RECORDS OF PHARMACEUTICAL AND BIOMEDICAL SCIENCES

Handwriting Changes as Characteristic Features of Diabetic Neuropathy

Moshira Elmadani[a]*, Shimaa A Fattah[b], Mohamed Awadallah[a], Eman T. Mehanna[b]

[a]Forgery and Counterfeiting Researches Department, Forensic Medicine Authority, Minister of Justice, Ismailia, Egypt, [b]Department of Biochemistry, Faculty of Pharmacy, Suez Canal University, Ismailia 41522, Egypt.

*Correspondence Author:

Tel: +201203844463

E-mail address:

moshirafawzi@yahoo.com

Abstract

Diabetic peripheral neuropathy (DPN) can injure the hand median nerve and cause extensive nerve damage. Neurodegenerative diseases (NDs) represent a large group of neurological disorders with heterogeneous clinical and pathological expressions affecting specific subsets of neurons in specific functional anatomic systems. An early diagnosis for these diseases strongly improves the effectiveness of the available treatments, but it is still a challenging task. Handwriting analysis is a method of predicting the writer's personality and gaining deeper insight into the author. It is a technical method for defining and evaluating author behaviors from handwriting based on line analysis. Handwriting results from a complex network made up of cognitive, kinesthetic, and perceptual-motor abilities. Standard handwriting tests are used to support disorder diagnoses is the DPN. It inspects such handwriting characteristics as: legibility, handwriting speed, form, alignment, size and spacing. DPN handwritings showed high speed with an imbalance in the writing pressure; changed acceleration; inside and on strokes edges; air strokes; natural tremors. These should be regarded as handwriting features of DPN and are not regular written defects, especially if they are present in the same positions with comparative signatures.

Keywords: Diabetic peripheral neuropathy, hand median nerve, handwriting analysis, tremors.

Characteristics of handwriting

Handwriting is often referred to as brain writing. Each personality trait is represented by a neurological brain pattern. Each neurological brain pattern produces a unique neuromuscular movement that is the same for every person who has that particular personality trait (**Rahman and Halim, 2022**).

There are a few simple tips on what to look for in handwriting. All people have a mixture of good and not so good features in their handwriting (**Hu et al., 2000**).

There are three principles for handwriting analysis:

1. Individuality

The principle of individuality, also known as the principle of uniqueness, forms the basis for handwriting analysis. That is, no two writers share the same combination of handwriting characteristics

given sufficient quantity and quality of writing to compare **(Amend and Ruiz, 2000)**.

1.1. Line quality

Do the letters flow or are they erratic or shaky? Line quality, that is, how letters flow normally or be shaky because of interference in performance **(Figure 1)**.
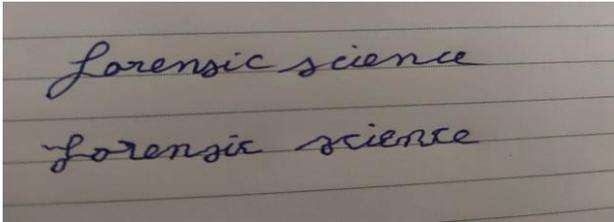

Figure 1: Line quality

1.2. Spacing

The combination of letter recognition and signature is intended to provide more complete overview the personality. Each feature recognized in parallel that indicates the distinct personality, in order to obtain a review of certain attributes **(Dang and Kumar, 2014)**. Graphology measure if letters equally spaced or crowded, spacing between the letters and spacing between the words **(Figure 2)**.
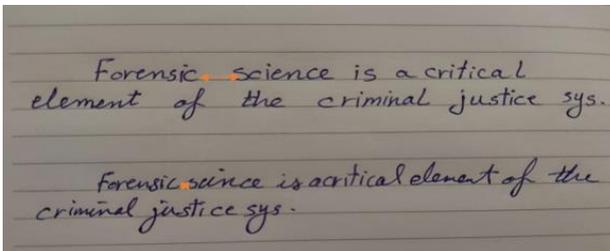

Figure 2: Letter spacing. The red arrows show the difference in spacing between the words of the first and second sentences.

