

Exploring Handwriting Variability When Using The Non-Dominant Hand

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ABSTRACT

Questioned document examination is one of the critical fields of forensic sciences. Comparison between the questioned and known documents is primarily practiced in this field of forensic sciences. One of the most standard ways of disguise writings is to perform the writings with unaccustomed hands or parts of the body. Practice of the unaccustomed hand can be done to an extent that unnatural features can be eliminated from the writings, and the writings attain features of both similarities and differences to the writings performed in the usual hand. Knowing which features are similar and which are different significantly improves the detection of disguised writing by the forensic experts. For this study, a sample size of 140 was taken; half of them wrote using their left hand, and the other half used their right hand for writing. Using different writing instruments, subjects wrote text on the same writing surface. Class and individual characteristics pertaining to slant, size and proportion of letters, space alignment, and line quality were done. This study is supposed to help in determining specific features of handwriting that can be used by forensic experts to detect attempts to disguise handwriting.

Keywords: Handwriting, Disguised handwriting, unaccustomed handwriting, slants.

Introduction

Handwriting is the result of neuro-muscular coordination, the brain visualizing what letters look like, the hand musculature representing the visualized letters in written symbols with the use of a writing instrument. In the field of questioned documents, handwriting identification is most significant. The act of writing is initially voluntary, but through practice, it becomes automatic and subconscious. The result is a product that is an amalgamation of the individual's education and training, practice in writing, environment, occupation, and mental, physical, and emotional conditions all affected by change throughout life. Handwriting is a system of communication, composed of small units and rules for combining the units into meaningful communications (1). The level of development is one of the evaluative features in graphology, though it cannot be statistically quantified, only qualitatively estimated (2). Handwriting can either be printing or cursive, both different from calligraphic or type handwritten. No two people have the same handwriting and is one of the ways to authenticate the authorship of a document (3). Not even identical twins have the same handwriting because of differences in life experience and first language learnt (4). Handwriting, or graphology, is a reliable predictor of personality and behavior (5).

Handwriting can exhibit various characteristics such as clumsiness, artistry, forcefulness, hesitation, laboriousness, or nervousness. Clumsy handwriting often suggests limited writing experience and is common among the illiterate or semi-literate. Artistic handwriting reflects a creative mindset. Forceful writing is typically found in individuals who write with vigor and freedom. Hesitant and laborious handwriting is often associated with individuals who are ill or feeble and is frequently observed in simulated or traced forgeries. Nervousness in a writer can be identified by irregularities in their handwriting.

Characteristics of handwriting

Individual characteristics in handwriting are subconscious and very personal, therefore unlikely to appear in other examples. These features distinguish one individual from another in any group and may often pinpoint a specific writer (6). At the same time, it is not merely these characteristics but rather the combination of individual features and their frequency of usage that is what makes handwriting unique. Contrary to this, class characteristics are general features that put a person into a group of scribes and offer a group identity to the written communication (7). These features appear from influences such as the writing system learned and have little value in pinpointing a particular writer, though they can be used to eliminate others. Examples of handwriting features include line quality, alignment, size, spacing, connecting strokes, pen lifts, pen pressure, and slant (8).

Disguised writing

Disguised handwriting is a deliberate attempt by a writer to alter or conceal normal writing habits in an attempt to avoid being identified. The motive for disguising handwriting is usually an attempt to avoid detection. Even so, a large amount of writing, such as a full page, disguises an individual's natural habits; however, the natural tendencies of the person creep in partially. Disguised handwriting can be differentiated from normal handwriting by characteristic features that manifest as a struggle between the natural tendencies of the writer and the deliberate attempt to suppress them. This kind of handwriting occurs in two basic scenarios: anonymous or threatening letters and forgery cases (9).

Characteristics of disguised writing

- 1) Change in slant
- 2) Alteration in size of letter
- 3) Change in pen pressure
- 4) Use of block letters
- 5) Artificial tremors
- 6) Change in speed
- 7) Writing with unaccustomed hand
- 8) Use alternate form

Examination of disguised writing

- Punctuation marks or sign
- Extra or added stroke of any kind
- Internal consistency
- Style of writing numerals
- Specific habit of writing

Unaccustomed handwriting

Unaccustomed handwriting, sometimes called left-hand or wrong-hand writing, it is the common disguise mode using the opposite hand from the one habitually used. The term "unaccustomed hand" means the hand with which the writer has the least skill and normally uses little or not at all for normal writing except in emergencies or for disguise purposes (10). Thus, this mode tends to result in bad quality writing. However, the writers feel confident in using this mode for disguise because the visual appearance of unaccustomed handwriting is significantly different from that of the accustomed hand. Generally, unaccustomed handwriting is said to be characterized by abnormal traits, such as uncoordinated strokes and a lack of rhythm in the writing line (11). Basically, handwriting is an individualistic graphic record of movement, which has an extremely complex interplay of pen pressure, grip pressure, and coordinated muscle movement. Hence, the writer has to suppress his normal muscular functions to adapt to the new, unfamiliar task of writing in a different way (12).

Objectives

- The aim of the project is to compare handwriting executed with the subject's right and left hand, in order to determine similarities and differences in features. Such knowledge may be helpful in casework, when suspicions are raised that a given piece of handwriting may have been disguised by execution with the unaccustomed hand.
- Study and describe the process of development of features of handwriting by a fluent writer who begins to write with the so far unaccustomed hand.

Review of Literature

Mikels observed that a "peculiar smudge pattern" often occurs in left-hand writing, particularly with ink or ballpoint pens. This is because the left hand must pass over newly written words, causing the smudging and ink deposits on the writing hand to be transferred to the paper (13). Conway noted that right-handed individuals using their left hand to disguise their writing tend to produce "awkward counter-clockwise ovals

and circles" and "clumsy left-hand uncertainty" in looped formations and curves, which might also include "trembling or jagged strokes" as observed by Hayes Dines emphasized that unaccustomed hand writing is characterized by poor line quality and an erratic appearance, with extreme distortions such as indistinguishable letter forms, tremor, varying slant, and irregular baselines (14,15).

Dawson found that right-handed writers who used their left hand presented primary differences in execution skill, while spacing between letters, words, and lines remained proportionate (16). Stangohr found no significant difference in skill between left- and right-handed writers, contrary to some opinions that left-handed writers are less skilled (17). Jasuja noted that writing with the unaccustomed hand introduces characteristics that differentiate it from other writings (18). Muhammad explained that handwriting is a personal style that is learned and cultivated through habit (19). Alford noted that people do not write with their unaccustomed hand frequently because it does not write artistically acceptable writing (20). Dziedzic added that exercise of the unaccustomed hand can make disguise more effective by reducing unnatural characteristics (21).

Dreifuss reported a 7:1 ratio of right- to left-handed individuals and noted that hand preference for manual tasks may differ from writing preference (22). Stevens considered whether questioned writing was produced by a naturally or circumstantially left-handed writer attempting to conceal identity (23). Singh and Gupta observed that unaccustomed hand writing is characterized by uncoordinated strokes and a lack of rhythm, often with heavy pen pressure (24). Alford mentioned that using the unaccustomed hand can explain significant differences in handwriting features. Schott and Schott found that mirror writing is easier for left-handers and is more prevalent among those whose languages are written leftward (25). Differences in right- and left-hand samples were due to the same designs stored in memory but executed with less dexterity by the left hand. Studies by Wójcik and Czeżot, and Widła, examined these similarities and differences in more detail (26). Harrison noted that about 5% of disguised writings are done with the "unaccustomed hand". Persistent differences between right- and left-hand writings were attributed to a lack of manual dexterity and differing neuro physiological processes. Forensic handwriting examination must address subdominant hand writing, commonly seen in cases where the writer seeks to conceal their identity, such as in anonymous letters or hold-up notes. Mirror writing, typically done with the left hand, is facilitated by left-handers and those whose languages are written leftward (27). Sahu and Kujur found differences in stroke direction and letter slope between left- and right-hand writers (28). Schott described mirror writing as script that runs in the opposite direction to normal, affecting letters, words, or sentences, and usually written right-to-left with the left hand in Latin languages (29).

