, and between 1 and 8 features of right-handed graphism occurred. In 16 out of 20 cases of writings produced with the left hand by left-handed persons, the features of left-handed graphism prevailed, in two cases a balance of the features was observed, and in another two cases the difference was negative, with dominant features of right-handed writing. Ambidextrous persons were treated by the author as a separate group, and in their left-handed writings

[8] T. Tomaszewski, 'Uwagi wstępne na temat możliwości ustalania leworęczności wykonawcy', [in:] *Księga pamiątkowa ku czci Profesora Andrzeja Szwarca*, Wrocław 2001, pp. 226–222, q.a.; J.V.P. Conwey, *Evidential Documents*, Springfield 1959, pp. 201–202; W.R. Harrison, *Suspect Documents, Their Scientific Examination*, London 1958, p. 369.

[9] T. Widła, op. cit., pp. 309–311.

between 3 and 9 left-handed writing features and between 4 and 10 right-handed writing features were identified, with prevailing right-handed writing features in just one person. According to T. Widła, the possibility to conclude whether a writing was produced with the left or the right hand has been supported[10], however it should be emphasised that the proposed method does not diagnose right or left-handedness, as it only offers a chance to determine the hand with which a writing was produced[11].

J.V.P. Conwey's opinions quoted above, concerning the occurrence of left-handed writing features, have been the object of pilot research conducted by T. Tomaszewski who concluded that they should be treated with caution. The reason is that except for the features which confirm left-handedness, i.e. drawing horizontal strokes in the letters t, ł, Ł, the numbers 7, 5, in diacritical marks, hyphens, commas, etc. from the right to the left, in the analysed writings also the features which do not confirm the verified opinions were found. Some left-handed persons wrote the letters, numbers and signs the way right-handed persons do, i.e. from the left to the right. In right-handed persons, definite stability in the direction of drawing those elements was observed. Diacritical marks were an exception, as they were sometimes written from the right to the left. In the author's opinion, since right-handed writing features may occur in left-handed writing, one cannot pronounce on the right-handedness of the executor's handwriting. On the contrary, the conclusions on left-handedness are slightly more certain. If features recognised to be typically left-handed (i.e. the manner of writing letters and numbers without punctuation or diacritical marks) appear in the text, it can be assumed that the text was probably produced by a left-handed person. The basic conclusion drawn from the studies described above assumes that one cannot make unambiguous identification findings on right or left-handedness of the writing person. This aspect should undergo further research[12].

Left-handed writing was also analysed in terms of the possibility to compare it with the right-handed writing of the same person. In this case, special attention was paid to its changes, and also to its common features.

[10] Ibid., p. 311.
[11] Ibid., pp. 311–312.
[12] T. Tomaszewski, op. cit., pp. 227–230.

As W. Wójcik pointed out, in 80 manuscripts produced with the left hand, which he analysed, many features of right-handed writing undergo changes. Left-handed writing is a deformed drawn reproduction of the basic properties of right-handed writing. In the description of the research process, he enumerated the features which he observed in left-handed writing, and which he did not identify in right-handed writing. They included:

— mirror reflections in graphic signs (inverted picture of a letter sign or its part, change in the direction of the hand — most anticlockwise movements of the right hand changed into clockwise movements);

— irregular sizes of letters, words, lines (left-handed writing is broader and bigger);

— simplified graphic elements (no opening or closing adjustments, no loops in upper and lower zone elements);

— unnormalised shading system (primarily, greater pressure on covering agent);

— irregular connecting system;

— a different lean angle of handwriting (straight handwriting, slanted to the left);

— missing letters.

Contrary to this, the similar features classified by him are handwriting topography, some properties of the connecting system, and similar proportions despite a changed size of handwriting[13].

The differences present in left-handed writing prompted the author to conclude that right-handed manuscripts alone are insufficient for research on this type of graphism. Some convergent features may be found at times. However, there are too few of them, and to offer a final opinion one needs to have access to extensive samples of left-handed writing[14].

On the basis of his own research consisting in a comparison between right and left-handed writing of the same person, Z. Czeczot points out both similarities and differences. In only a few persons (15 persons out of 100 examined), he observed a general similarity of right- and left-handed writing (these persons had not written with the left hand earlier).

[13] W. Wójcik, op. cit., pp. 750–760.

[14] Ibid., p. 761.

In the remaining cases, the handwriting picture was different.

