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Variations in Handwriting Characteristics due to Different Grip Patterns

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Abstract:

The identification of the writer group attributes like gender, age and handedness from handwriting is an important goal in forensic studies field. In most criminal cases where handwriting is used as evidence where few handwritten characters extracted from tax form, ransom letters, anonymous letters, wills etc. are the disposal of the forensic document examiner. The analysis of handwritten documents from the view point of determining the writer has great bearing on the criminal justice system. A writer's identity cannot be established through a single individual or general feature in the writing. Rather, identity is established through a combination of the significant features of writers. In order to analyze and identify a handwritten document "grip" also play an important role which give a particular type of handwriting with different handwriting characteristics. This can help a document expert to eliminate a suspect or group of suspects on the basis of their grip pattern.

Keywords: *Handwriting characteristics, Questioned documents, Grip pattern, Handwriting, Handwriting variations*

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Introduction

All handwriting exhibits identifying features which will hereafter be referred as its "characteristics". The characteristics of handwriting fall into two classes these are:

1. Those derived from the general style to which the handwriting conforms, termed as "style characteristics" and
2. Those which have been introduced into the handwriting, whether consciously or unconsciously by the writer. These will be referred to as personal characteristics.

A handwriting comparison is generally made between the known standards and suspected document in order to establish that the writings are consistent, replete with individual handwriting habits and identifiable with each other. If all three criteria are met and the questioned writing is contemporaneous to the known standards that are supplied, positive identification of authorship or non-authorship can normally be made.
Pencil grasp is a term used to describe the position of the fingers involved in grasping a pencil. Two distinct types of grips, described by **Napier (1956)** as a power grasp or a precision grasp. A power grasp clamps the object between the fingers and the palm with the thumb in the same plane as the fingers. A precision grasp pinches the object between the fingers and the thumb with the thumb in opposition to the fingers.

There are generally two kinds of pencil or pen grip as described by **Selin (2003)**

1. **Efficient grip** –This type of grip include:

a) A dynamic tripod grasp consists of the ring and pinkie finger being tucked into the palm of the hand with the thumb and index finger pinching the writing utensil and the middle finger supporting the underside of the writing utensil.

b) A lateral tripod grasp resembles the dynamic tripod with the thumb crossing and bracing the pencil on the pencil on the side of the index finger. The wrist has more extension

c) A dynamic quadrupod grasp consists of the finger being tucked into the palm of the hand with the thumb, index and middle finger pinching the writing utensil and the ring finger supporting the underside of the writing utensil.

d) Static Tripod-grasps resembles the dynamic tripod in structure. However, when the writing student will demonstrate the movement of the entire arm instead of individualized finger

e) The most commonly used pencil grasp is termed the (dynamic) tripod grasp **(Wynn and Parry, 1966)**, which involves the thumb, index and middle fingers functioning a tripod. This grasp allows small, well-coordinated movements of the involved finger **(Ziviani and Elkins, 1986).**

2. **Inefficient grip –**

a) Fisted- grasp consists of fingers and thumb being wrapped around the pencil with the pencil being held in the vertical position

b) Thumb Wrap-grasp consists of tight wrapping of the thumb around the pencil to try to increase grasp stability. Results include tightness and pain of the thumb and webspace and fatigue in handwriting

c) Index- grasp consists of writing instrument being stabilized by the pads of the thumb and finger. The movement of the writing instruments stems from the pad of the middle finger and the side of the index.

d) An adapted tripod grasp is another grasp. This grasp consists of placement of the pencil in the space between middle and index fingers supported by the thumb, index and middle fingers. This grasp is beneficial for those with weak hand muscles **(Summers, 2001)**.

Tseng (1998) also described four major types of grip pattern which can be frequently seen among the population which are as follows

a) The dynamic tripod pencil grip
b) The dynamic quadrupod pencil grip
c) The lateral tripod pencil grip
d) The lateral quadrupod pencil grip

The identification of the writer group attributes like gender, age and handedness from handwriting is an important goal in the forensic studies field. In most criminal cases where handwriting is used as evidence few handwritten characters extracted from tax forms, ransom letters, anonymous letters, wills etc. are at the disposal of the forensic document examiner. In these cases, the knowledge of the individual discriminatory, as well as some of the general discriminatory characters, can be used to estimate the validity of the writer verification and identification task to improve their accuracy **(Briggs, 1970)**.