Material and Methodology

In the present study, total 140 handwriting samples were collected in which 70 were left- handed and 70 were right-handed from school and university students and between the age group of 18 to 25 years. None of the subjects were suffering from any type of disease affecting the brain or neuro-muscular co-ordination. These handwriting samples were executed with both hands – the accustomed as well as the unaccustomed hand – on white paper. The hand with which the given subject was accustomed to write in their normal routine was termed the accustomed hand, and, conversely, where the subject wrote with the hand other than the accustomed hand, the writing was describes as having been executed with the unaccustomed hand. Throughout the text of this dissertation work, these terms should be understood in this way. Furthermore, none of the subjects was trained to write with the unaccustomed hand.

The handwriting samples contain a standard sentence in English in which all alphabets are includes and that was, "The quick brown fox jumps over the lazy dog" as shown in figure-1.

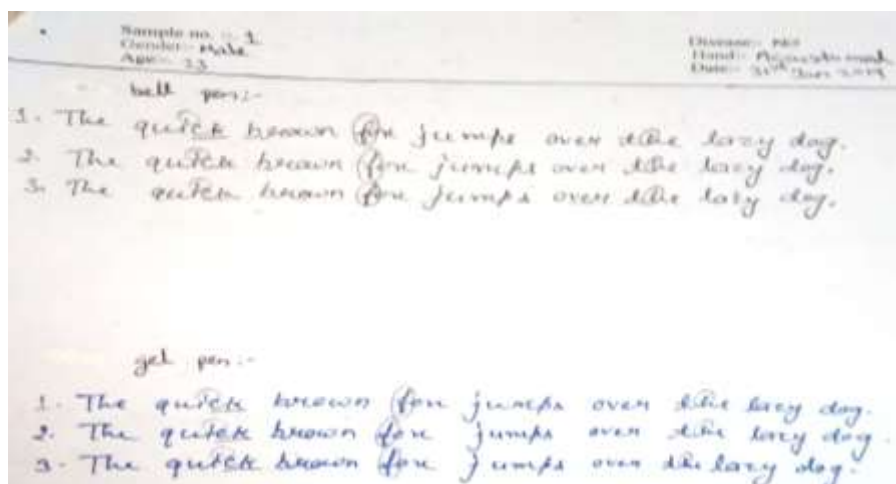


Figure 1: Sample

The subjects were asked to generate their handwriting samples by the copying method on smooth unlined sheets of A4 size paper. The handwriting samples contain 3 lines of the standard sentence written by ball point pen and 3 lines written by gel pen. Each sample was studied to determine the similarities and differences in the handwriting samples of both the hands on the basis of characteristics and mirror writing. Those characters which were identified were recorded and further studied for other characteristics with the help of magnifying glass.

Results and discussion

In this study the results reported here in form of Tables 1-8 along with the related Charts 1-8. Each case contained 2 groups of data i.e. accustomed handwritten and unaccustomed handwritten on the basis of class and individual characteristics of handwriting.

Although each feature had a data population from accustomed handwritten and unaccustomed handwritten that were not significant different, but there was some subject that of each feature had significant difference data.

Class characteristics

Slant

The reason was angle of hand while they were writing. When the subjects wrote with the accustomed hand the slant of the letter was mostly vertical but while wrote with the unaccustomed hand the slant was more tend to backward and forward slant (as shown in the figure-2 and chart and table no.-1).

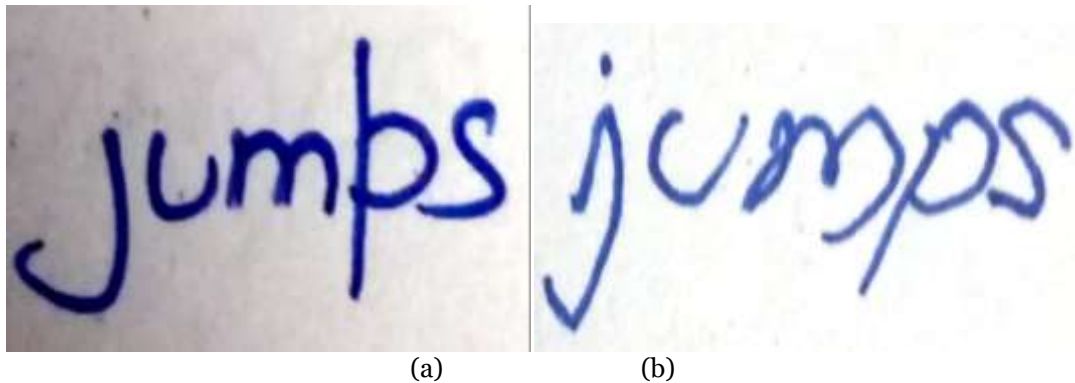


Figure 2:- (a) accustomed hand vertical slant and (b) unaccustomed hand forward slant (sample no-8)

Chart 1:- Graph showing difference between accustomed and unaccustomed handwriting slant

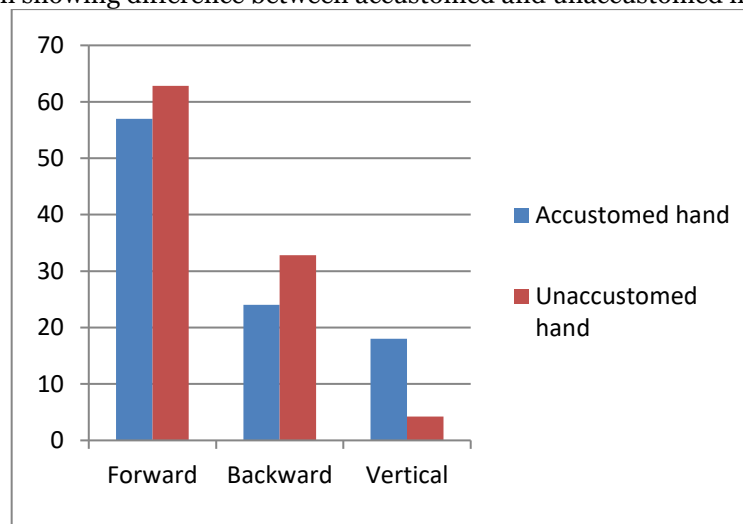


Table 1:- Showing percentage of slant in accustomed and unaccustomed hand

SLANT	ACCUSTOMED HAND	UNACCUSTOMED HAND
Forward	57	62.8
Backward	24	32.8
Vertical	18	4.2

Size

The size of the letters was medium when wrote with the accustomed hand but while wrote with unaccustomed hand the size of the letters was larger and uneven. The reason was that while the subjects wrote by the unaccustomed hand; they had little skill to control their hand to write in a usual way (as shown in the figure- 3 and chart and table no.-2).

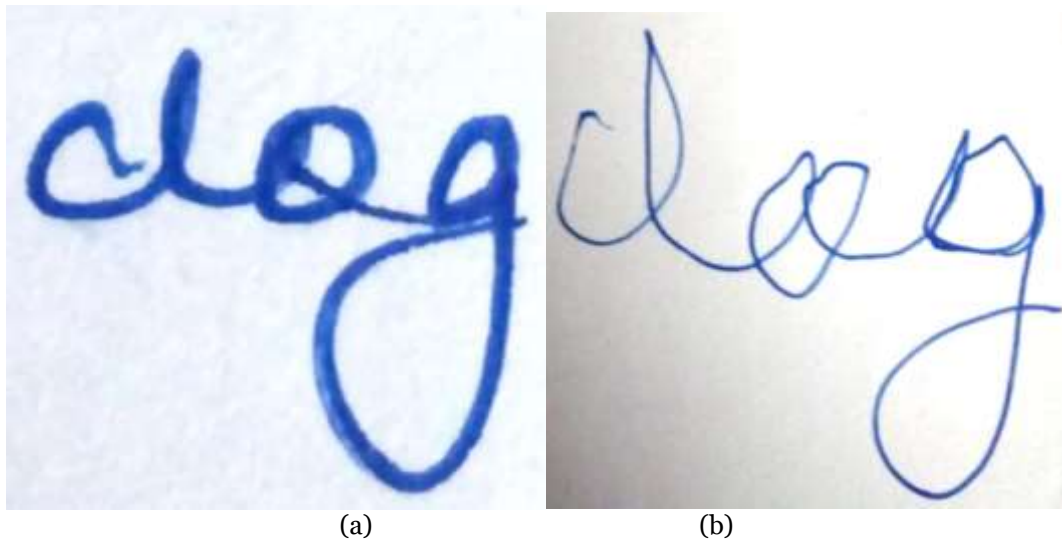


Figure 3:- (a) accustomed hand medium size and (b) unaccustomed hand larger size (sample no- 33)

