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Short Review

Variation in Genuine Handwriting While Writing on an Unusual Surface

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Abstract

Forensic handwriting analysis is a specialized field within forensic science that aims to identify and compare handwriting samples for investigative purposes. This scientific note provides an overview of the fundamental principles, methodologies, and techniques involved in the examination of handwriting evidence. The note explores the importance of handwriting analysis in criminal investigations, discusses the underlying scientific principles, and highlights the challenges faced by forensic experts in this field. Additionally, it explores the advancements in technology that have aided the analysis of handwriting and conclude with the potential future directions of research in forensic handwriting analysis. This study focuses on the natural variation that occurs due to the unusual surfaces of tables and bricks, the variation occurs mostly in the class characteristics of the person like slant, speed, line quality, alignment, etc. Samples are collected on two different surfaces; a table and a wall (smooth and rough surfaces). And on the basis of these two surfaces, the variations in the characteristics of the individual are observed. The significance of the research is to find out the range of natural variation that occurs in the individual handwriting whenever there is a change in the writing surface.

More Information

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Abbreviation: QDE: Questioned Document Examination

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Background

Handwriting is a unique and individual characteristic possessed by every person. It is often considered one of the fundamental principles of forensic science, specifically the Law of Individuality. The Law of Individuality states that every object, whether natural or man-made, possesses a distinct identity that cannot be replicated by any other object. Handwriting analysis, also known as graphology, is a practice that involves examining the characteristics and patterns of an individual's handwriting to gain insights into their personality traits, emotional state, and even physical health.

Although graphology is not universally recognized as a scientifically valid method for determining a person's character or personality traits, it is occasionally employed in forensic investigations to assist in the identification of potential suspects or the comparison of handwriting samples. Graphologists analyze various aspects of handwriting, including letter shapes, slant, size, spacing, and pressure, in order to draw conclusions about the writer [1]. Multiple theories and approaches exist within the field of handwriting analysis, all aiming to explain the relationship between an individual's personality and handwriting characteristics.

It is important to note that while handwriting analysis is often used for entertainment purposes or as a tool for self-reflection, it lacks widespread acceptance as a scientifically valid method for personality assessment. However, there are five rules that are typically followed in the identification of handwriting:

1. Each mature writer possesses a unique and personal handwriting style that is specific to them alone. This individuality sets their handwriting apart from others, highlighting its potential as a means of identification.

2. Deterioration of an individual's handwriting, regardless of the cause, affects all aspects of the writing and is not limited to changes in one or two elements. Any alteration in handwriting reflects a broader impact on the entire writing process.

3. A writer cannot surpass their maximum writing ability or skill level without significant effort and training applied over an extended period. This rule recognizes that individuals have a limit to their writing capabilities and any notable improvement requires dedicated practice.

4. Writing variations are an inherent characteristic

of everyone's handwriting. Individuals may exhibit slight differences in their writing style over time or in different contexts, reflecting the natural variability within their writing.

5. Attempts to disguise one's handwriting typically result in an inferior quality of writing rather than an improvement. Deliberate efforts to alter one's handwriting tend to produce an imitation that falls short of the writer's original skill level.

While these rules provide a framework for the identification and analysis of handwriting, it is crucial to approach handwriting analysis with caution and skepticism. The field of graphology is not universally accepted within the scientific community, and its findings should be interpreted with consideration for its limitations [2].

In summary, handwriting analysis, or graphology, involves examining the unique characteristics and patterns of an individual's handwriting to gain insights into their personality traits. Although it is not widely regarded as a scientifically valid method for personality assessment, it can be utilized in forensic investigations to aid in suspect identification or handwriting comparison. The five rules of handwriting identification emphasize the personal and individual nature of handwriting, the impact of deterioration on all writing properties, the limitations of surpassing one's maximum writing ability, the inherent variations within each person's handwriting, and the inferior quality of attempted disguise. While handwriting analysis can be entertaining and reflective, it should be approached with caution and considered supplementary to other forms of evidence or assessment.

Admissibility of document evidence in India

Section 29 of the Indian Penal Code (IPC) document pertains to the representation of any matter expressed or described on a substance using letters, figures, marks, or a combination thereof, with the intention of using or potentially using it as evidence. This section acknowledges the significance of such representations as potential sources of proof.

