

# Mirror Writing: Trait of an Unaccustomed Hand

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## **ABSTRACT**

To conceal their identity, writers may try to change the way they write. This will change the way the writing looks and may help the writer to conceal their handwriting. One technique involves switching to the opposite hand; for instance, someone who typically writes with their right hand might switch to writing with their left hand. A very odd type of inconsistency, mirror image writing, has been noticed in this kind of disguised handwriting, which may help identify the use of the unaccustomed hand to carry out the disguise. A thorough examination of the mirror image form of writing was done in the current work. It can be difficult for handwriting experts to determine the authorship of questioned handwriting (in English) written by an unfamiliar hand compared to handwriting samples written by a familiar hand during the Questioned Document Examination.

Criminals prefer mirror handwriting for criminal activities such as extortion, defamation, and other such activities through letters or anonymous letters. Samples of both accustomed and unaccustomed handwritings must be available if unaccustomed handwriting of a suspect(s) is being questioned to form an opinion. If only one hand (the accustomed handwriting) is present, it can be challenging to form an opinion. Handwriting samples from 50 right-handed people with both accustomed and unaccustomed hands were gathered and analyzed to assess the possibilities and limitations for identification of unaccustomed handwriting of the English language. This report focuses on the similarities between the writing styles of the authors, written in English with both an unfamiliar and familiar hand.

**Keywords:** handwriting, mirror-writing, disguised writing, question document, unaccustomed hand.

## **1. Introduction**

Writing that is done by hand with a pen, pencil, digital stylus, or another tool is known as handwriting. Penmanship is the term for the practice of writing by hand.

To determine who wrote a piece of handwriting, a document expert is asked to look at two factors: the class and individual characteristics of the handwriting.

The term “class characteristics” refers to writing traits that are specific to a group, such as a common handwriting pattern, letter shapes, or a language. Simply put, it is a model that is taught to us when we learn the writing process and is almost identical to a class of people.

On the other hand, when a letter deviates from its typical copybook form, individual characteristics show up. All handwriting identifications are based on these writing components. The specific elements or characteristics of writing that are unique to a particular author.

### 1.1. Class Characteristics of Handwriting

**1.) Movement:** The movement of the writing instrument as a result of the hand's contact with the writing surface.

The writer may combine the movements of their fingers, wrists, elbows, and shoulders. Holding the pen with the thumb, index finger, middle finger, or occasionally the ring finger causes the motion. The writing is of poor quality because the hands are resting in the air.

#### Features of Writing with Finger Movement:

When writing across the page, the writer must constantly readjust his or her hand. The letters' sharp turns and breaks reveal this constant adjustment.

It is typically used by inexperienced writers, illiterates, and young children to show lack of familiarity with the writing process. There will be many pauses and stops in the writing.

- Horizontal Writing
- Absence of distinct strokes
- Absence of Rhythm
- Wrist Movement: The wrist, which rests on the writing surface, moves when writing.
- Wrist Movement Writing Characteristics Inclined Writing
- Less space between the letters and an angular shape.
- Additional degree of freedom
- Fast
- Forearm movement: The writer's elbow moves while their arm is resting on the writing surface.
- Forearm movement: The writer's elbow moves while their arm is resting on the writing surface.
- Elbow and Forearm Movement Writing Characteristics
- Good caliber
- Writing quickly
- Gives more lateral and command freedom
- Smooth
- Precise strokes
- Full arm movement and shoulder movement

From the shoulder comes movement, mostly detached writing style. On large surfaces like blackboards, whole arm writing is used to write on the surface.

**2.) Pen Pressure:** Pen Pressure is the weight or force that is unintentionally applied to the writing instrument while writing. When writing is done with a nib pen, the results of varying the amount of pressure applied to the writing instrument as it moves across the paper are clearly visible. The more force used by the hand and fingers, the more the nib tips will separate. Pen pressure for writers can be classified as light, medium, or heavy.

**3.) Pen Presentation:** This refers to the angle the pen makes with the paper or the line of writing. When the angle is 45 degrees, the writing results are the best.

By drawing a tangent to the stroke and calculating the angle between it and the base line, this angle can be calculated.

#### 4.) The 5S Qualities:

- Speed
- Skill
- Slant/Slope
- Shading
- Spacing

##### a. Speed

Speed is the time it takes a writer to complete a handwritten task. Speed can be deliberate, fast, medium, or slow.

##### Qualities of Quick Writing:

- Streamlined letter formats
- Smooth Movements and Good Connections
- I have carelessly poked and placed i dots.
- T-intersections have a tapered edge or can join with another word.
- Conclusions are abrupt

##### Slow Writing Characteristics:

- T bars take a lot of work to place.
- The round dots on the stem are close together.
- Vertical Slant Pressure is frequently boring.

##### b. Skill

The ability or expertise to do something is known as skill. Writing is a skill that must be practiced repeatedly to become ingrained. Writing is a skill that gets better the more one writes. There are three levels of handwriting ability: Poor, Medium/Normal, and Superior/Good.

**High Skill:** Flowing, artistic, embellished, and aesthetically pleasing rhythm **Low Skill:** Slow, laborious, and non-rhythmic

The number of words one can produce in a minute is known as speed.

Skill, which is proportional to movement, is directly inversely related to speed. Higher movement, faster speed, and higher skill.

##### c. Slant/Slope

Slant/Slope refers to the angle that the letter axes are inclined with respect to the baseline of the writing. Slant can be straight or vertical.

- Left/Backward
- Right/forward

##### d. Shading

Shading is the deliberate or voluntary act of applying pressure to the pen as certain strokes are being completed. When using a nib pen, writing with more force results in wider strokes than writing with less force. Most often, it appears in downward strokes.

### e. Spacing

The amount of space between letters, words, and lines of writing is referred to as spacing. Words should be separated by one to two letters according to writing conventions. In order to prevent upper and lower loops from overlapping, there must be enough space between the lines.