Chart 2:- Graph showing the difference in size of both the hands

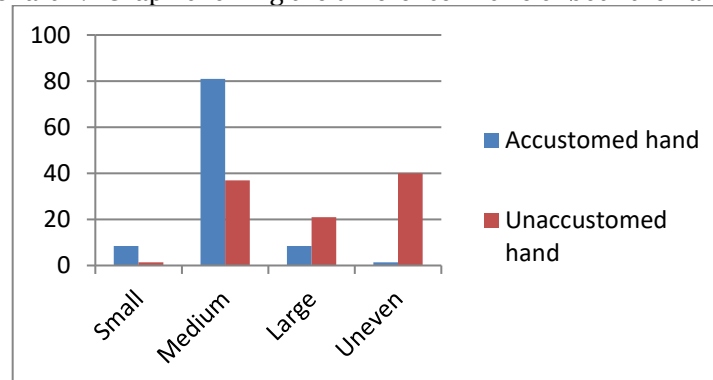
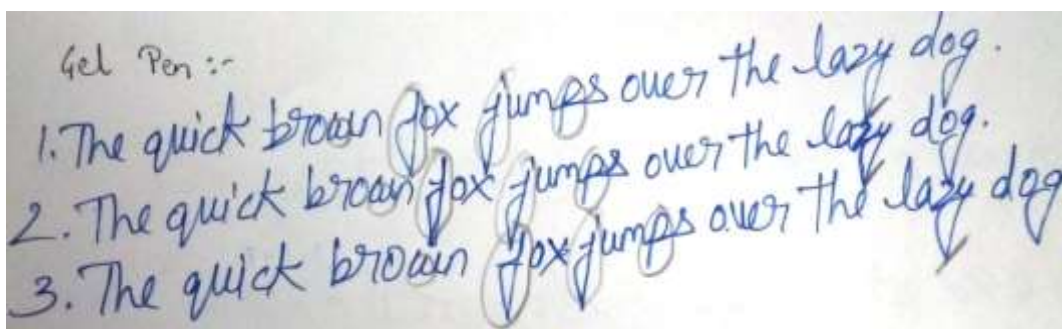


Table 2:- Showing percentage of size in accustomed and unaccustomed handwriting

SIZE	ACCUSTOMED HAND	UNACCUSTOMED HAND
Small	8.5	1.4
Medium	81	37
Large	8.5	21
Uneven	1.4	40

Alignment

The alignment when wrote with accustomed hand was ascending but while wrote with unaccustomed hand the alignment was uneven. The reason was that while the subjects wrote by the unaccustomed hand; they had little skill to control their hand to write in a usual way (as shown in the figure- 4 and chart and table no.-3).



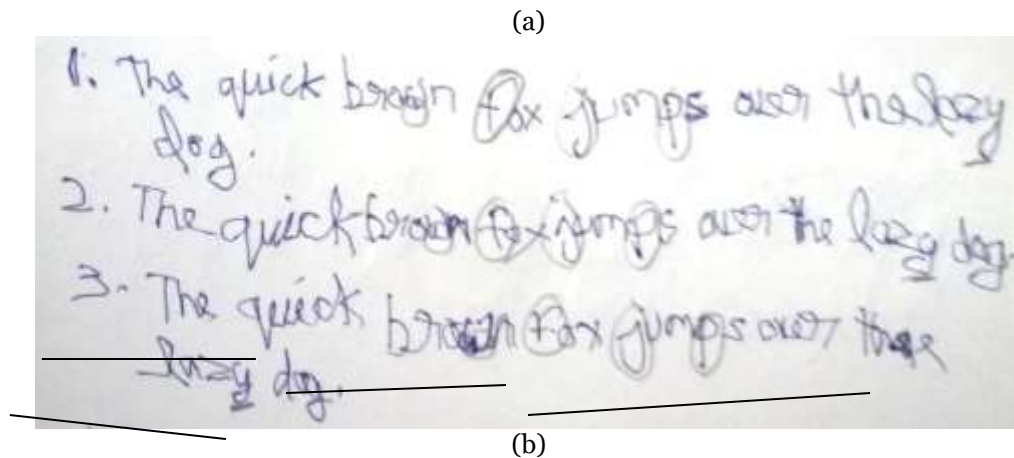


Figure 4:- (a) accustomed hand ascending alignment and (b) unaccustomed hand uneven alignment (sample no- 19)

Chart 3:- Graph showing alignment in accustomed and unaccustomed hand

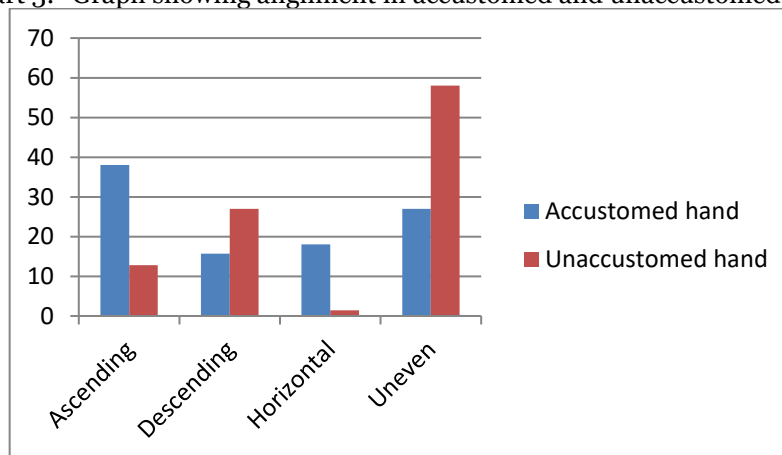


Table 3:- Showing percentage of alignment in accustomed and unaccustomed handwriting

ALIGNMENT	ACCUSTOMED HAND	UNACCUSTOMED HAND
Ascending	38	12.8
Descending	15.7	27
Horizontal	18	1.4
Uneven	27	58

Pen pressure

The pen pressure is heavy when wrote with accustomed hand but while wrote with unaccustomed hand the pen pressure is light due to the uncontrolled grip of the pen. None of the subjects was trained to write with unaccustomed hand. Some subjects wrote free hand writing while write with opposite hand (as shown in the chart and table no.-4).

Chart 4:- Graph showing pen pressure in accustomed and unaccustomed hand

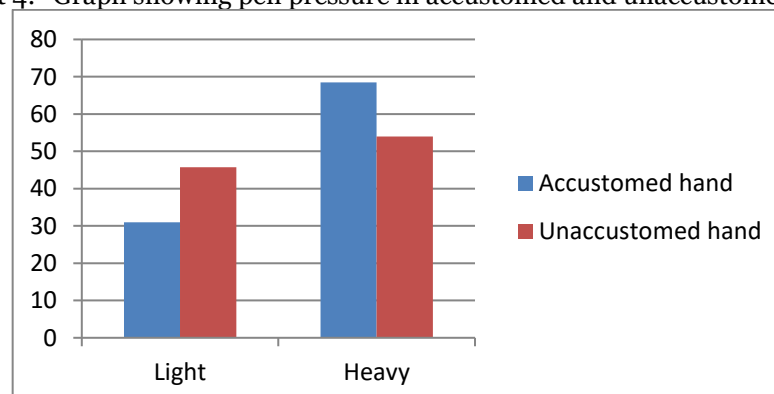
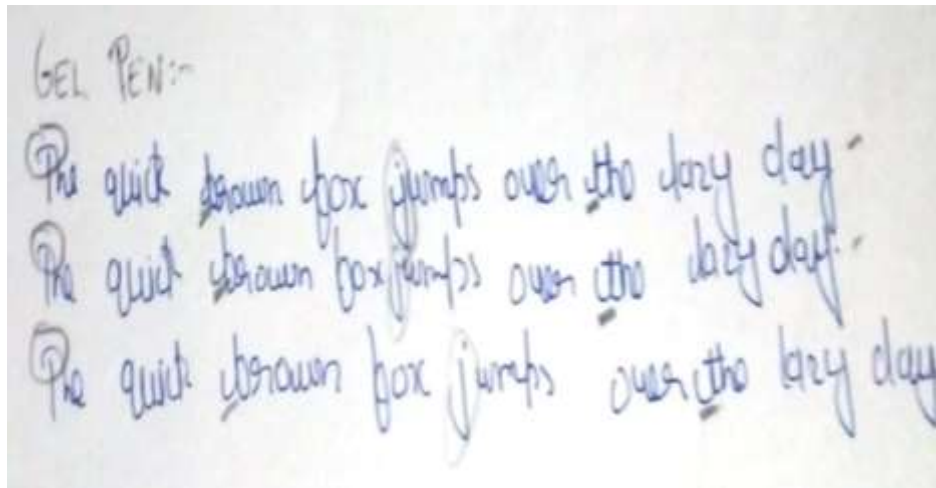