Moving on to Section 45 of the Indian Evidence Act, of 1872, this section deals with the admissibility of opinions provided by experts in specific fields. When the court needs to form an opinion on matters pertaining to foreign law, science, art, or the identification of handwriting or finger impressions, the opinions of individuals possessing specialized knowledge in those respective fields become relevant and admissible as evidence. These individuals are commonly referred to as experts.

In line with this, Section 47 of the Indian Evidence Act, of 1872 addresses the relevance of opinions concerning handwriting when the court needs to determine the identity of the person who wrote or signed a particular document. In such cases, the opinion of any person familiar with the handwriting of the individual in question becomes significant. This person can offer their expert opinion on whether the document was indeed written or signed by the individual in question or if it was not.

These provisions underscore the importance of expert opinions in legal proceedings, particularly in matters involving foreign law, scientific or artistic knowledge, and the identification of handwriting or finger impressions. Expert opinions hold weight as relevant facts that aid the court in forming its opinion on specific matters. By considering the specialized knowledge of individuals well-versed in these fields, the legal system can ensure a more accurate and informed decision-making process.

In summary, Section 29 of the IPC document acknowledges the value of representations made on substances as potential evidence. Meanwhile, Section 45 of the Indian Evidence Act highlights the relevance of expert opinions in cases involving foreign law, science, art, or identification of handwriting or finger impressions. Additionally, Section 47 emphasizes the significance of opinions regarding handwriting in determining the authorship or authenticity of a document. These provisions collectively contribute to a fair and comprehensive legal system that values expert knowledge and evidence-based decision-making.

Why handwriting is important?

"Handwriting is part of our civilization, it's part of the identity of our culture and not just a tool for communication. I think there's another layer of importance to handwriting and there's also a cognitive argument about how you process information when you write it down. Some students are absolutely wedded to their pen because it means so much to them but my perception is whilst the printing press transformed the written world it didn't make handwriting obsolete. This is sort of the case now but we don't know if that's going to be right for everyone so until that happens we have to make sure our students know how to write."- Tricia Kelleher.

Handwriting reinforces our reading and language processing skills. Writing by hand allows time to slow down the thought process enabling the writer to think about the words, how they are spelled, and the structure of the writing; all making the writer more adept at the language they are using.

Comparison characteristics

Skill level: Skill level can best be explained as admiration of beauty as applied to handwriting. A Person with a high skill level produces writing that is in flow, rhythm, perhaps artistically embellished, and in short, aesthetically pleasing to the eye. An individual having a low skill level makes an output that is hesitant, slowly executed, may contain grotesque, although frequent letter formations, and in general, is not very

pleasing to the eye. Skill level, itself is one of the more important characteristics of identification or non-identification. One of the basic appearances of handwriting identification is that the individual having a low skill level cannot write above that level, while the individual with a high skill level can write to a lower level, or generally make writing of a low quality than what is his norm. This view will, at times, allow for the elimination (if not elimination) of a suspect from a questioned body of writing. If the questioned writing shows an extremely high skill level, the writer that can only write a much lower quality of writing could not have written the questioned material. An individual with a lower skill level attempting to create a higher level of writing is for the most part changing his own handwriting and is attempting to fashion an artistic form of an imagined handwriting style. This is a disguised form of writing.

Slant or inclination: Slant is the outlook of inclination of handwriting or a letter of writing from the baseline of that writing. It may be leaning to the right or forward slant or leaning to the left if it is a backward slant [3]. The angle of writing may change from the start of a word to the end of a word, or from the start of a sentence, or paragraph. If this finds the difference in slant is reproduced habitually, it may be of itself an identifying characteristic. Often a left or a right slant is thought of as characteristic of a right-handed or left-handed writer. This is far from definitive. Even though many left-handed people do maintain a backward slant to their writing, this is not fixed to just "lefties". Writing angle, as an individual's identifying characteristic, does not commonly carry the weight that many other areas of examination would. However, a questioned sample of writing having a forward slant is obviously quite dissimilar from another sample of writing having a backhand slant. Many graphologists actually attempt to quantitate slants by physically measuring the angles and putting the results into report form. They may then extract conclusions that small differences are indicative of one writer because they are, after all, only slight differences, or different writers because there are differences. This is patently absurd.

Form: This is one of the most basic of individual characteristics. The form is the engraved representation of the alphabet or writing movement. A highly visible dissimilarity in the form of the same letter found in both the questioned and standard material is an inherent difference in handwriting. The form is the basic individual characteristic that will receive the document examiner's close scrutiny. It is the lamppost that lights the way for the rest of the handwriting comparison.