#### **There are two categories for spacing:**

Both intra word (within) and inter word (between)

There are several features of spacing in writing that develop into habits for the person and are useful during the identification process. These include the interlinear spacing, also known as wide, narrow, mixed, or uniform spacing between letters, words, and lines on unruled paper.

The distance between capital letters and lowercase or small letters within the same words also develops habits that are of some significance.

**5.) Alignment:** The baseline is the line, whether it be fictitious or real, on which writing is positioned. Some authors write above the baseline, while others write on the line, and still others write below it.

- Descending
- Ascending Uneven

**6.) Relative Size:** This measure compares the size of small and tall letters. The circumstances under which handwriting is written can affect its size. A letter's height and width are both considered to be its relative size. The size difference between tall and short, short and tall, and tall and tall letters is taken into account. Relative size is a subject on which some authors disagree. According to Harrison, a letter's relative size is determined by how it compares to other letters in the writing or by its own apparent standard size. The fact that the size of the letters changes as they appear is another crucial aspect to pay attention to when analyzing handwriting.

**7.) Ratio:** Two groups of letters are possible. - Letters with upper or lower loops or both, that is, letters that span above or below the middle zone of writing, are referred to as tall letters. Examples of such letters include o, a, and e, which are entirely written between the lines.

The letters that make up the middle zone are: a, c, e, i, m, n, o, r, s, u, v, w, and x. The letters in the upper and lower Zones are: b, d, g, h, k, p, q, y, and z. In cursive writing, only the letter f fully extends into each of the three zones.

Normal handwriting is defined as having a ratio that is close to the required copybook. The ratio is said to be high if the tall letters are significantly longer than the small letters, whereas the ratio is said to be low if there is little to no height difference between the two.

**8.) Line Quality:** Line quality is defined as the evenness, continuity, smoothness, and directness of the strokes. The most crucial aspect of a handwriting analysis is line quality. A good line has smooth, even, no tremors, and is quickly written.

Slow writing results in poor line quality, which could be a sign of forgery or an intentional alteration of the writing. When forging, the signature is attempted to be drawn rather than written. Drawing is a slow, laborious process that produces trembling strokes.

We are unable to identify a writer with certainty based solely on the characteristics of their writing, so we look for specific traits in their handwriting.

## 1.2. Individual Characteristics of Handwriting

When comparing handwriting samples, individual characteristics stand out because they deviate from the system of writing that has been taught.

### **Individual traits fall into several categories:**

- Consciously formed routines
- Acquisitions made unconsciously

The writing habits a writer develops are ones that are consciously chosen. Although a writer may forget to do so when attempting to hide his or her handwriting, ingrained habits are simpler to change.

The unusual letter designs, slant, writing speed, and writer skill level are the most obvious consciously developed deviations. Penmanship will be practiced by writers until they are happy with their progress. Writers frequently change their works without realizing it. One such instance is the use of space.

A writer must modify their writing to fit the space that is available. Although the writer is aware of changing the writing's size, he or she may not be thinking about this as they are doing it.

Without conscious awareness, subconscious habits seep into handwriting. These unconsciously present traits in the writer's handwriting cannot be altered or eliminated because they are not conscious of them. Conscious growth occurs more subtly. The majority of authors are unaware of the presence of these components in their works.

Their letter forms may contain hooks and ticks. Pressure patterns emerge subconsciously. Because it is difficult for the writer to change these subconscious traits, the more subconscious the habit, the stronger the identifying factor.

### **How Handwriting becomes individualistic in nature?**

Form includes the way the letters are put together and connected, including the initial and terminal strokes, and goes beyond the physical appearance of the letters.

Designs for letters -the writing strokes are made up of lines and curves that point in different directions to form the different letter shapes. Vertical, horizontal, or diagonal lines are all possible. Loops, circles, or fragments of circles make up curves. The most recognizable aspect of handwriting is its letter designs. Falsifiers imitate letter designs while ignoring other aspects of the writing.

Each letter has a distinctive feature that makes it distinct from the others. For each letter, many authors employ a different design. In addition to slight variations in each letter's form, it is not uncommon to see two or three different letter designs in a person's handwriting.

Every writer's handwriting contains some element of natural variation. Everybody has an image in their head of learned letter formations.

A writer may experiment with various letter designs until they come up with one, they like, or they may just create one that accurately depicts the letter form they are creating.

**Method of Construction:** Forgers will imitate letter forms, but they won't always create words and letters using the same process. Consistent habits in letter form construction are formed by writers. Whether they are starting their letters above, below, or on the baseline, they all do so roughly in the same spot. Each time, they join strokes at the same spot while moving the writing instrument in the same direction. They all end their letters in the same way. To identify the construction method, a document examiner should carefully follow the writing line's direction.

**A) Initial strokes** – Initial strokes are the first few letters and words that are written. They could be

long or short, straight, curved, or hooked.

**B) Terminal Strokes** - Ending strokes for letters and words are referred to as terminal strokes. They are common among writers and can be long or short, straight, curved, or hooked. Unless the terminal stroke is very recognizable, forgers also ignore these.

**C) Medial Strokes** - Between the initial and terminal strokes, there are lateral strokes. They comprise the letter shapes and the connecting strokes used in cursive writing to form words.

**D) Connecting Strokes** - These strokes link the letters of a word together. Ligatures are another name for them. Words can have connected or unconnected letters. Arches, garlands, angles, and thread connections are all examples of connectors.

Letters may be embellished with additional strokes to enhance their appearance. These ornaments are wavy and curved lines that are added to the start or end of letters. Hooks are quick changes in direction made by a writer unconsciously in small strokes. Although some will be in the middle, hooks can be found at the start or end of words.