Table 4:- Showing percentage of pen pressure in accustomed and unaccustomed hand

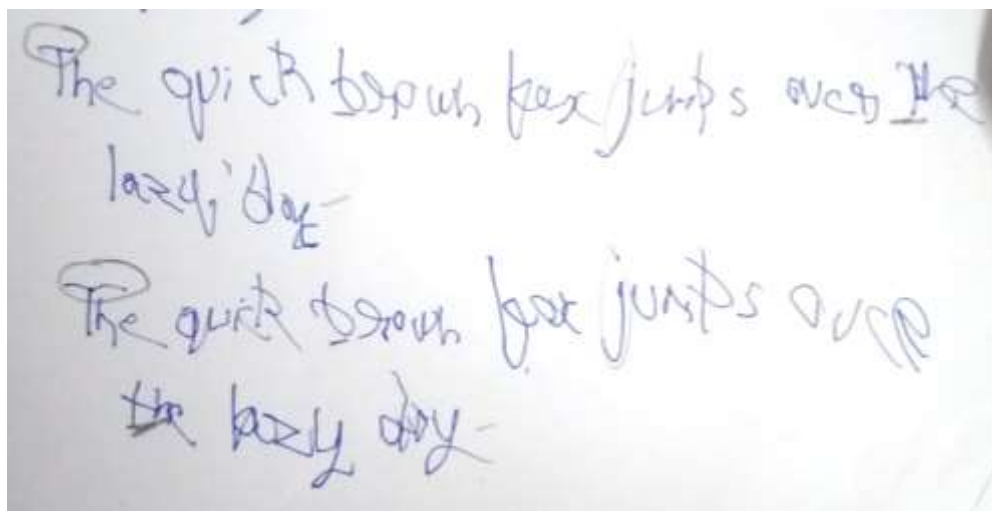
PEN PRESSURE	ACCUSTOMED HAND	UNACCUSTOMED HAND
Light	31	45.7
Heavy	68.5	54

Line quality

Proper connections, smoothness and uniform continuity of the writing are few characteristics of good line quality. When subjects wrote with accustomed hand the line quality was smooth but while they were wrote with unaccustomed hand the writing was uneven and poor quality. The reason was that while the subjects wrote by the unaccustomed hand; they had little skill to control their hand to write in a usual way (as shown in the figure-5 and chart and table no.-5).



(a)



(b)

Figure 5:- (a) accustomed hand smooth line quality and (b) unaccustomed hand uneven line quality (sample no- 47)

Chart 5:- Graph showing line quality of accustomed and unaccustomed hand

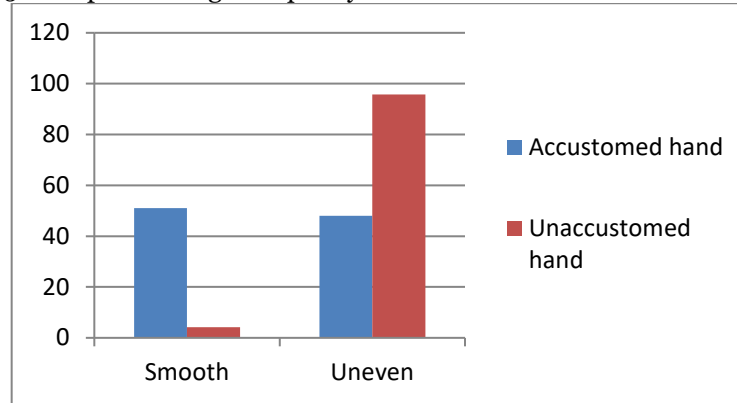


Table 5:- Showing percentage of line quality in accustomed and unaccustomed hand

LINE QUALITY	ACCUSTOMED HAND	UNACCUSTOMED HAND
Smooth	51	4.2
Uneven	48	95.7

Spacing

The reason was that while the subjects wrote by the unaccustomed hand; they had little skill to control their hand to write in a usual way. So when subjects wrote with accustomed hand the space was normal between letters and while wrote with unaccustomed hand the space was wider and variable. In the word quick of unaccustomed hand the space between the letter 'q' and 'u' is wide due to the uncontrolled grip of the pen (as shown in the figure 6 and chart and table no. 6).

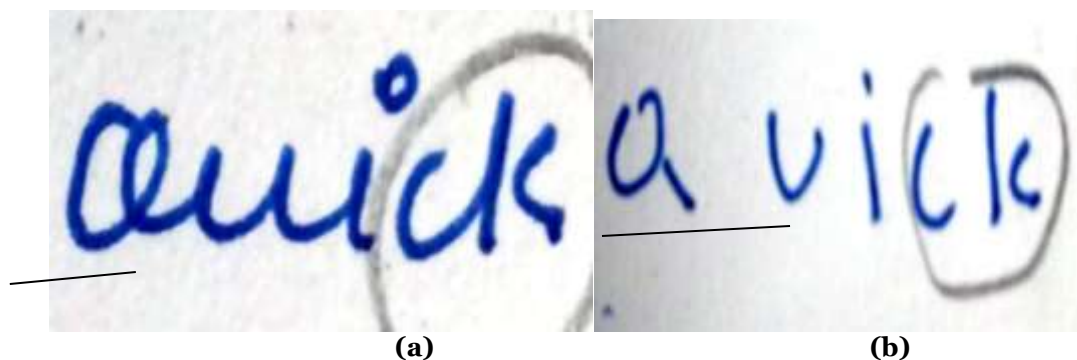


Figure 6:- (a) accustomed hand normal spacing and (b) unaccustomed hand wide spacing (sample no- 24)

Chart 6:- Graph showing spacing of accustomed and unaccustomed hand

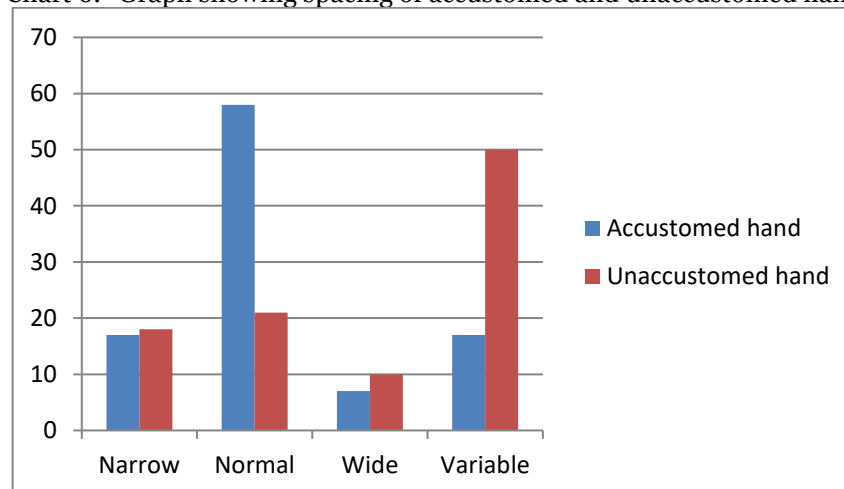


Table 6:- Showing percentage of spacing in accustomed and unaccustomed hand

SPACING	ACCUSTOMED HAND	UNACCUSTOMED HAND
Narrow	17	18
Normal	58	21
Wide	7	10
Variable	17	50

Individual characteristics

There are some features which are majorly used by unaccustomed hand different from accustomed hand to simplified the writing while wrote with unaccustomed hand (which are shown in the chart- 7 & 8 and table- 7 & 8).

- The subjects wrote the letter 'z' majorly in the form of upper case letter 'z' by unaccustomed hand due to its simplified manner of forming it. And by accustomed hand the letter 'z' was made by subjects mostly in the form of lower case letter 'z' (as shown in figure 7).
- The second feature was loop of small letter 'g' in both the hand, while the subjects wrote with unaccustomed hand they were majorly used as complete loop of 'g' and when the subjects wrote with the accustomed hand they were majorly used half loop of 'g' (as shown in figure 8).