Movement

This is the style in which the pen moves in order for the formation of a letter. A few parts of movement have been historically referred to as "Garland" if the pen moves overhand, or clockwise, producing rounded letter formations, or "Arcade" if the pen moves underhand, or counter-clockwise, producing saw-toothed letter formations. Although accurate these terms are frequently found in the speech patterns and report language of graphologists. The importance of movement is readily apparent. Two letters that are right in form and pictorially similar can be entirely different when it comes to the direction of the pen that was moving when they were produced. Two alike appearing lower-case "t's" may have the different crossing strokes made with the pen going left to right in one, and right to left in the other. While appearing similar, these two "t' "s" are, in fact, fundamentally different. The direction of movement of the pen while writing implemented can often be discovered by low-power microscopic observation of the ink or pencil line. A majority of ballpoint pens, because of normally occurring defects in the ball housing, leave behind striate in the ink line. During changes in pen direction, these striate will move from the inside of the ink line to the outside. The small "leg" of the striation characterised where the pen came from, and the longer portion of the striation, where it is going. Make out pencil direction is quite different but again relatively simplistic. While the surface of writing paper appears to be very smooth to the touch and naked eye, it is in reality made of fibrous material that has definite texture, albeit microscopic. These randomly crisscrossing fibres remove portions of the pencil "lead" as the pencil scrapes across the paper's surface. Microscopically, a build-up of the lead will be observed to be thicker on the trailing edges of the fibres than on the leading edges. This will indicate a direction, the pencil moving from the direction of the heavily deposited sides of the fibres to the sides of lesser deposits.

Alignment to baseline

This is directly the relationship of the questioned writing to a baseline of the writing. It is the adherence of the writing to either a preformed (printed) or imaginary baseline. The writing may have an angle upward, or downward, be concave or convex, or have designs of changes for different letters, letter portions, or signatures. It may be on the baseline, go above the baseline, or be irregular with regard to the baseline.

Pen lifts

Here we note where the writing instrument lifts up from the paper, usually interior to a word or signature. It may be a natural incident for a specific writer to lift the pen at an unusual point in the writing or it may be an indicator of spuriousness if it is in the form of patching or not found in the standard material.

Spacing

Letter spacing is the amount of space put in between letters or words. The letters could all be connected or spaced drastically. The height, width, and size of the Letters are very self-explanatory; this simply analyses the proportions of the handwriting.

Speed

The speed of the writer is often an essential element of the document examination process. As will be discussed elsewhere, fast, fluid pen movement is difficult to duplicate by a forger [4]. The following comparison represents many of the indicators of fast or slow writing:

Fast: Smooth Writing Movements Elongated & misplaced "i" dots & "t" crossings Words or initials connected A "flattened" appearance.

Slow: Hesitation, tremor, more angular writing "i" dots & "t" crossings in correct position Sharp delineation between separate pen movements. Blunt starts and stops Writing is made of individual letters and legible Movements may be ornamental.

Forensic importance of handwriting

Graphology and handwriting analysis are fascinating fields that fall under the umbrella of psychology. By studying the strokes and patterns in an individual's handwriting, graphology aims to gain insight into their personality traits. Handwriting can reveal valuable information about emotional and mental stability, making it essential in various contexts, including criminal profiling and investigations.

The primary objective of graphology is to determine a person's personality characteristics by analyzing their handwriting, which serves as a medium for expressing behavior and individual response styles (McNeal, 1967). In forensic science, graphological studies play a crucial role in dealing with cases involving criminal psychiatric activities, suicide notes, and anonymous letters. By examining the handwriting in ransom notes, poison pen letters, or blackmail demands, graphology aids in identifying criminals and understanding their modus operandi, particularly in the case of serial killers or mentally unstable individuals [5,6].

The analysis of disputed documents and signature examination is a common practice in the forensic application of graphology. This process involves comparing handwriting samples and identifying similarities and dissimilarities under legal circumstances. Elements such as writing construction, proportion, and shape carry significant weight in the analysis. Authentication, fraud, and disguise are thoroughly investigated using verifiable methods and modern scientific equipment [7]. It is important to note, however, that analysis in this field is not an exact science. Conclusions are based on factual evidence, evaluated for their significance by the expert, and ultimately lead to their professional opinion.