**Grammar:** In addition to the rules of grammar, spelling and punctuation are crucial components in handwriting recognition. Although they cannot be used exclusively, spelling and punctuation can help identify handwriting. Writing in the opposite direction of how a language naturally develops produces mirror writing, which is the mirror image of regular writing and looks normal when reflected in a mirror. It occasionally serves as an incredibly basic cypher.

## 2. Objectives of the Research

The document examiner comes across disguised writings quite frequently, especially when it comes to anonymous letters. Due to the inconsistent writing in these situations, it can be challenging to determine who wrote the disguised writings. The criminal believes they can conceal their identity by hiding their handwriting. However, as was correctly noted, taking too many precautions when committing a wrong can result in the introduction of additional errors. Write with a hand you are not used to using as it is one of the preferred ways to disguise handwriting. By writing with a hand that is unfamiliar to you, you can conceal your identity by adding features to your writing that can set it apart from other writing.

Mirror writing is one example of such a feature. Common inconsistencies include the presence of certain characters in inverse form or shape. In the current work, a thorough analysis of the mirror image writing style was carried out. The character types that appear in mirror image form the most were noted.

## 3. Review of Literature

In experiments conducted by Dzied-zic (2011, 2013), right-handed writers were taught to write with their left hand. The writing underwent significant changes over the course of three years of training with the unaccustomed hand. The differences between writings produced by the accustomed and unaccustomed hands were observed to be caused by these changes in hand motor skills. However, because they were related to the human psychological realm, some features displayed similarities.

The phrase "mirror writing" was first used by Buchwald in 1878, and it is defined as "an unusual script, in which the writing runs in the opposite direction from normal, with individual letters in reversed direction, so that it is most easily read using a mirror" (Schott, 2007).

McIntosh and Sala (2012) examined various mirror-writing manifestations and discussed accidental mirror-writings.

According to Schott and Schott (2004), left-handers are better at mirror writing. Chinese, Japanese, and Hebrew were among the languages with a high prevalence of left-handed mirror writing that are typically written in a left-to-right direction.

Schott (2007) outlined the factors that tend to prevent mirroring as well as the reasons why left-handed writing produces mirror images.

According to research by Tankle and Heilman from 1983, left-handed people wrote mirror words (but not regular words) more quickly than right-handed people.

Both right-handed and left-handed subjects were examined under both normal and mirror writing conditions by Tucha, Aschen-Brenner, Lange (2000) and Zaman, Karolina, Roberts (2002).

It was investigated how left-handed, right-handed, and left-handed subjects who typically write with their right hand performed on the normal and mirror writing tasks.

According to the hand used and hand use order, Vaidand Davis (1989) compared the mirror writing abilities of normal right- and left-handed adults. They were able to gather proof that people who started writing in the mirror with their right hand did so more quickly.

Yang (1997) investigated mirror writing with both legitimate and untrue Chinese characters.

In comparison to regular writing and mirror writing with pseudo characters, they claimed that mirror writing with legal characters performed better. Functional magnetic resonance imaging, or fMRI, was used by Zaman, Karolina, and Roberts (2002) to investigate the neural correlates of both normal and mirror writing of the alphabet. Regardless of whether the non-preferred (unaccustomed) hand was used or the preferred (accustomed) hand, the mirror writing activity was bilateral in both groups of subjects.

Mirror writing may not be found often, but when it does, it can be used to infer how handwriting can be disguised. The literature has only sparingly discussed this aspect of disguise (Dawson, 1985).

Therefore, in this study, we attempted to thoroughly examine which strokes are more likely to be written in mirror image with respect to mirror writing and handedness, how this affects the overall appearance of the writing, and whether or not mirror writing stroke formation is different from that of normal writing, among other things.

## **4. Materials and Method/ Methodology**

### **4.1. Materials**

- A4 size sheets
- Pens-blue/black
- People for taking samples [total sample size - 50 people]

### **4.2. Method**

In the current study, right-handed university students who were proficient writers provided handwriting samples. None of the participants had any conditions that would have affected their ability to coordinate their muscles or their brains.

On white paper, these handwriting samples were produced using both hands—the dominant hand and the less dominant hand.

The hand that the subject was accustomed to using to write in their daily activities was referred to as the accustomed hand, and when the subject used a different hand, the writing was referred to as having been done with the unaccustomed hand.

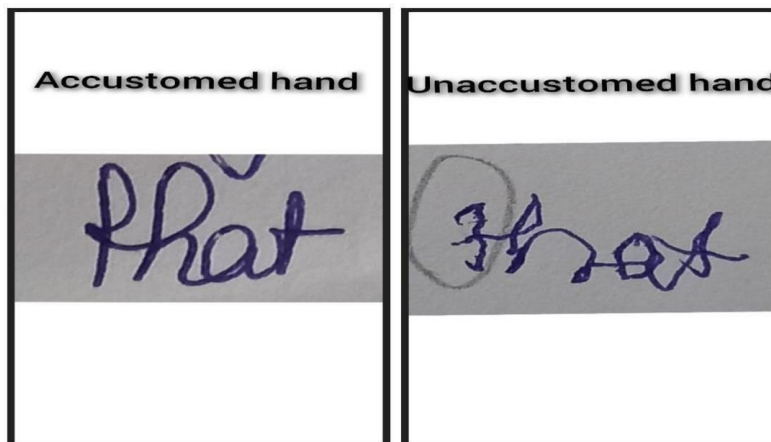
Additionally, none of the subjects had any training in writing with a hand they weren't used to. The handwriting samples consist of standard English lines with numbers and mix of capital and small letters of the alphabet. The handwriting samples using a pen.

One handwriting sample was obtained from each subject, bringing the total number of handwriting samples collected to 50. We checked each sample for mirror writings. With the aid of a magnifying glass, the characters that were confirmed to have been written in this manner (mirror) were noted and further examined for other aspects of form and formation.