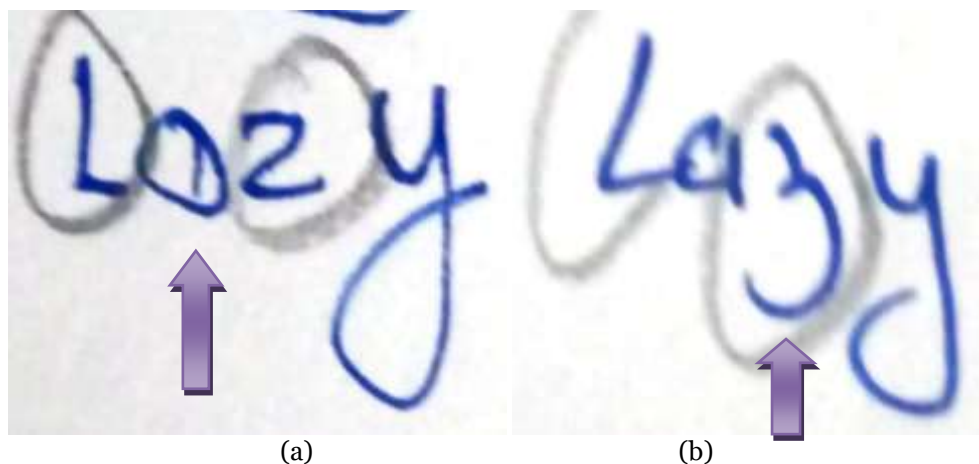


Figure 7:- (a) Capital letter 'z' by unaccustomed hand and (b) Small letter 'z' by accustomed hand (sample no- 39)

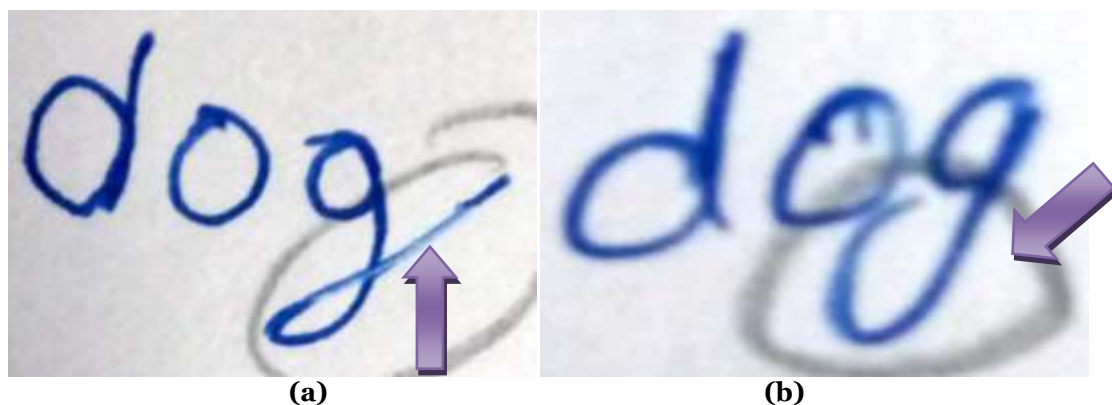


Figure 8:- (a) complete loop of 'g' by unaccustomed hand and (b) half loop of 'g' by accustomed hand (sample no- 20)

- Next feature was loop of letter 'f', when subjects wrote with unaccustomed hand they were majorly used the letter 'f' without loop due to the uncontrolled grip of the pen and while the subjects wrote with accustomed hand they were used 'f' which had loop in it (as shown in figure 9).
- The letter 'q', by unaccustomed hand subjects majorly wrote it in the form of upper case letter 'Q' and while wrote with accustomed hand majorly it was in the form of lower case letter 'q' (as shown in the figure 10).

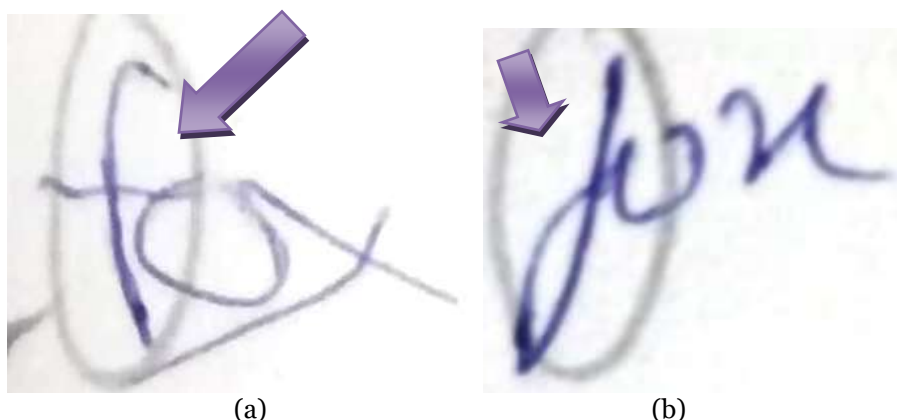


Figure 9:- (a) Letter 'f' is without loop by unaccustomed hand (sample no- 45) and (b) Letter 'f' is with loop by accustomed hand (sample no. 48)

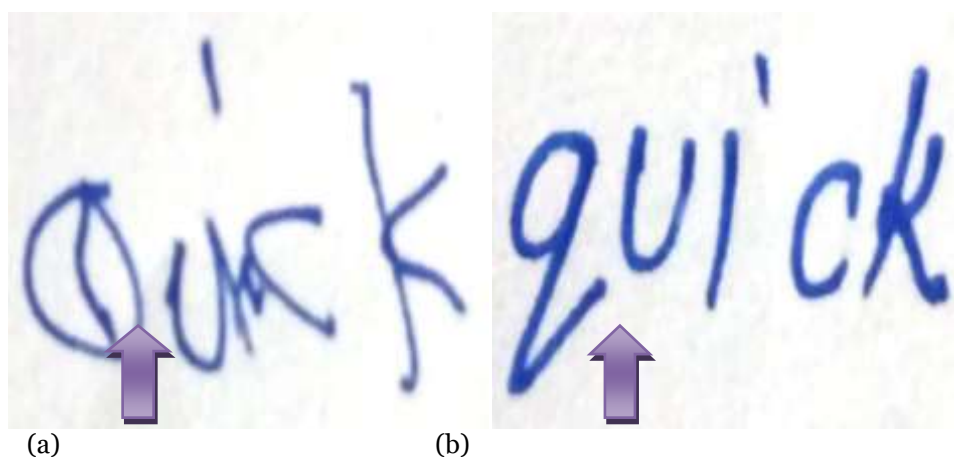


Figure 10:- (a) Capital 'Q' by unaccustomed hand and (b) Small letter 'q' by accustomed hand (sample no- 55)

Chart 7:- Individual characteristics of accustomed and unaccustomed hand-1

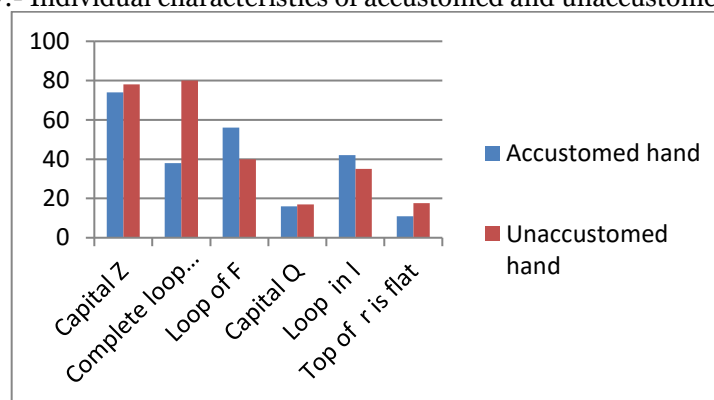


Table 7:- Showing percentage of individual characteristics by accustomed and unaccustomed hand-1

CHARACTERISTICS	ACCUSTOMED HAND	UNACCUSTOMED HAND
Capital Z	74	78
Complete loop of g	38	80
Loop of F	56	40
Capital Q	16	17
Loop in L	42	35
Top of r is flat	10.9	17.6