Gardner (1997) Suggested that there are 12 handwriting characteristics that an expert considers during handwriting examination:

- Line quality
- Spacing of word and letters
- Ratio of the relative height, width and size of letters.
- Pen lifts and separations
- Connecting strokes
- Beginning and ending strokes

- Unusual letter formation
- Shading or pen pressure
- Slant
- Base habits
- Flourishes and embellishments
- Diacritic placement

A writer's identity cannot be established through a single individual or general feature in the writing. Rather, identity is established through a combination of the significant features of writers, with no significant differences. The analysis of handwritten documents from the viewpoint of determining the writer has a great bearing on the criminal justice system. Handwriting and hand printing identifications have been performed since the late 1800's. Since each person's handwriting and hand printing habits are unique, it can be established whether someone wrote a certain word, initials, signature or document. No other crime is as prevalent in our society as the crime related to documents. Crimes with guns, bombs and other crimes of violence draw the attention of media and the public; however, crimes committed with documents involve billions of dollars and accurately have a great impact on our global economy. In order to analyze and identify a handwritten document "grip" also play an important role which gives a particular type of handwriting with different handwriting characteristics. This can help a document expert to eliminate a suspect or group of suspects on the basis of their grip pattern

Review of Literature

Napier (1956) suggested that Stability, which in the normal hand can be achieved by a precision grip or a power grip, is a pre-requisite for all refinements of hand function. In the precision grip the object, *e.g*. the pencil, is pinched between the flexor aspects of the finger and the opposition of the thumb. In the power grip the fingers and the palm, and the thumb lying more or less in the plain of the palm, hold the pencil Napier's method of classifying prehensile movements are based on the anatomical and functional distinction between these two discrete patterns.

Callewaert (39-54) used detailed descriptions of the index finger to classify grips resulting in skilful or defective handwriting. The index finger plays a crucial role in skilful writing by being dependent on the coordination and the movements of the hand. The index finger has the same position in both the usual type and in the combined type.

Jacobson and Sperling (1976) developed a method of classification by which hand grips can be verbally described in great detail, thus enabling small differences between types of grip which are similar in principle. By means of a code system each handgrip can be described in the form of a code consisting of designations for the different variables which together define the handgrip. The method has been tested in a pilot study in which six subjects with normal hand function participated. The experiments were filmed and the hand grips coded; the coded material was then submitted to automatic data processing. The study showed that using the method described it is possible to classify and evaluate a large quantity of information concerning the function of the healthy and injured hand.

Rosenbloom and Horton (1971) observed both the hand posture and the movements of 128 children from one-and-a-half to seven years of age while the children were drawing. The study described both the finger postures of the dynamic tripod pencil grip and also the intrinsic movements that make the grip dynamic instead of static. There is a variation in the development of the pencil grip both in the order of appearance of grips and in whether they appear at all.

Schneck (1991) investigated the developmental progression in pencil and crayon grip in 320 non-dysfunctional children aged 3 years to 6 years 11 months. Their cross-sectional study gives a guideline for understanding the normal fine motor development in children. The developmental progression was shown by the increasing percentage of children at each age level using both the dynamic and the lateral tripod grips, which are considered mature grips. The percentages of children using such grips ranged from an initial level of 48 percent of the youngest three-year-olds to 90 per cent of the oldest children aged seven years.

Ziviani and Elkins (1986) described how the speed and legibility of fourth grader's handwriting was affected by the type of pencil grip on the evaluation tool of children's handwriting. It described that out of 99 students 38 students have dynamic tripod grip,22 have lateral tripod grip and 21 have lateral quadrupod grip which concluded that lateral quadrupod and four-finger grips to be as functional as a dynamic tripod, dynamic quadrupod and lateral tripod .

Benbow (255–81) gave an explanation for the existence of non-normative pencil grips, which differ from the observed developmental patterns, could be that the hand is seeking stability, which is lacking as a result of premature writing. When the hand is not mature enough to adopt the dynamic tripod grip, it spontaneously deals with the situation by finding other functional grips. As the hand seeks stability, positions like instability in the meta carp phalangeal joint of the

thumb and a collapsed web in an immature hand will cause the hand to seek spontaneous adaptations such as a thumb wrap or thumb tuck grip Another adaptation described in is a narrowed space between the index and the third finger, which also increases the stability of the grip. These interpretations support the conclusions that stability is a prerequisite for the functional pencil grip and that stability can be gained either by positioning the fingers in different pencil grip configurations or by force.

Selin (2003) introduced a descriptive two-dimensional model for the categorization of pencil grip suitable for research applications in a classroom setting. The model is used in four empirical studies of children during the first six years of writing instruction

Schwellnus (2012) did a large study to evaluate the kinetics of pencil grasp patterns in terms of speed and legibility of handwriting of children. He suggested that the dynamic tripod pencil grasp as an optimal pencil grasp for handwriting. His research findings also suggested that three other pencil grasps may be functional for handwriting, though there was still inconclusive evidence upon which to base clinical practice

Objectives

1. To analyze and characterize variable handwriting features.
2. To compare the handwriting features of the disguised grip pattern with the genuine grip pattern.

Hypothesis considered for the study

• **H0 (Null Hypothesis**) – There are no significant variations in the handwriting characteristics due to different grip patterns.

• **H1 (Alternate Hypothesis)** – There are significant variations in the handwriting characteristics due to different grip patterns.