The features which appear in left-handed writing and make the handwriting picture different from right-handed include:

— handwriting impulse — it becomes weaker;

— greater handwriting width;

— greater handwriting height;

— a different lean angle of handwriting (sometimes different within one writing; nevertheless, a tendency to lean to the left occurs);

— greater handwriting pressure;

— smaller smoothness of writing or its absence;

— presence of mirror signs, inverted in relation to right-handed writing.

The quantity and quality of similar features depends, however, on the legibility degree of left-handed writing. Some groups of letters (in particular, letter groups fixed in the writing person's mind), intervals between letters or groups of letters, as well as the topography of writing, remain consistent.

The author also emphasises that both right- and left-hand writings must be used for research purposes. Moreover, he indicates that the more abundant the left-handed text is, the easier it is to identify its author[15].

The possibility to compare writings produced with the right and the left hand, and to identify its author on their basis were an indirect object of reflections of T. Dziedzic, who conducted an experiment lasting three years, which consisted in analysing writings of a right-handed person, i.e. the author who, for the purposes of that experiment, undertook training in writing with her left hand. The aim of this undertaking was an attempt to identify similarities and differences in samples executed with the right and the left hand. Based on the conducted analysis, T. Dziedzic distinguished similar features (i.e. legibility, ratios of lower zone to middle zone, and lower zone to upper zone characters, the shape of the right margin, word width, line spacing direction of writing ovals), neutral features (line quality in signatures, ratios of heights of upper zone characters to middle zone characters, general structure of characters) and the largest category of different features (i.e. writing speed, line quality in text, impulse level, pen pressure, system of shading in graphic lines, location of

[15] Z. Czeczot, *Badania identyfikacyjne pisma ręcznego*, Warszawa 1971, pp. 33–39.

the axis of characters against the baseline, shape and direction of baselines, heights of characters, width of left margin and word spacing, mirror reflections in characters, direction of horizontal strokes). However, he concluded from this experiment that common features may be defined only as accidentally similar. In his further reasoning he referred to the research which demonstrated the presence of symptomatic common features, however in an ambidextrous person whose motor skills were nearly identical in the right and the left hand, i.e. that person had been writing with both hands since childhood[16].

According to the author of the experiment, identification of symptomatic similarities in right and left-handed writing is possible in persons who have developed sufficiently high ability to write with the other hand, and may be particularly important when disguising handwriting[17]. Identification of such features suggests that collection of relevant comparative material is indispensable[18].

To confirm, or optionally, verify the above views, the authors decided to analyse the handwriting of a person who produced writings with the left and the right hand. The collected samples were executed by a young woman — a law student — who had been forced to acquire left-handed writing ability because she had damaged her right hand in a car accident. The injury was so serious that writing and performing more complex ac-

[16] T. Dziedzic, 'Porównanie pisma kreślonego prawą i lewą ręką przez jedną osobę', *Z Zagadnień Nauk Sądowych* 2013, No. 94, pp. 573, 576.

[17] Earlier considerations by T. Dziedzic are also worth mentioning, in which — based on the same example — he indicated how particular handwriting features evolve in the process of learning to write with the unaccustomed hand. It turns out that the features which are "rooted in the psychological human sphere" stabilise sooner than those which depend on a hand's motor ability. The first group includes legibility, disappearance of trembling, pen pressure, absolute size of graphic signs, height ratios of lower to middle zone elements, shape and direction of baselines, size, shape and direction of side margins, direction of executing ovals, and the manner of executing horizontal strokes. More resistant features comprise: writing impulse, location of the axis of characters against the baseline — these features stabilised later. On the contrary, throughout the whole period of the study the following evolved: speed of writing, shading, the process of disappearing of irregularities within graphic lines, mirror writings. T. Dziedzic, 'The Development of Left-Handed Writing Features of a Right-Handed Person Who Has Undertaken Training in Writing with His Left Hand', *Problems of Forensic Sciences* 2011, No. 86, pp. 93–102.

[18] T. Dziedzic, 'Porównanie pisma…', p. 577.

tivities was out of the question (her radial nerve had been damaged). This case serves as an example of the presence of a process to adapt to specific activities performed by the other hand, with undamaged speech and motor centre in the nervous system, however with the executive apparatus damaged. Cases have been reported when a person with damaged limbs is able to learn to write even with arm stumps, the mouth or feet.