Chart 8:- Individual characteristic by accustomed and unaccustomed hand-2

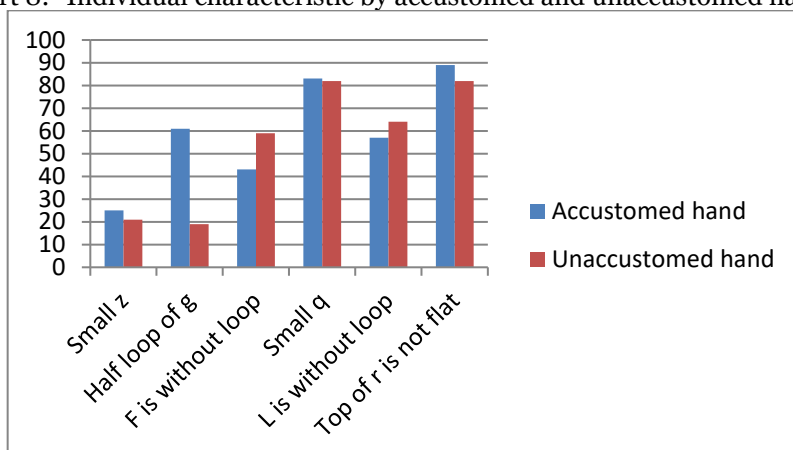


Table 8:- Showing percentage of individual characteristics by accustomed and unaccustomed hand-2

CHARACTERISTICS	ACCUSTOMED HAND	UNACCUSTOMED HAND
Small z	25	21
Half loop of g	61	19
F is without loop	43	59
Small q	83	82
L is without loop	57	64
Top of r is not flat	89	82

- The next feature was observed loop of 'l', when subjects wrote with unaccustomed hand majorly used of 'l' without loop and while wrote with accustomed hand majorly used the letter 'l' has loop in it (as shown in figure 11).
- The top of 'r', by unaccustomed hand subjects majorly used the letter 'r' which has top of 'r' was flat and while wrote with accustomed hand the top of 'r' was not flat (as shown in figure 12).

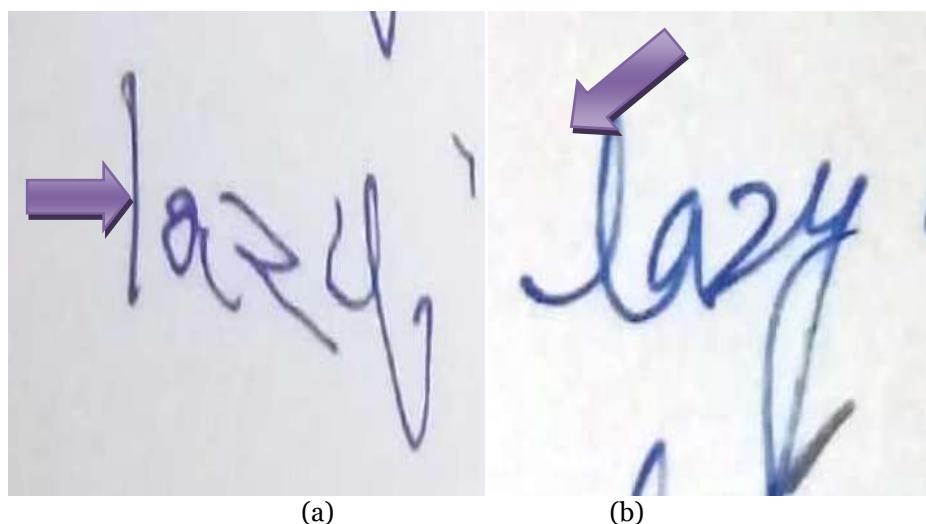


Figure 11:- (a) No loop in letter 'l' by unaccustomed (sample no-47) and (b) Loop in letter 'l' by accustomed hand (sample no-19)

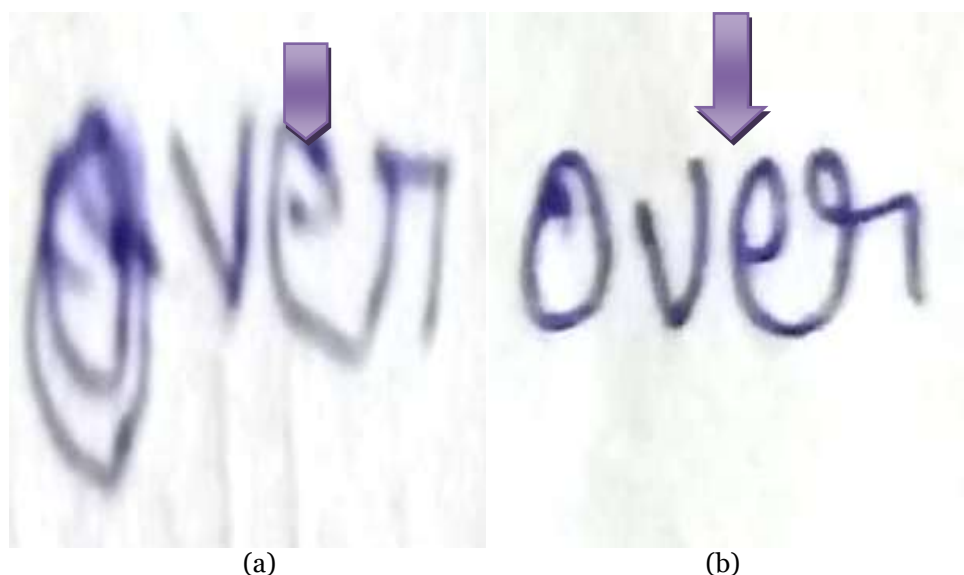


Figure 12:- (a) top of the 'r' is flat in unaccustomed hand and (b) top of the 'r' is not flat in accustomed hand (sample no- 63)

Mirror writing

It was observed that mirror writings were not present in writings executed with accustomed hand, and thus no writer had a mirror writings written with the right-hand. Left-hand writings – that is writings with the unaccustomed hand contained mirror writings. Only some of the characters in a word were written in mirror image form. It was found that not all the writers generated mirror writings in their handwritings with the unaccustomed hand. It is interesting to note that in the present study, not even a single writer wrote the whole text in mirror image form. Just a few particular characters were written in mirror image form. The character “f” was found to be the most frequently written in mirror image form in unaccustomed writings. Ten mirror images were found in the writing of unaccustomed handwriting. Most frequent character which was found in the form of mirror writing was “f” in the word “fox” (as shown in figures 13, 14, 15, 16 and 17).

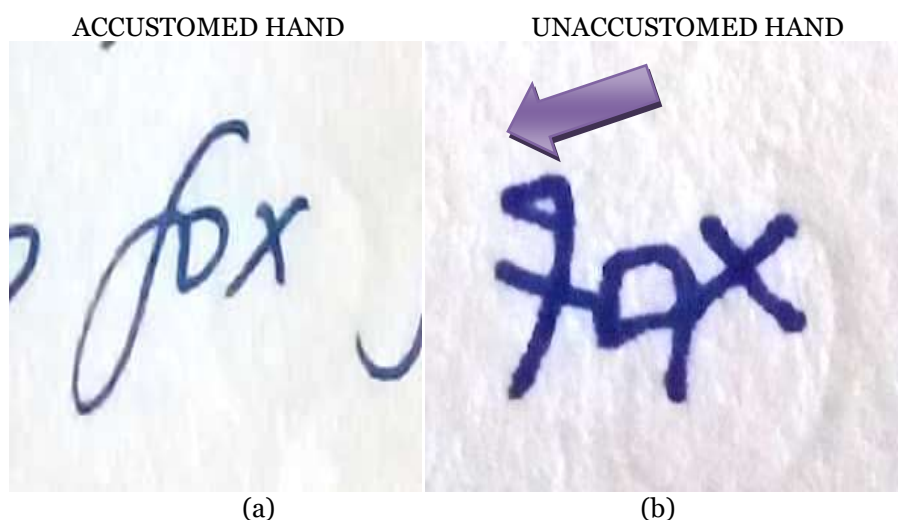


Figure 13:- (a) “f” in accustomed hand and (b) mirror image of “f” in unaccustomed hand (sample no- 11)