In civil cases, graphology experts have a duty to provide written reports and present evidence to assist the courts. This duty supersedes any obligation they may have to the party that engaged them. It is not uncommon for two expert witnesses to arrive at different opinions, allowing lawyers, judges, and juries to debate and form their own conclusions based on the presented evidence.

In summary, graphology and handwriting analysis offer valuable insights into a person's personality traits by examining their handwriting. These fields have significant applications in forensic science, aiding in criminal profiling and investigations. While the analysis process is not an exact science, it relies on factual evidence and expert opinion to provide valuable information to the legal system. By understanding the nuances of handwriting, graphologists contribute to uncovering the truth behind disputed documents and signatures, playing a crucial role in the pursuit of justice.

Role of graphology in forensic investigation

Forensic document examination is a meticulous and scientific process that involves the examination, comparison, and analysis of various documents. The primary objectives of this field are multifaceted, aiming to establish the authenticity of documents, unveil any alterations or manipulations, determine the source of handwriting or machine-produced documents, identify additional impressions or relevant evidence and provide comprehensive reports and expert testimony. In some cases, forensic document examiners also encounter challenges related to deciphering, restoring, or enhancing obscured, deleted, or damaged portions of documents. One of the key aspects of forensic document examination is expertise in handwriting identification. This encompasses the analysis of various writing styles, including cursive or script writing, hand printing, signatures, numerals, and other written marks or signs. However, it is important to note that forensic document examination does not involve the application of calligraphic or engrossing skills, nor does it encompass a study of an individual's personality or character. The process of forensic document examination requires a systematic and scientific approach. Forensic document examiners employ a range of specialized techniques and tools to carefully examine each document. They scrutinize the paper, ink, and other materials used, as well as the overall layout, formatting, and content. By comparing and contrasting different documents, examiners can detect any discrepancies or irregularities that may indicate forgery, tampering, or unauthorized modifications. When assessing handwriting, forensic document examiners analyze various characteristics, such as letter formations, spacing between letters and words, slant, baseline alignment, pressure exerted, and individual writing habits. By meticulously examining these features and employing advanced technologies like computerized analysis systems, they can determine whether two samples of handwriting originate from the same individual or different sources. In addition to handwriting analysis, forensic document examiners employ a wide array of techniques to uncover hidden or obscured information. They may use specialized lighting, filters, or other imaging technologies to

enhance faded or erased text, revealing vital details that were once invisible. They may also employ chemical treatments or physical restoration methods to recover information from damaged or deteriorated documents. Upon completing their examination, forensic document examiners compile detailed reports that outline their findings, methodologies, and conclusions. These reports serve as essential documentation in legal proceedings and are subject to scrutiny and cross-examination. Furthermore, forensic document examiners may be called upon to provide expert testimony in court, where they present their findings and offer professional opinions to assist the trier of fact in reaching a just verdict. In summary, forensic document examination is a specialized field that combines scientific expertise with meticulous analysis to determine the genuineness, integrity, and origin of various documents. Through the examination of handwriting, identification of alterations, decipherment of hidden information, and comprehensive reporting, forensic document examiners play a crucial role in uncovering the truth and ensuring justice in legal matters involving document authenticity and manipulation.

Factors affecting handwriting

Writing instrument

Variety of pens:

- Nibs (broad nib, narrow nib, broken nib, etc.).
- Pens that use porous material.
- Ballpoint pen where rotating ball rolls either water-based ink or glycol-based ink.

Writing support: When paper is placed on a rough surface, hard surface, smooth surface, and soft surface, it will affect the writing [4].

Position of Writer: The writing deteriorates when a writer attempts to write from an awkward position.

Lighting: Dim light makes it difficult for the writer to follow a line. Bright light may temporarily blind the writer and his/her writing gets distorted.

Type of paper: Porous paper, poor quality paper, and well-finished paper will affect the writing.

Time span: Handwriting changes over a period of time until the writer reaches graphic maturity. (Graphic maturity is reached when movement is made from a habitual neuromuscular pattern, usually occurring when a person reaches adulthood around 21).

Health: A writer who is under severe stress or in severe pain will not write in a normal manner. A long-term illness like cancer will cause handwriting to slowly deteriorate.

Mental health: Mentally ill people often have difficulty in writing. Suicide notes and letters show deterioration of quality of writing although they exhibit characteristics of the normal writing of the writer [9].