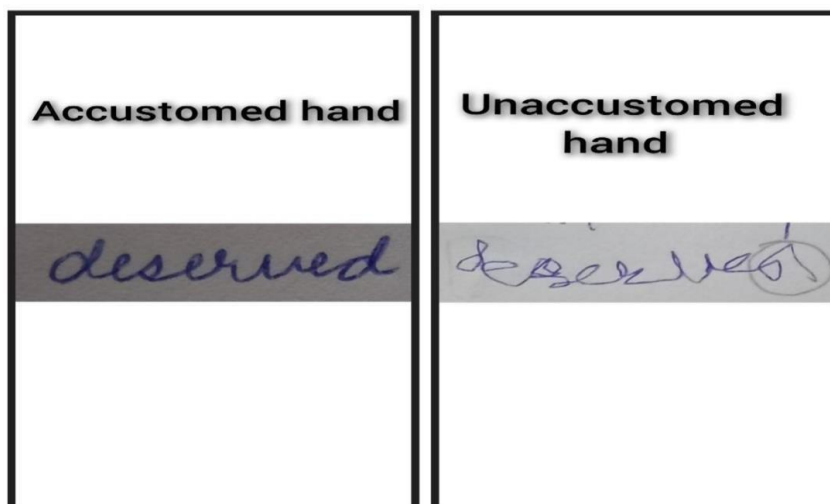
## 5. Observations and Result

### Observations:

#### 5.1.Character “t”

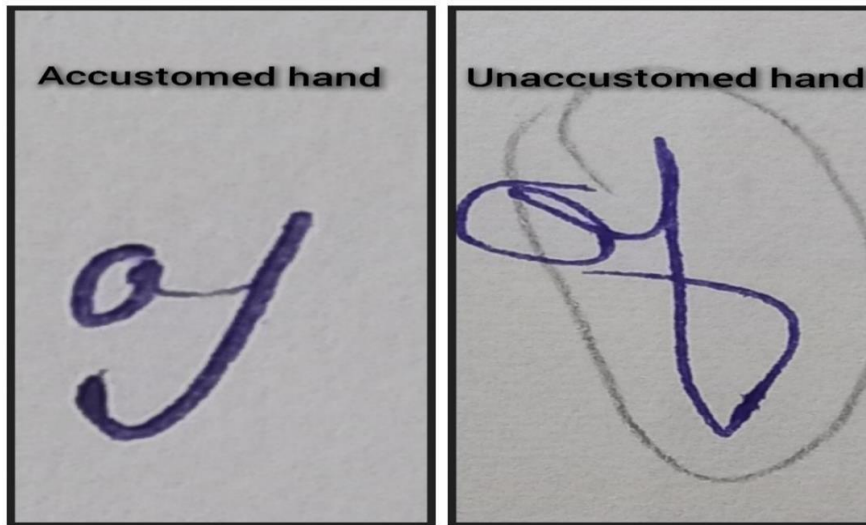


#### Character “d”

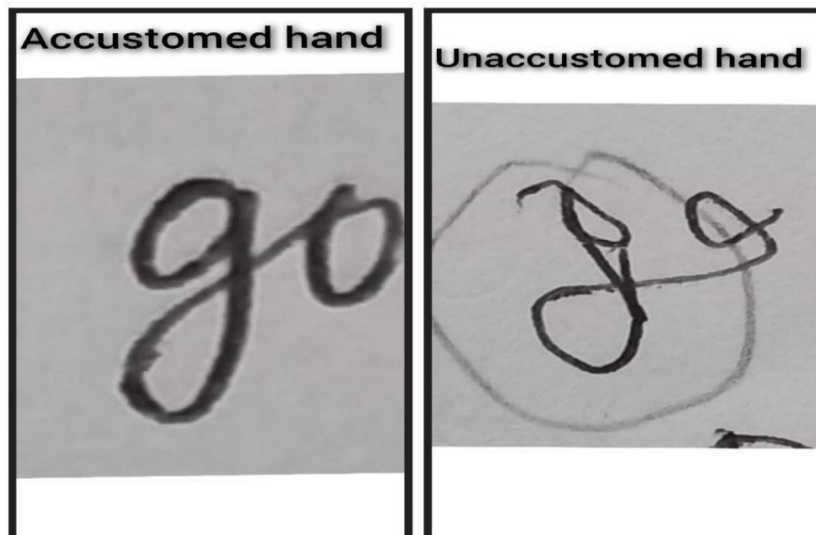




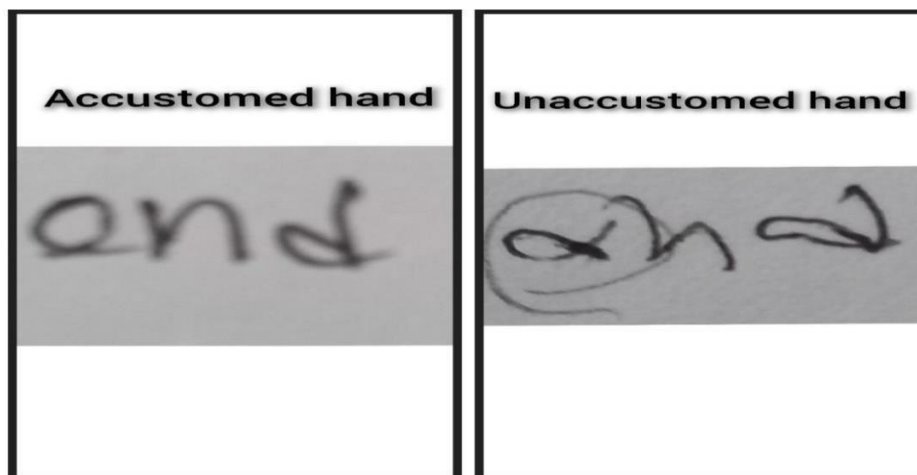
### 5.2.Character “f”