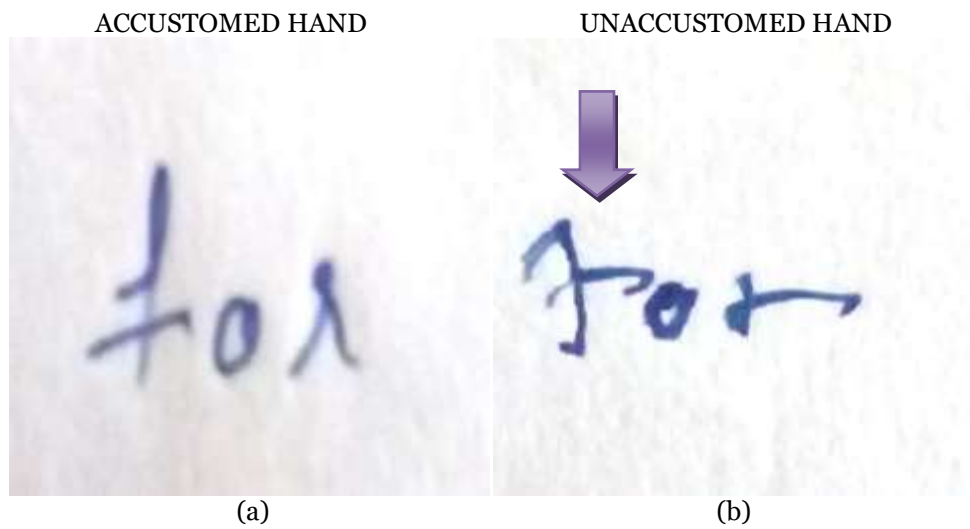


Figure 14:- (a) “f” in accustomed hand and (b) mirror image of “f” in unaccustomed hand (sample no- 15)

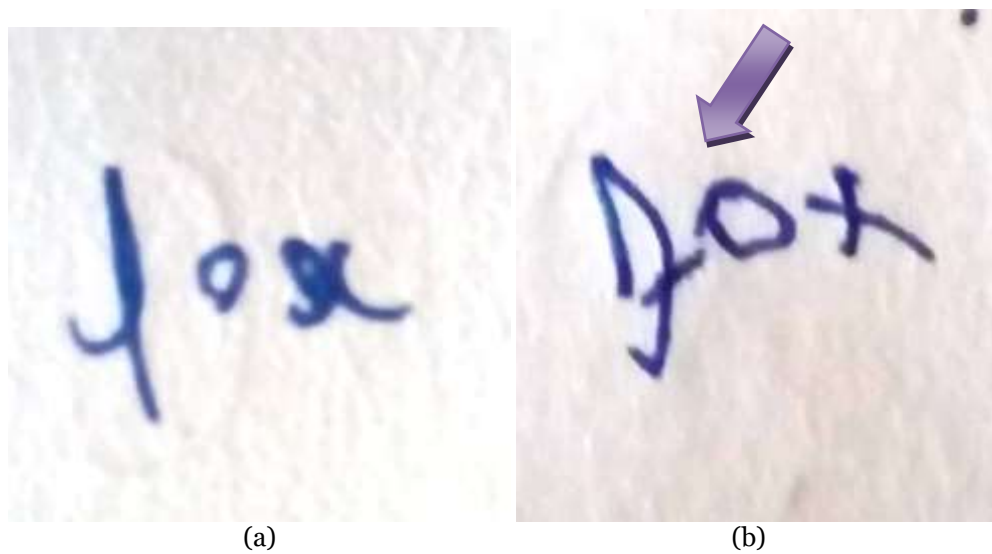


Figure 15:- (a) “f” in accustomed hand and (b) mirror image of “f” in unaccustomed hand (sample no- 41)

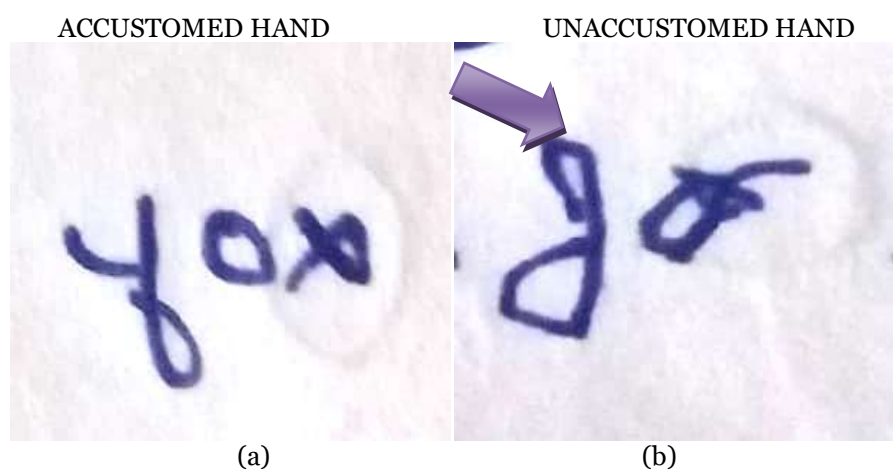


Figure 16:- (a) “f” in accustomed hand and (b) mirror image of “f” in unaccustomed hand (sample no-42)

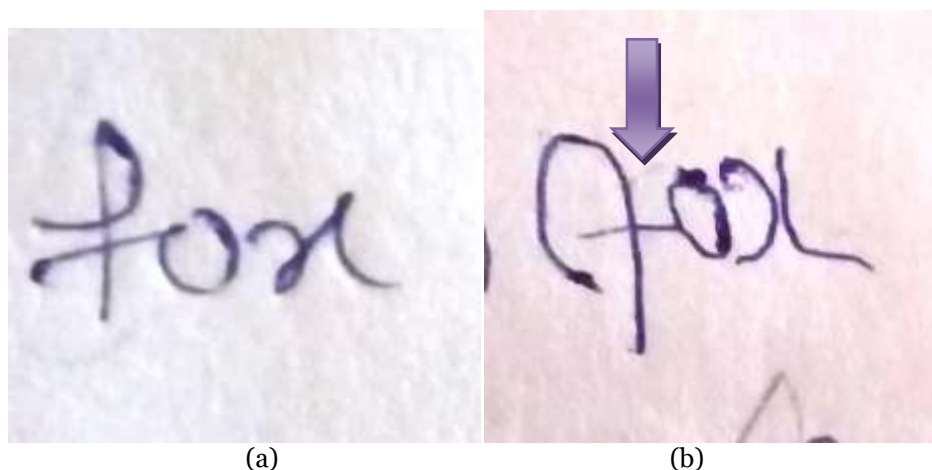


Figure 17:- (a) “f” in accustomed hand and (b) mirror image of “f” in unaccustomed hand (sample no-58)

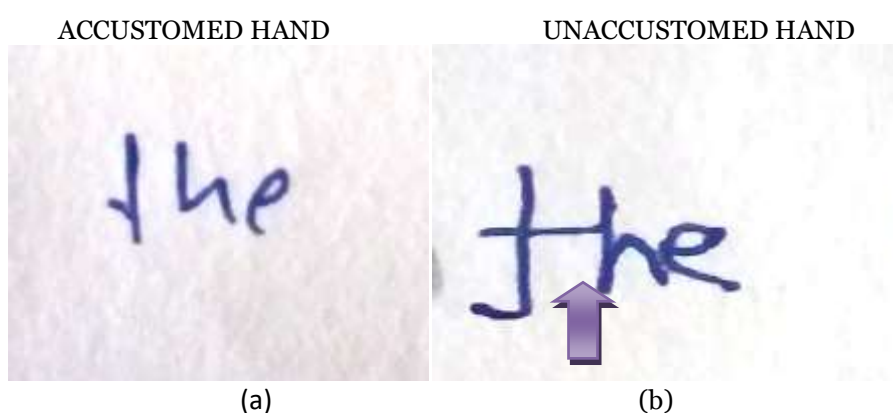


Figure 18:- (a) “t” in accustomed hand and (b) mirror image of “t” in unaccustomed hand (sample no-37)

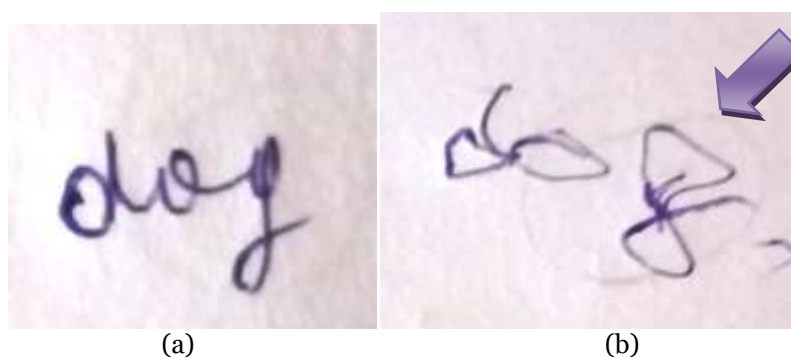


Figure 19:- (a) “g” in accustomed hand and (b) mirror image of “g” in unaccustomed hand (sample no-38)