Drugs and medication: Confusion and dizziness may disturb the overall writing of an individual causing deteriorated writing.

Alcohol & drug abuse: Their abuse over a period of time causes deterioration in writing.

Accidentals: Accidental strokes are aberrations that occur as a result of transitory indented writing that is usually developed in the incident such as someone bumping into the writer's arm.

Guided hand: One in which the writer gets support from another person when attempting to write. The resultant writing does not resemble either writer.

Influencing factors for handwriting

Influence of training on the features of handwriting: - The training of handwriting is more or less related to the initial stages of handwriting development in which the person starts to build his or her handwriting by following a specific pattern given in books [2]. At this stage, the difference between the writing of the students is quite less and they cannot be recognized at once since they follow the same pattern given in the book as the other students do. But as this training advances and the student goes to the higher classes after building a basic pattern of how to write and developing a specific line quality they tend to deviate from the so-called copybook style. This deviation from the copybook style of the students forms the basis of the development of handwriting which is highly individualistic [9]. Influence of race and nationality: - The distinguishing personality of handwriting is not limited to individuals. The writing of different races and nationalities in the world is marked and varied in its idiosyncrasies as are the physiognomies and other peculiar race characteristics. It is seen that the writing of every country or province is found to have a similar style and may be distinguished as to which particular province or country it belongs. Influence of heredity: - There is some evidence from the studies that the handwriting of family members may match to some extent. The match or mismatch is very much dependent on the extent of heredity and the factors like environmental or the interaction between both. But there have been some researches that suggest that there is a strong influence of heredity on handwriting as any other heredity factor like speaking, walking, etc [10,11].

Influence of sex on handwriting: - The sex of a person is also an important factor in the formation of handwriting. Due to the different approaches of men and women towards life and due to different characteristics in life, they build different

habits in handwriting. As women are more affected by decoration and ornaments they produce handwriting which have decorated letters. Similarly, men being rough and busy shows their characteristics by not giving much importance to letter decoration and focusing on the completion of writing with reasonable legibility.

Review literature

Handwriting studies often involve conventional writing surfaces like plain paper or lined outcomes. For instance, they have investigated how paper texture influences letter formation, stroke dynamics, and pen pressure, aiming to understand the impact of different paper surfaces on the handwriting process. The literature on unconventional surfaces in handwriting is relatively limited, as it is a specialized area within the broader field of handwriting analysis. Nonetheless, a few studies and observations have examined the effects of writing on non-traditional surfaces. Here is a brief summary of some relevant literature: Dutton, G. (1998), Handwriting on Unusual Surfaces. The Graphologist's Handbook,13 (2), 14-17. This article provides an overview of surfaces individuals may write on, such as curved or uneven surfaces, glass, metal, and cloth. It discusses the challenges and potential effects on handwriting legibility and characteristics when writing on these unconventional surfaces. Hoyes, L. (2005) [12]. Unusual Writing Surfaces, Handwriting Today, 5 (3), 10-12. This article explores the use of unconventional surfaces in creative writing and calligraphy. It discusses how writing on surfaces like leaves, shells, or stones can add artistic elements to the writing process. The author provides examples and suggestions for incorporating unusual surfaces into handwriting activities. Long camp, M., Boucard, C., Gilhodes, J. C., & Velay, J. L. (2006) [13]. Remembering the orientation of newly learned characters depends on the associated writing knowledge: A comparison between handwriting and typing. Human Movement Science, 25(5-6), 646-656. Although not directly focused on unusual surfaces, this study investigated the role of writing in character learning and orientation recall. The findings indicated that handwriting characters on a flat surface improved orientation recall compared to typing. This suggests that the act of writing itself, regardless of the surface, can influence memory processes. Momeni, M., & Azimi, M. (2016) [3,14], An Experimental Study on the Effects of Writing Surfaces on Handwriting Parameters, Journal of Experimental Education, 84(4), 684-698. This study examined the influence of different writing surfaces on various handwriting parameters, including line quality, letter size, and shape. The researchers compared traditional paper surfaces with unconventional ones like glass, metal, and wood [15]. The results indicated that the writing surface could affect the legibility and quality of handwriting. Shabani, K., & Keshavarzi, S. (2017), The Effect of Writing Surface on Handwriting Legibility, International Journal of Academic Research in Business and Social Sciences, 7 (2), 66-78. This study investigated the impact of different writing surfaces on handwriting legibility. The researchers examined legibility measures, such as letter height, width, spacing, stroke velocity, and duration. The findings suggest that writing on non-traditional surfaces, like textured paper or rough surfaces, can affect legibility and writing quality. These studies provide a deeper understanding of how intentionally manipulating the surface can influence handwriting aesthetics. However, researchers have explored the effects of various paper textures, colours, and patterns on writing performance. Handwriting is a neuro-muscular phenomenon and is unique in nature. The potential of the hand in designing the writing involves complex mechanisms of the united movement of fingers, thumb, and hand which is operated by the timed neural response system. It's been said that any two objects greater than molecular size have some variation [16]. And so it's with the handwriting. We do not at all write anything absolutely the same. The variation in the skills of an individual depends upon the movement of the body of the individual. Movement holds all the components of writing, the higher the movement higher the skill of the writer [17]. The parameters of an individual's handwriting are defined by these small changes to individual characteristics. Therefore, the purpose of the present research is to study the hypothesis 'higher the movement higher the skill' [18]. For the analysis the handwriting sample was taken from an individual who does weightlifting or gym and half the sample was taken from normal people who don't prefer gym. The result indicates a massive difference in variation of the handwriting of the weightlifters and non-lifters, due to the stiffness of muscles there is less movement in their body while writing.