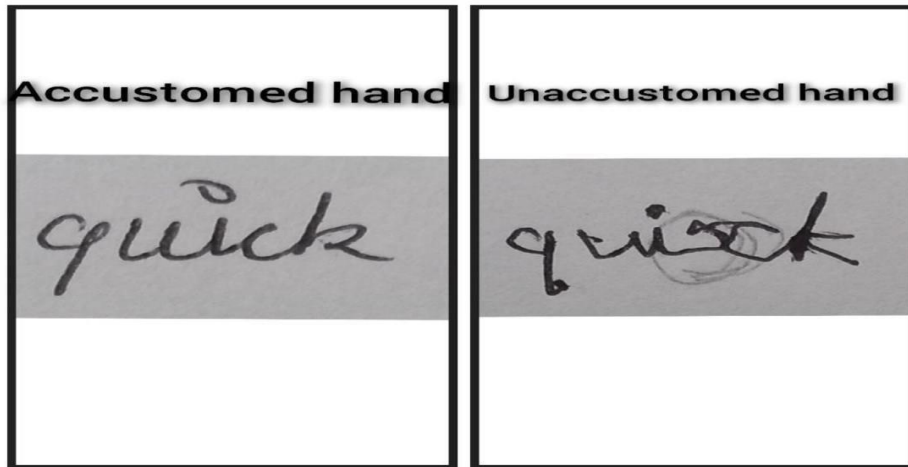
### 5.3.Character “g”



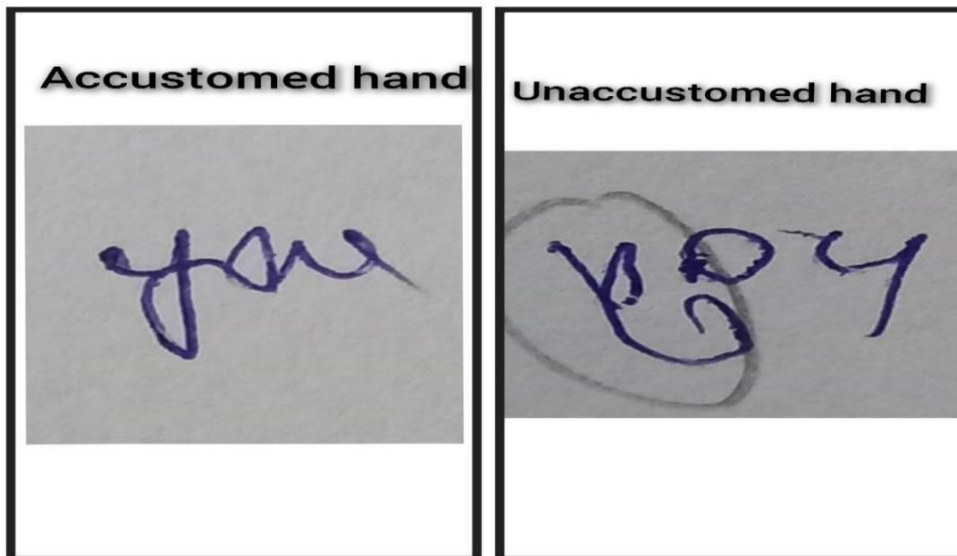
### 5.4.Character “e”



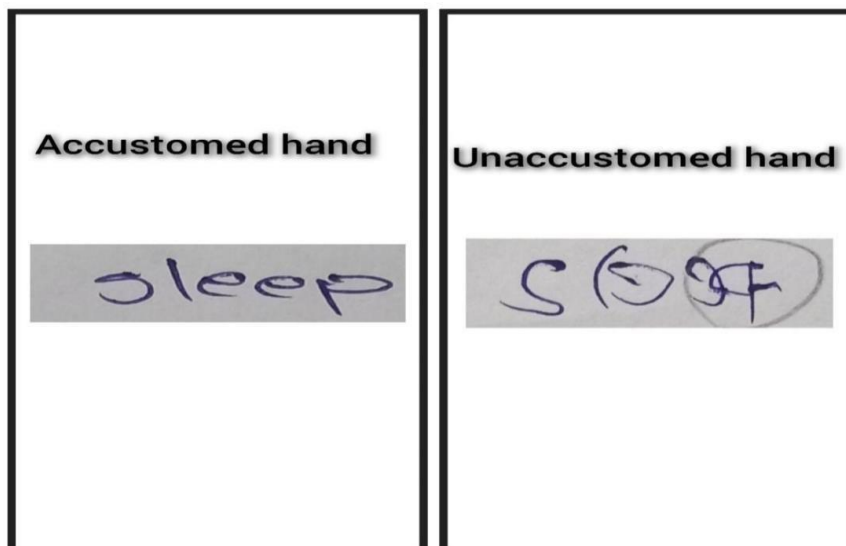
### 5.5.Character “c”



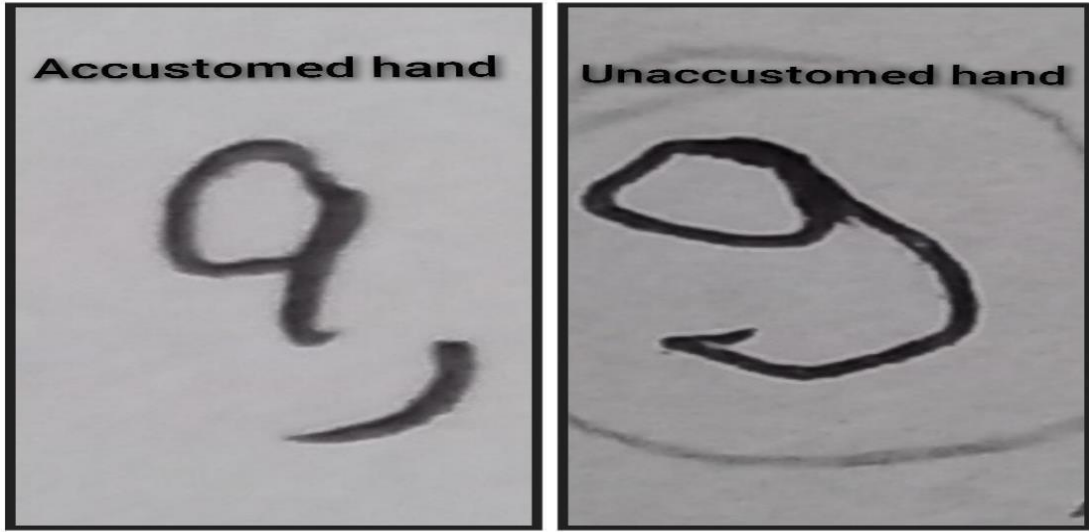
### 5.6.Character “y”