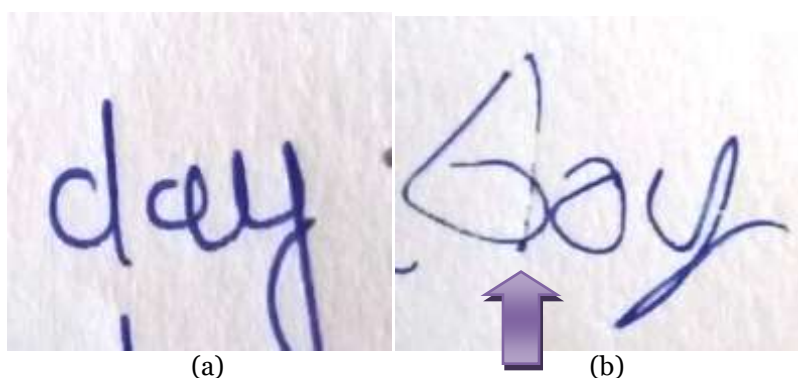


Figure 20:- (a) “d” in accustomed hand and (b) mirror image of “d” in unaccustomed hand (sample no- 47)

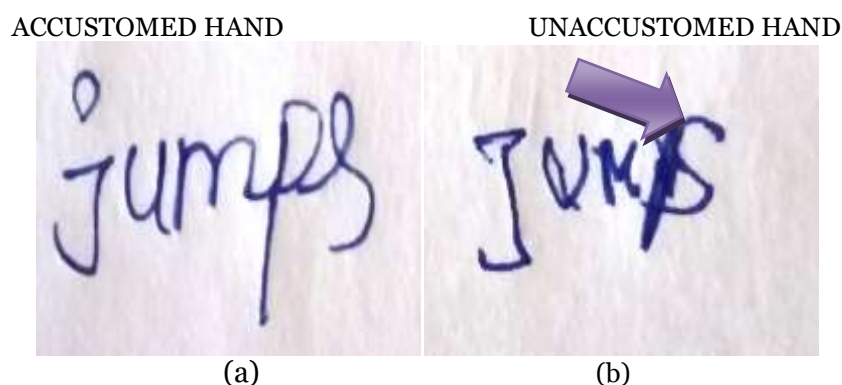


Figure 21:- (a) "p" in accustomed hand and (b) mirror image of "p" in unaccustomed hand (sample no-58)

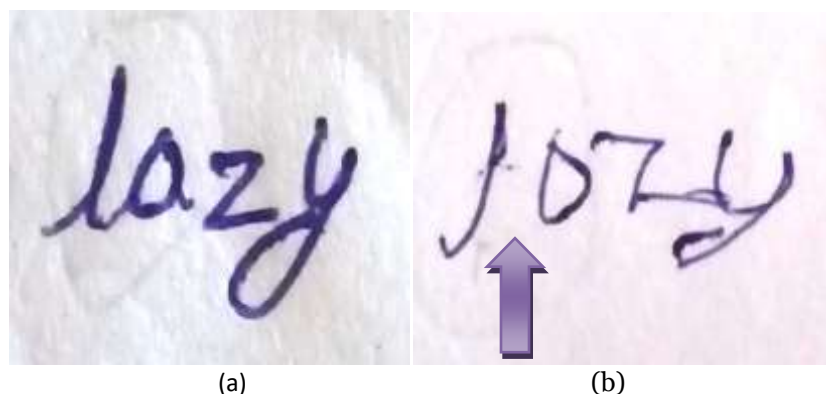


Figure 22:- (a) "l" in accustomed hand and (b) mirror image of "l" in unaccustomed hand (sample no-60)

The mirror writing was observed in the following character "t", "g", "d", "p", and "l" which are shown respectively in the figure 18, 19, 20, 21 and 22. These types of writing deviations may be due to a sudden change in hand and thus difficulty with directional orientation. In the present work it was also observed that a change in the hand for writing resulted in spontaneous changes in normal writing. Mirror images are formed due to an uncontrolled grip of the writing instrument with the unaccustomed hand. Even though the writer always tries to write the characters correctly with the unaccustomed hand, due to the uncontrolled grip of the pen, the letters are formed abruptly, and thus, by chance, mirror images are formed. From the forensic point of view, if we consider a case where a writer tries to disguise their handwriting by intentionally using their unaccustomed hand then it is quite possible that mirror images may appear in their disguised writing. Particularly in cases of anonymous letters where disguise is attempted, it can be assumed that for a longer text, disguise is not possible, and disguise defects will be obvious under observation. In such cases, when mirror writings are observed, then it can definitely be concluded that the anonymous writer must have used their unaccustomed hand to write the disguised text in question.

Discussion

Writing is a complex process that requires a lot of effort and practice to perfect it. It is initiated by the brain, and executed by several parts of the body, including the fingers, hand, wrist, and forearm. The handwriting characteristics of an individual include class characteristics, which are general patterns, and individual characteristics, which are unique to the writer. Several differences are noted between accustomed and unaccustomed handwritings when they are compared. Slant: The accustomed handwritings slant vertically while the unaccustomed handwritings slant forward. Size: The size of the letters is larger and uneven due to the lack of skill in controlling the hand movements that result in longer horizontal strokes. Alignment: It is also uneven because the writer cannot maintain a steady grip of the pen. Pen pressure: The pen pressure is lighter with the unaccustomed hand, resulting in poor quality of lines that are not smooth, and discontinuous. Spacing is wider and more variable because it is hard to maintain a consistent control. Individual characteristics With the unaccustomed hand, most people use simplified letter formations, for instance, capital "Z" the letter "g" is mostly written with a complete loop, the letter "f" is written with no loop, the letter "Q" is capital, the letter "l" is written with no loop, and the letter "r" is written with a flat top. Those are the features used to determine whether the writing was done with the accustomed or the unaccustomed hand. Some mirror writing is noted, which although rare, it is also used as an attempt to disguise handwriting. The letters include a mirror image of the letter "f" in the word fox, among other characters such as "t" "d" "g" "l" and "p". None of the subjects in the study population were trained to write with their unaccustomed hand, which made it very hard and unique to write with that hand.

Conclusions

In an attempt to disguise writing, a writer may shift to their unaccustomed hand with the idea that significant changes in the appearance of the writing will help to hide their authorship successfully. But such a writer is unaware that in doing so they have introduced one feature in their writing which is very specific (unusual), indicating that the hand for writing has been changed to perform the disguise. Similarities and differences of each feature on the basis of their characteristics was estimate the probability that evidence was written from accustomed and unaccustomed hand.

The mirror image form of the writing was studied and it was found that it is not possible for a writer to write a whole text in mirror image form. It was found that only certain letters were more conducive to being written in that form. Lower case “f” was found to be the most frequently written letter in mirror image form. It is difficult at this stage to elucidate a pattern of mirror imaging for writing but it can definitely be said that if mirror image writing is present in a person’s writing then there must be an attempt to disguise the handwriting by changing the writing hand.

Disguise handwriting is one in which the person had made a deliberate attempt to remove or to modify all or some of his normal writing habits. A purpose of disguise is to avoid detection. From Alford study, mostly used methods of disguise were methods that change obviously appearance such as change size of letter, slant, alignment, and spacing. But in will or ransom note that contained many letters, if writer disguise by those methods, appearance of letters were unstable because there were both disguised letter and writer habitual letter. So a writer would disguise and show stable style of letters. The disguise method that showed stable style of letters was wrong-hand writing. By this method, writer would produce unsuspicious writing and different from accustomed writing. So writer would deny that the writing was not of his own. This study showed the method to investigate a similarity of each feature that measure from accustomed and unaccustomed handwritings and use a similarity of each feature to estimate probability of written evidence. However, handwriting is not just “hand” writing. There are many factors that influence in letter formation. The result obtained from this study was used to help handwriting examiner estimated probability.

List of abbreviations

- **FDA:** Forensic document examiner
- **QD:** Questioned document

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