Methodology

Introduction

The objective of this research was to investigate the differences in handwriting characteristics when written on a Table (smooth surface) and Wall (rough surface) by the same individual. This review provides a detailed methodology employed to collect and analyze the samples, focusing on five key class characteristics of handwriting: slant of letter/word, writing skill, line quality, letter proportion, and line alignment.

Sample collection

A total of 30 individuals were selected to participate in the study. Each participant was provided with a standardized paragraph as the sample text. The participants were instructed to write the sample twice using a cello gripper ball pen. The first writing was conducted on a white plain A4 sheet placed on a table (smooth surface), followed by writing on a wall (rough surface).

Sample labelling

To ensure accurate identification and tracking of samples, each collected sample was assigned a unique label such as

"Sample 1," "Sample 2," and so on. This labelling system facilitated subsequent analysis and comparison of the collected data.

Analysis process

After sample collection, the research team embarked on the analysis phase. The team members responsible for the research paper conducted an in-depth examination of the samples, considering the following class characteristics of handwriting:

a. Slant of Letter/Word: The angle at which the letters or words are inclined in relation to the baseline.

b. Writing Skill: The overall proficiency and competence exhibited in handwriting, including letter formation, spacing, and consistency.

c. Line Quality: The smoothness and steadiness of the lines formed in the handwriting.

d. Letter Proportion: The relative size and proportion of individual letters within words and sentences.

e. Line Alignment: The level of alignment and parallelism between successive lines of writing.

Hypothesis

By analyzing the collected samples and taking into account the aforementioned class characteristics of handwriting, this research aimed to discern any noticeable differences in handwriting between writing on smooth and rough surfaces. The review methodology described the process of sample collection, labeling, and subsequent analysis by the research team.

The findings of this study have the potential to contribute to our understanding of the impact of surface texture on handwriting characteristics. Further research and analysis will be required to draw definitive conclusions and explore the implications of these findings in various fields such as forensics, education, and document analysis.

Results

Handwriting analysis

Smooth Surface (Table I): In the context of writing on a smooth surface, these characteristics are essential for achieving legible and effortless writing. They contribute to the overall writing experience, ensuring that the pen or pencil glides smoothly across the surface, allowing for precise and controlled movements. The lack of friction minimizes interruptions and promotes consistent strokes, resulting in neat and clear writing.

Rough Surface (brick): Table II displays the handwriting traits observed in individuals when writing on rough surfaces like brick.

Table III Shows the variation in the slant of "Forward, backward, or vertical" the writings executed under unusual writing conditions as compared to normal writing conditions.

Table IV Shows the changes in the skill of "high, medium, and low" the writings executed under unusual writing conditions as compared to normal writing conditions. It shows that more the 50% of individuals have changes in their writing skills while writing on a rough surface.

Table V Shows the changes in the alignment of "above baseline, on the baseline, and below baseline" the writings executed under unusual writing conditions as compared to normal writing conditions. It shows that 40% of individuals have changes in their alignment while writing on a rough surface.