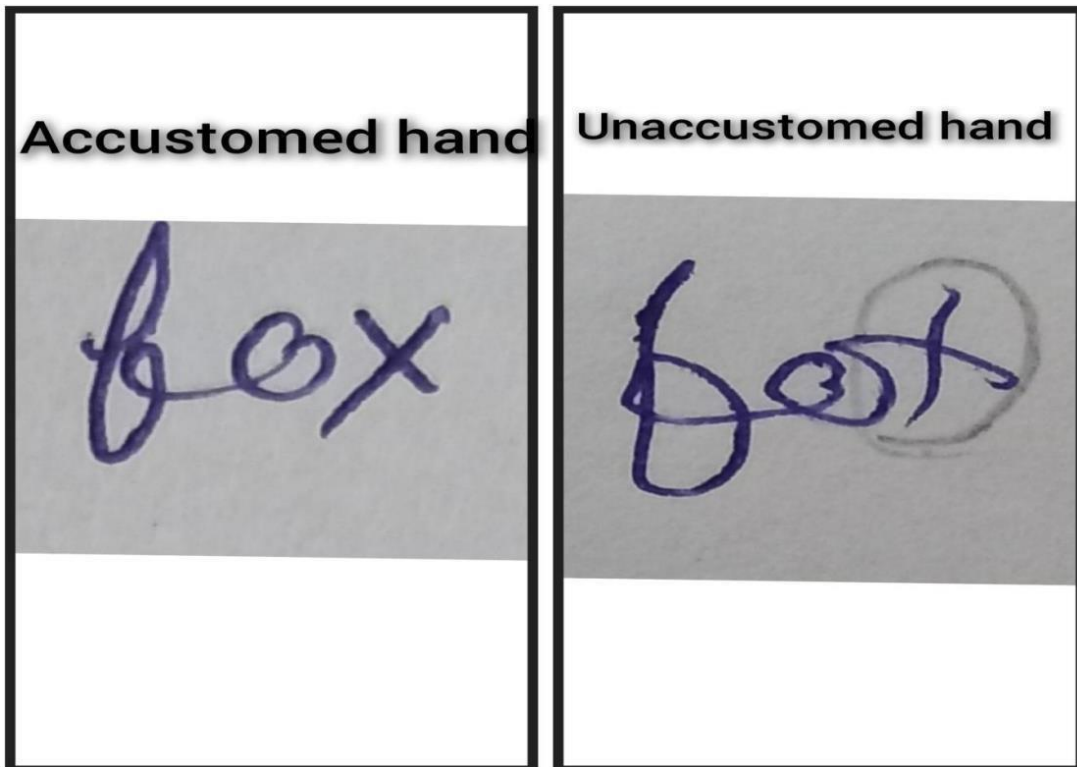
### 5.7.Character p/e



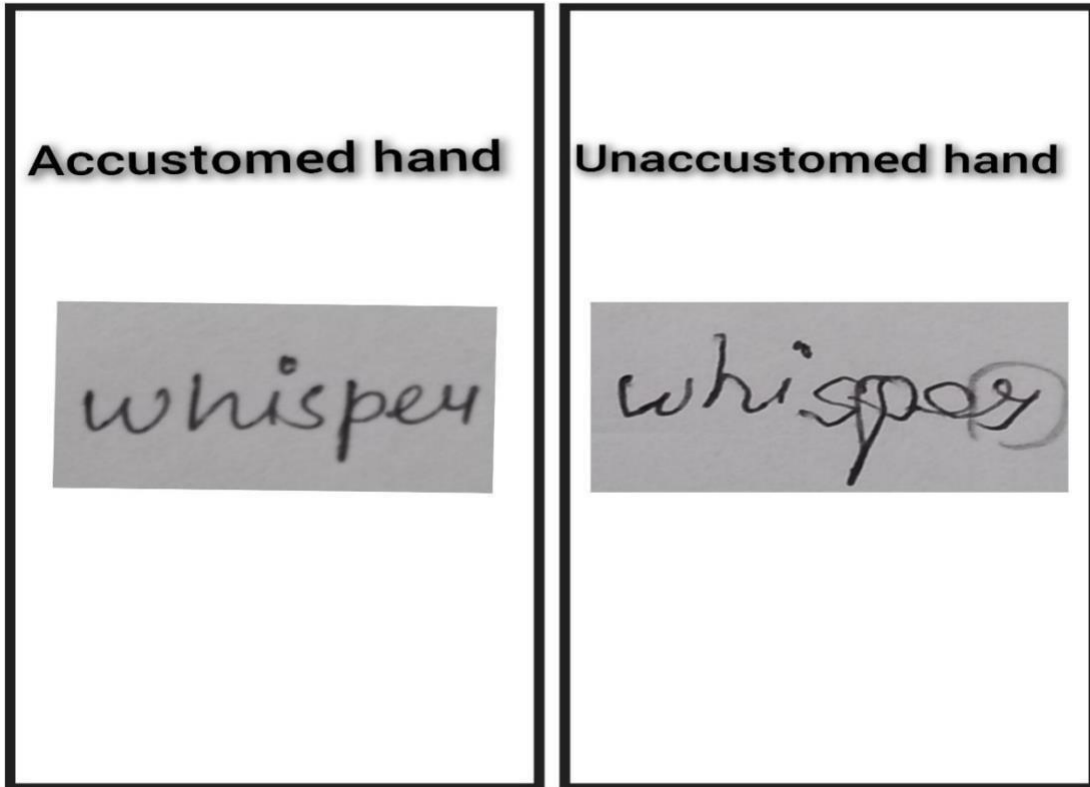
5.8. Numeral - “9”