1.3. Size consistency

Studying size consistency by measuring the ratio of height to width consistent **(Figure 3)**.
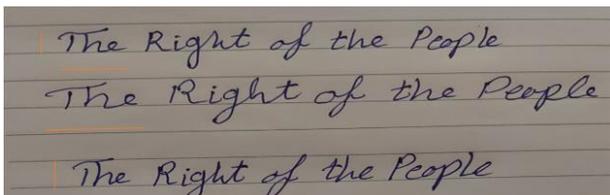

Figure 3: Size consistence. The red lines show differences in handwriting due to unequal height and width of letters.

2. Variation

No one person writes the same way, even within several repetitions of writings. This is known as natural variation, or intra-writer variation, and represents the second principle of handwriting analysis **(Bandyopadhyay et al., 2016)**.

2.1. Continuity

Is the writing continuous or does the writer lift the pen? Writing letters in continuous or discontinuous is a characteristic fingerprint in forensic medicine **(Figure 4)**.
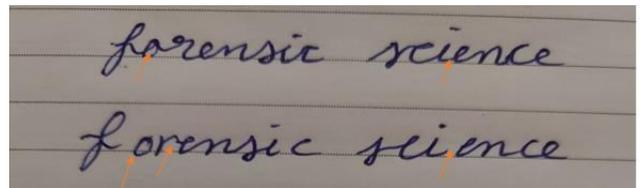

Figure 4: Writing continuity

2.2. Completion of the letters

Human beings are not capable of machine-like precision and repetition. As a result of the neuromuscular process, some variation in style is expected. Variation is an integral part of an individual's writing. It describes the changes and deviations, that are found in repeated samples of one person's writing. More specifically, variation refers to the different way(s) that a writer makes each letter or character. This variation is normal and serves as an added factor to personalize and individualize writing **(Harrison et al., 2009)**. For example, are letters completely formed or is a part of the letter missing? The writer may ignore writing complete letters due to hurry, enforcement, or a physical disease **(Figure 5)**.
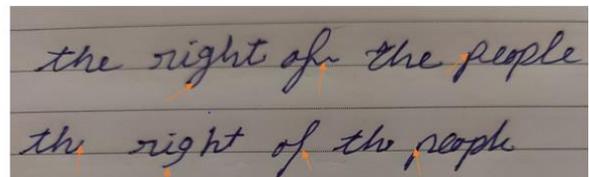

Figure 5: Completion of the letters.

2.3. Pen pressure

The handwritten text can be viewed as "symbols of repeated strokes" and, hence, fractals. Each individual possesses a unique fractal writing signature, that, in some sense, distinguishes is writings from everybody else **(Padua et al., 2013)**. Some writers get used to type with high pressure all

over the writing and others apply low pressure especially in upward and downward directions due to difficulties in the appropriate modulation of force **(Figure 6)**.
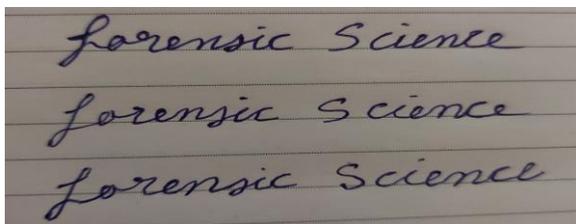

Figure 6: Pen pressure during writing.

2.4. Directions: Left, right, or variable?

Writers may lean toward right or left in writing letters with different angles. This is considered a fingerprint in forensic medicine **(Figure 7)**.
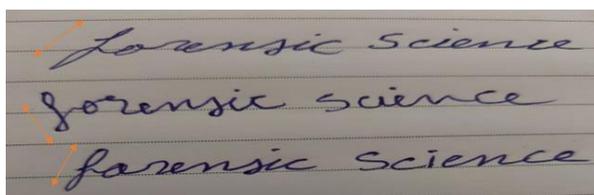

Figure 7: Directions of writing.