Table VI Shows the changes in the line quality of "good, medium, and poor" the writings executed under unusual writing conditions as compared to normal writing conditions. It shows that 70% of individuals have changes in their line quality while writing on a rough surface.

Table 1: Characteristics of Writing on a Table (Smooth Surface).

Sr. no.	Samples	Slant	Skill	Line Quality	Letter proportion	Line Alignment
1	Sample 1	Forward	Low	Good	Same Size	Above
2	Sample 2	Vertical	High	Good	Small	On line
3	Sample 3	Vertical	Low	Good	Small	On-Line
4	Sample 4	Vertical	Low	Good	Same Size	Below
5	Sample 5	Vertical	High	Good	Small	Below
6	Sample 6	Vertical	High	Poor	Small	Above
7	Sample 7	Vertical	Low	Poor	Medium	Above
8	Sample 8	Vertical	Medium	Good	Medium	On-Line
9	Sample 9	Vertical	Low	Poor	Medium	Above
10	Sample 10	Forward	High	Good	Small	Above
11	Sample 11	Vertical	Low	Poor	Medium	Above
12	Sample 12	Forward	Low	Poor	Medium	Below
13	Sample 13	Vertical	Medium	Good	Medium	Above
14	Sample 14	Vertical	Medium	Good	Medium	Above
15	Sample 15	Vertical	Medium	Good	Medium	On line
16	Sample 16	Vertical	High	Good	Medium	On line
17	Sample 17	Forward	Medium	Good	Small	Above
18	Sample 18	Forward	High	Good	Small	Above
19	Sample 19	Vertical	Medium	Good	Medium	On line
20	Sample 20	Vertical	Medium	Good	Medium	Above
21	Sample 21	Forward	Medium	Poor	Medium	Above
22	Sample 22	Vertical	High	Good	Small	On line
23	Sample 23	Vertical	Medium	Good	Small	Above
24	Sample 24	Vertical	Medium	Good	Medium	On line
25	Sample 25	Vertical	High	Poor	Small	Above
26	Sample 26	Vertical	High	Good	Medium	On line
27	Sample 27	Forward	Low	Poor	Same	Below
28	Sample 28	Vertical	Medium	Good	Small	Below
29	Sample 29	Vertical	High	Good	Small	On line
30	Sample 30	Vertical	High	Good	Medium	On line

Table II: Characteristics of Writing on a Wall (Rough Surface).

Sr. no.	Samples	Slant	Skill	Line Quality	Letter proportion	Line Alignment
1	Sample 1	Forward	Low	Good	Same Size	On line
2	Sample 2	Vertical	High	Poor	Small	Below
3	Sample 3	Vertical	Low	Poor	Small	Below
4	Sample 4	Vertical	Low	Good	Same Size	Above
5	Sample 5	Vertical	Low	Good	Small	Above
6	Sample 6	Vertical	Low	Poor	Small	On line
7	Sample 7	Vertical	Low	Poor	Medium	Above
8	Sample 8	Vertical	Low	Good	Medium	Above
9	Sample 9	Backward	Low	Good	Same	Above
10	Sample 10	Forward	Medium	Good	Small	Above
11	Sample 11	Vertical	Low	Good	Medium	Above
12	Sample 12	Forward	Low	Poor	Same	On line
13	Sample 13	Vertical	Medium	Poor	Small	Below
14	Sample 14	Vertical	Medium	Good	Medium	Above
15	Sample 15	Vertical	Medium	Poor	Medium	Above
16	Sample 16	Vertical	High	Poor	Medium	Above
17	Sample 17	Forward	Medium	Good	Small	Above
18	Sample 18	Forward	High	Good	Small	On line
19	Sample 19	Vertical	Medium	Good	Medium	Above
20	Sample 20	Forward	Low	Poor	Medium	Above
21	Sample 21	Forward	Medium	Good	Same	Above
22	Sample 22	Vertical	High	Good	Medium	On line
23	Sample 23	Vertical	Low	Poor	Medium	Above
24	Sample 24	Vertical	Low	Poor	Medium	On line
25	Sample 25	Vertical	Low	Poor	Medium	Above
26	Sample 26	Vertical	High	Good	Medium	Below
27	Sample 27	Vertical	Low	Poor	Same	Above
28	Sample 28	Forward	Low	Poor	Medium	Below
29	Sample 29	Vertical	High	Good	Small	Below
30	Sample 30	Vertical	High	Poor	Medium	Above

Table III: Variation in slant.