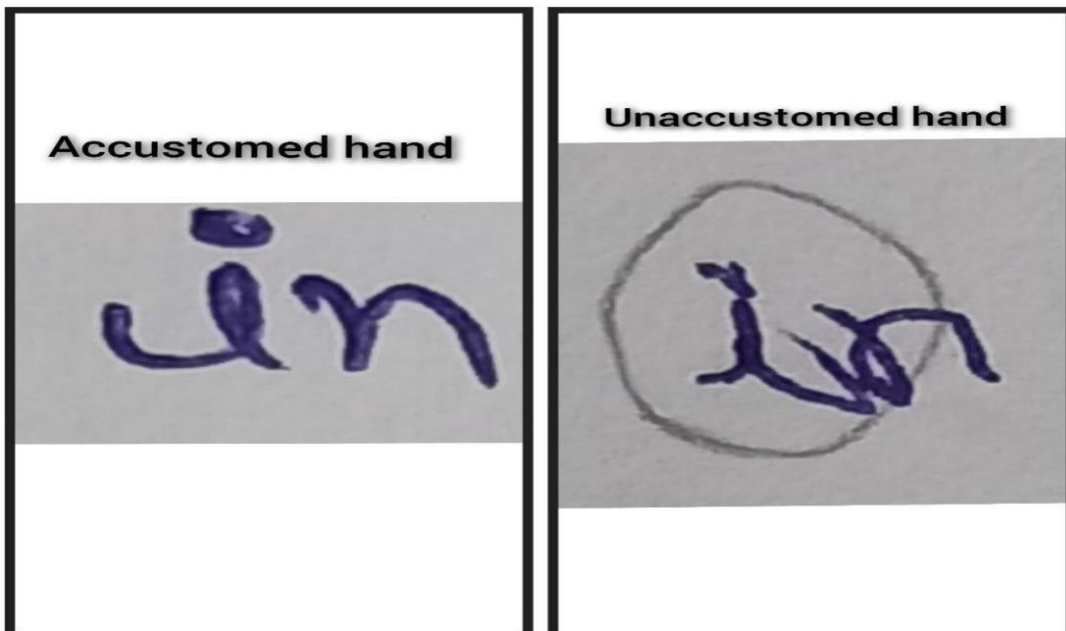
5.9. Character “x”



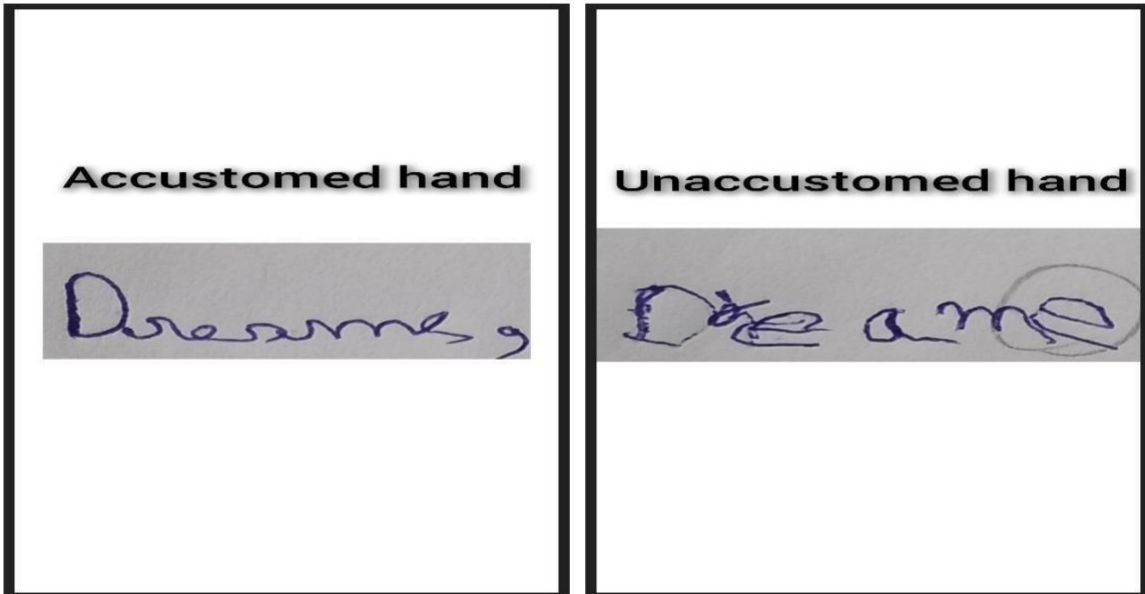
5.10. Character “r”