3. Writing Skill

Every writer has a writing skill that cannot be dramatically improved in a short time frame while maintaining all appearances of natural writing. For this reason, the third principle of handwriting analysis is skill level, or the writer's ability to physically reproduce the letter formations they visualize. Is the text on the line, above the line, or below it **(Morris, 2020).**

3.1. Line habits

Some people are committed to writing on printed lines as an ordinary way. Others writes above the line, while others write below it. This may be according to how they learned initially to write **(Figure 8)**.
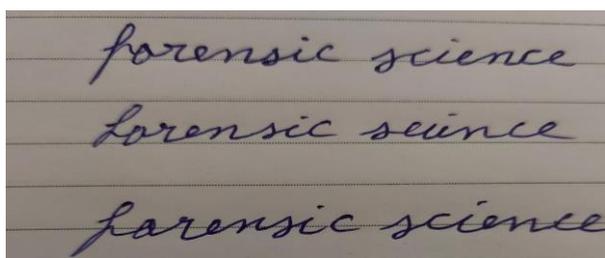

Figure 8: Line habits.

# Diabetic neuropathy patient's handwriting

Diabetic neuropathy patient's writing shows overall deterioration of rhythm. The writer begins his writing with low pressure, followed by high writing pressure, then the natural ends with low writing pressure without continuous movement, because the writer has not full control of the pen due to the change in the writing impulse of the affected hand. Slow speed of writing is also observed, indicated by the presence of hesitations or tremulous line at unexpected positions, as well as natural tremors and diffusion of air strokes in addition to ink deposits inside and on strokes edges.

Also the increase in the overall size of writing (large size) that appears consistent in the ratio of height to width because writing is a stressful act; and stress reaches its maximum in upward movements than in horizontal movements, and is least possible in descending movements

The affected writings show the presence of irregularities like an abrupt change in the curvature, indicative of the poor quality of handwriting as opposed to their corresponding old samples. Naturally there are sudden changes in writing stroke directions; writing stumble and ink deposition at the beginning of upward movements in writing configuration and lines become more crowded and angularities **(Figure 9)**.

A) Handwriting of diabetic neuropathy patient
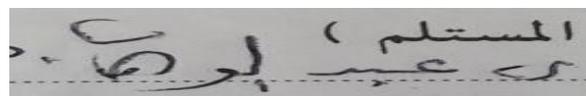
B) Normal handwriting of the same person before the disease

Figure 9: changes in handwriting in diabetic patients

Conclusion

DNP handwritings show high speed with an imbalance in the writing pressure; changed acceleration; inside and on strokes edges; air strokes; natural tremors. These should be regarded as handwriting features of DNP and are not regular written defects, especially if they are present in the same positions with comparative signatures. Hence, the questioned documents expert must examine these phenomena well to avoid interpreting them as written defects. The correct interpretation of such examined signatures is that these handwriting defects have become written features, not written defects.

References:

Amend, K. K. and Ruiz, M. S. (2000). Handwriting analysis: The complete basic book: Red Wheel/Weiser.

Bandyopadhyay, A., Mukherjee, B. and Hazra, A. (2016). Perception Based Decision Support System for Handwriting Behaviour Analysis. Procedia Computer Science, 84, 177-185.

Dang, S. and Kumar, M. (2014). Handwriting analysis of human behavior based on neural network. International Journal of Advanced Research in Computer Science and Software Engineering, 4, 227-232.

Harrison, D., Burkes, T. M. and Seiger, D. P. (2009). Handwriting examination: Meeting the challenges of science and the law. Forensic Science Communications, 11, 1-13.

Hu, J., Lim, S. G. and Brown, M. K. (2000). Writer independent on-line handwriting recognition using an HMM approach. Pattern Recognition, 33, 133-147.

Morris, R. N. (2020). Forensic handwriting identification: fundamental concepts and principles. Padua, R. N., Barrera, D. J. S. and Arabis, R. O. (2013). Fractal similarity index for forensic handwriting analysis. PRISM, 18, 1-10.

Rahman, A. U. and Halim, Z. (2022). Predicting the big five personality traits from hand-written text features through semi-supervised learning. Multimedia Tools and Applications, 81, 33671–33687.