The examined person was involved in an accident just after completing secondary education, i.e. at the age of 19 (at this age, handwriting is essentially developed, although individual predispositions should not be omitted). The recommended treatment and rehabilitation failed to bring any effects, at least on writing abilities. At the same time, in order to find her life purpose, and encouraged by her family, the examined person decided to take up law studies. This step also forced her to undertake training in writing with the left hand. Nevertheless, that task was easier for her, as she fulfilled one of the writing conditions, i.e. she already knew graphic signs. The only thing she had to do was to coordinate the movements of her left hand. After four years of her studies, she acquired certain skills in performing that activity. The examined person was able to write a legible text at a moderate pace.

It should be emphasised that her training was not divided into stages, like in a child who starts school education. Her training could start from the word stage and a higher stage which consisted in gradual automation of movements.

As part of the analysis, an attempt to identify features proving left-handedness was made. At the next stage, the left-handed and right-handed writing produced by that person was compared in order to establish which features had, and which had not changed. The following conclusions were drawn.

In left-handed writing itself, some features are present which could raise suspicion as to the hand used for writing. This is supported, amongst others, by the manner of writing some horizontal strokes in the letters ł, t (i.e. from the right to the left, as well as classically from the left to the right, like in right-handed writing).

Other features which may draw attention are ovals in the letters a, o, d, etc. started on the right side of the character, and not on the left side like

in right-handed writing. However, the direction of writing is not reversed, but it is also conformant and similar to that of right-handed writing.

The manner of writing lower zone elements in some letters may also suggest left-handedness. In these characters, a loop intersects the lower zone element from the right rather than from the left side.

While comparing the two handwritings, first of all their different pictures can be noticed. Left-handed writing is less developed, i.e. less smooth, angular and sharp, less regular in some places. It is more simplified, lacking starting adjustments, as well as loops in upper zone and usually lower zone elements.

While analysing the layout of handwriting, also discrepancies can be observed. In right-handed writing, the baseline of the words and lines is straight, while in left-handed writing various features can be identified, from straight and rising to falling. Moreover, the line strip is more distinct in left-handed writing. While the distances between words are similar, the distances between letters are bigger in left-handed writing.

In addition different impulses can be identified — weaker for strokes and letters in left-handed writing, mixed from single-letter to two-letter and multi-letter in right-handed writing.

Mirror writing can also be observed. It relates to the type of connecting strokes which are at present arcade ones. They used to be both of the arcade and garland type before.

The aforementioned manner of writing horizontal strokes in some letters, such as ł, t or Ł, as well as the side on which writing ovals is started, should also be treated as a difference.

Excepting the presented differences, some common features can be shown. They manifest themselves, amongst others, in proportions. Similar proportions are present in lower zone elements. Also the proportions of upper zone elements are comparable. The height of the middle zone is also similar, although the height of individual characters is more varied in left-handed writing. Similarities also refer to the structure of some graphic signs, the writing of which relates to a strong habit.

On the basis of the observed similarities, also with the present differences, it is difficult to conclude with certainty that a text has been executed by one person. Undoubtedly, an opinion on the present case, and similar

cases, may not rely on a comparison of only right-handed and left-handed writing, but samples of left-handed writing also need to be used, which is justified by the features of left-handed writing noticeable in writings executed after hand damage.

In summary, one can conclude that the opinions of various authors of the research and experiments mentioned above, as well as the conclusions reached by the authors, do not discredit research capacities, or maybe even formulation of categorical identification conclusions. However, it should be noted that each case is strongly individual and for this reason various conclusions may be drawn. Undoubtedly, the above findings can be helpful for opinion-making practice. Nevertheless, it should be strongly emphasised that extensive research, analyses and studies in this scope are indispensable, since most of those conducted so far have resulted in descriptions of a limited number of cases.

Summary

Undoubtedly, handwriting research contributes to broadening knowledge about the mechanism of development of handwriting ability. Most papers tend to discuss this issue on a global basis, taking into account graphisms of persons who are learning to write from first principles, although it should be noted that the sphere of handwriting examiners' interest also covers more detailed issues, such as left-handedness. This problem has involved handwriting experts for years, and for that reason the objective of the present publication is to present, in an abbreviated form, the directions of experimental studies conducted on left-handed handwriting, and the results obtained in that field.

Keywords: handwriting expert opinion, left-handedness, right-handed and left-handed writing, handwriting features, quantity and quality, identification.