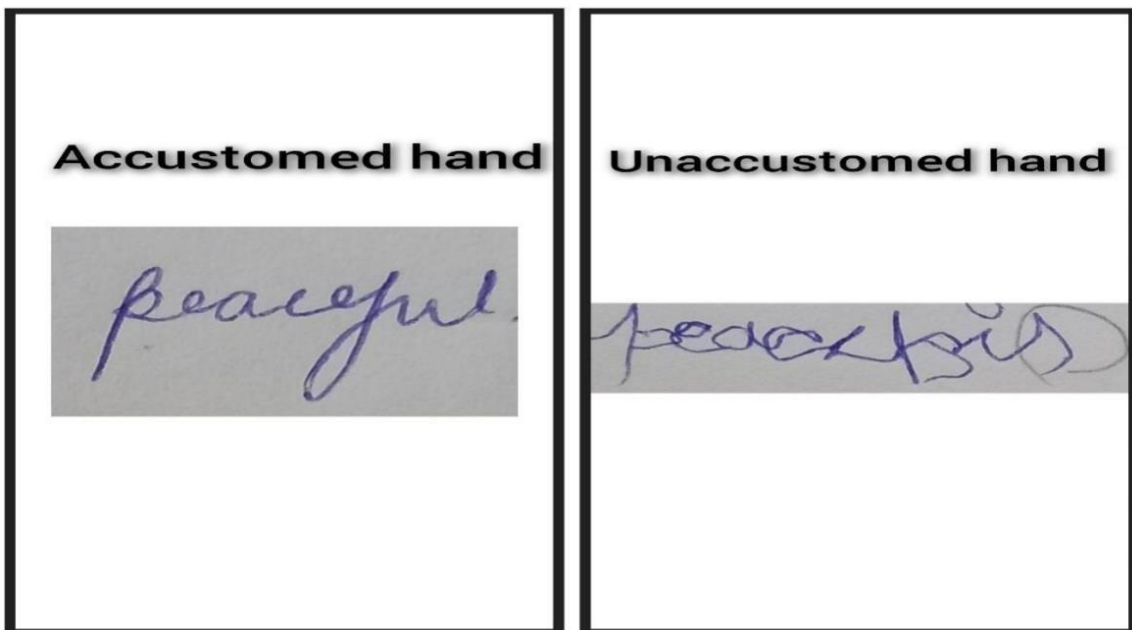
5.11. Character “i”



5.12. Character “s”



5.13. Character “l”



**UNACCUSTOMED HAND**

**Sample analysis**

**1. List of mirrored characters observed:**

Sample no.	Mirrored Characters	Non-mirrored Characters
1	t, x, f, p, e	all except the ones mentioned under mirrored characters
2	t	all except the ones mentioned under mirrored characters
3	t, l, d, y	all except the ones mentioned under mirrored characters
4	t	all except the ones mentioned under mirrored characters
5	f, 9	all except the ones mentioned under mirrored characters
6	N/A	N/A
7	N/A	N/A
8	c, 9	all except the ones mentioned under mirrored characters
9	q, t	all except the ones mentioned under mirrored characters
10	t, f, g, y, 9	all except the ones mentioned under mirrored characters
11	N/A	N/A
12	g, r	all except the ones mentioned under mirrored characters
13	i	all except the ones mentioned under mirrored characters
14	e	all except the ones mentioned under mirrored characters

15	d, l	all except the ones mentioned under mirrored characters
16	f, t, e	all except the ones mentioned under mirrored characters
17	t	all except the ones mentioned under mirrored characters
18	t	all except the ones mentioned under mirrored characters
19	s, r, e	all except the ones mentioned under mirrored characters
20	t, l, s	all except the ones mentioned under mirrored characters
21	t, f	all except the ones mentioned under mirrored characters
22	t	all except the ones mentioned under mirrored characters
23	t	all except the ones mentioned under mirrored characters
24	N/A	N/A
25	N/A	N/A
26	t, d	all except the ones mentioned under mirrored characters
27	s	all except the ones mentioned under mirrored characters
28	t	all except the ones mentioned under mirrored characters
29	N/A	N/A
30	t	all except the ones mentioned under mirrored characters

31	p	all except the ones mentioned under mirrored characters
32	N/A	N/A
33	t	all except the ones mentioned under mirrored characters
34	t	all except the ones mentioned under mirrored characters
35	t	all except the ones mentioned under mirrored characters
36	t	all except the ones mentioned under mirrored characters
37	t	all except the ones mentioned under mirrored characters
38	t, e	all except the ones mentioned under mirrored characters
39	t	all except the ones mentioned under mirrored characters
40	t	all except the ones mentioned under mirrored characters
41	t, d	all except the ones mentioned under mirrored characters
42	t	all except the ones mentioned under mirrored characters
43	t	all except the ones mentioned under mirrored characters
44	t	all except the ones mentioned under mirrored characters
45	t, g	all except the ones mentioned under mirrored



		characters
46	t	all except the ones mentioned under mirrored characters
47	t	all except the ones mentioned under mirrored characters
48	N/A	N/A
49	N/A	N/A
50	N/A	N/A

**2. Number (No.) of times mirrored characters observed:**

S. No.	Character/numeral	No. Of samples character/numeral found mirrored
1	t	31
2	d	4
3	f	5
4	g	3
5	e	5
6	c	1
7	y	2
8	p	2
9	x	1
10	Numeral 9	3
11	i	1
12	r	2
13	s	3
14	l	3
15	No mirrored character	10

**Result:** All samples were analyzed to find out the most repeated character in all collected samples.

**6. Summary and Conclusions**

After analyzing all 50 samples, the character “t” which was found in almost 31 samples out of 50 samples that were taken. Characters “f” and “e” were found in 5 samples each. Character “d” was found in 4 samples. Characters “g”, “l”, “s” and numeral-9 were found in about 3 samples each. Characters “y”, “p”, and “r” were found in 2 samples each. Characters “x”, “c”, “i” were found in 1 sample each. In about 10 samples there were no mirrored characters at all.

In conclusion, the most repeated character was found to be character “t”. Other characters such as - “f”, “e” and “d” were found to be repeated a couple of times as well.

Writing with the unaccustomed hand produces poor quality writing that some writers feel is an effective

disguise because the pictorial effect of other handwriting is considerably different than the accustomed hand, writers feel safe in using this method. Lack of muscle control of the unaccustomed hand will cause poor line quality and poor rhythm as well. Tremor may be present. Abrupt changes of direction may be seen in the loops and circle letters. The baseline will be uneven. Mirrored letter forms may be found. Many of the writers' normal characteristics of writing will be present in the other handwriting because handwriting is a brain writing, that is, the brain directs the movement. Many handwriting characteristics will carry over to the non-dominant hand.

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