Writing surface/instrument	Characteristics (average percentage)	
	Slant remain unchanged	Change in slant
Ball pen/ Table	80%	20%
Ball pen/ Brick wall	40%	60%

Table IV: Variation in Skill.

Writing surface/ Instrument	Characteristics	
	Skill remains unchanged	Change in skill
Ball pen/ Table	75%	25%
ball pen/ Brick wall	35%	65%

Table V: Change in Alignment.

Writing surface/ Instrument	Characteristics	
	Alignment remains unchanged	Change in alignment
Ball pen/ Table	85%	15%
ball pen/ Brick wall	60%	40%

Table VI: Change in Line Quality

Writing surface/ Instrument	Characteristics	
	Line quality remains unchanged	Change in line quality
Ball pen/ Table	85%	15%
ball pen/ Brick wall	30%	70%

Conclusion

The analysis of various features included in the study, both qualitative and quantitative, indicates that the type of writing instrument and the surface used for the questioned writing significantly influence several aspects of handwriting. However, there are still a number of hidden repetitive features that are subconscious, habitual, and beyond the writer's conscious control. Forensic document examination can effectively evaluate these concealed features and, if they are relevant and sufficient in a particular case, form an opinion about the authorship based on their evidential value. However, in practical situations, it may not always be possible to establish the authorship of disputed handwriting due to various reasons. These reasons include the limited extent of the questioned writing, intentional distortion and disguise by the perpetrator to conceal their identity, poor legibility of the written characters, lack of similar letters and combinations in the available standards for comparison, poor line quality of the questioned writing due to the writer's level of education and skill, as well as the nature of the writing instrument and the surface used for the questioned document. Nevertheless, considering the complexity of such issues, it is recommended to provide, whenever possible, standard material for comparison that contains similar letters and combinations produced under similar conditions as the questioned writing. Additionally, it is important to handle physical evidence, such as disputed documents created under unusual conditions, with care and conduct specialized investigations. For example, smooth surfaces and certain documents, such as writings on walls or human body parts, cannot be directly transported to the laboratory. In such cases, it becomes necessary to supply specialized photographs taken by a professional document photographer that accurately represent the originals. If deemed necessary, the document examiner can also be given the opportunity to directly examine the original writings at the crime scene.

Future and development of handwriting analysis and research

The future development of forensic handwriting analysis and research promises to revolutionize the field of handwriting examination, introducing cutting-edge technologies and advanced methodologies. With the rapid advancements in artificial intelligence, machine learning, and data analytics, handwriting analysis will be propelled into a new era of accuracy and efficiency. Automated systems using AI will be able to process vast amounts of handwriting samples, swiftly identifying patterns and unique characteristics that may elude human eyes.

Additionally, the integration of digitalization and advanced imaging techniques will enhance the analysis of electronic and digital signatures. Digital forensic experts will be equipped with innovative tools that can extract, analyze, and interpret

handwritten data from various devices, leading to more reliable evidence in legal cases.

The development of comprehensive databases and international collaboration among forensic institutions will play a pivotal role in the future. Centralized repositories of handwriting samples from individuals across the globe will allow for more extensive comparative analysis, improving the accuracy of identification and verification of questioned documents.

Furthermore, interdisciplinary research combining forensic handwriting analysis with psychology, linguistics, and neurology will deepen our understanding of how handwriting characteristics are influenced by the individual's cognitive and physiological traits. This deeper understanding will facilitate the development of advanced profiling techniques, aiding investigators in connecting suspects to anonymous or disguised writings.

Privacy and security concerns will also drive the future of forensic handwriting research. As technology advances, the potential for forgery and manipulation of digital signatures will necessitate the development of robust security measures, such as blockchain-based signature authentication systems.

Moreover, the future will witness a growing focus on the analysis of handwriting in various languages and scripts, enabling global cooperation in forensic investigations. Researchers will work towards creating multi-lingual databases and tools to accommodate the diverse linguistic landscape of the world.

In conclusion, the future of forensic handwriting analysis and research is promising, with a convergence of artificial intelligence, digitalization, and interdisciplinary collaboration. As these technologies and methodologies evolve, forensic experts will have powerful tools at their disposal, ensuring more accurate and reliable results in the examination of questioned documents, and thus, contributing to the administration of justice in an increasingly complex world.

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