Materials and Methods

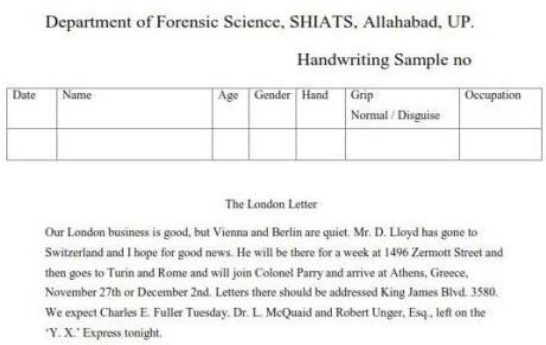
The present work was carried out at the document laboratory of the Department of Forensic Science, SHIATS.

The materials used for the present work are as follows:

1. Magnifying hand lens
2. Ruler
3. Slant scale
4. 3 mm Grid
5. Digital camera
6. Markers
7. Digital Imaging scanner
8. Stereoscopic Microscope
9. Handwriting Sample

Collection of Samples

Handwriting samples were collected from the volunteers having ample writing experience. The writing instrument and surface have been kept the same for each student and only the handwriting of right-handed writers have been taken into consideration. For the present study in total 130 samples were collected from the 65 volunteers. Two samples have been collected from each volunteer out of which one was their genuine grip writing pattern and the other was their disguised grip writing pattern. Volunteers were requested to write the same paragraph given on their sample collection format sheet.



Department of Forensic Science, SHIATS, Allahabad, UP.

Handwriting Sample no

Date	Name	Age	Gender	Hand	Grip Normal / Disguise	Occupation

The London Letter

Our London business is good, but Vienna and Berlin are quiet. Mr. D. Lloyd has gone to Switzerland and I hope for good news. He will be there for a week at 1496 Zermott Street and then goes to Turin and Rome and will join Colonel Parry and arrive at Athens, Greece, November 27th or December 2nd. Letters there should be addressed King James Blvd. 3580. We expect Charles E. Fuller Tuesday. Dr. L. McQuaid and Robert Unger, Esq., left on the 'Y. X.' Express tonight.

Figure No. 1: London Letter

Photography of grips

While the collection of handwriting samples photographs of writers were taken and saved in order to protect its evidential value as well as for future classification purposes as a dynamic tripod, dynamic quadrupod, lateral quadrupod, adaptive grip etc.

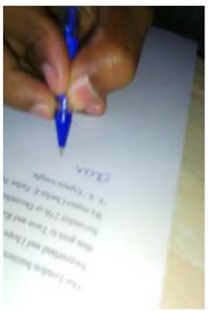


Figure No. 2: Dynamic Tripod

Figure No. 3: Dynamic Quadrupod

Preservation of sample

The sample after the collection was preserved properly in transparent plastic folders so that it could not be torn from edges and to avoid any harm to it.

Classification of samples into different grips

The samples after collection were matched with their individual photographs and were classified into different grip patterns as-

a) The dynamic tripod pencil grip
b) The dynamic quadrupod pencil grip
c) The lateral tripod pencil grip
d) The lateral quadruped pencil grip.

Preliminary examination of handwriting samples

The handwriting samples were closely observed for the various characteristics features of the handwriting with special reference to variation in the handwriting of writers of different grips. Some major features observed are:-

1. **Pictorial effect**- The pictorial effect of the handwriting is the appearance of handwriting which gives an idea about the skill of the writer

2. **Line quality**- Line quality generally tells about the pen marks in handwriting that are they smooth and free-flowing or shaky and wavering?

3. **Rhythm**- It is indicated by the flow of writing, correct line quality and punctuation and proportionate formation of letters and figures. It is the product of reading and writing experience and cannot be imitated.

4. **Style**-Style depends upon the initial training but it gets modified according to individual and adoption of certain forms which appeals to the individual. It can be round, angular or a mixture of two, artistic or simple.

5. **Word alignment**-The baseline in a handwritten document is the ruled or imaginary line on which the writing rests. Some individuals have acquired the habit of placing all written words above, below or parallel to the baseline. In most cases, however, only certain letters or letter combinations are misaligned rest of the letters are placed on the baseline. This can be determined by drawing an imaginary line and observing the alignment of writing.

6. **Slant**-One of the most obvious features in an individual's handwriting is the slope or slant. Writers who intentionally alter the slope of their writing cause a dramatic change to the appearance of letters. Gross changes in writing slant are relatively easy to achieve, slight changes in the slope are exceedingly difficult to maintain. It is observed on the basis of left slant, right slant, or vertical slant more over with help of protractor keeping on letters containing upper loops: the b, d, h, 1, k, and t which gives the idea about the slant.

7. **Spacing**-The space between letters, words, lines etc. when they are handwritten. Reveals lots of information about the writer of the document essentials for the shortlisting of the culprit. This can be determined by measuring the distance between the words or paragraphs with the help of a ruler. It can be divided into three categories, values less than 0.6 are said to have minimum spacing, values lying in the range greater than 0.6-0.8 are said to have medium spacing whereas values greater than 0.8 are said to have maximum spacing characters.

8. **Letter size ratio**- It is the ratio of the size of large letters to the size of small letters. It can be determined with the help of a grid or graph by keeping the graph on upper-zone letters (small letters) b, d, h, k, /, and t and the lower-zone letters (large letters) are the g, j, p, q, y, and z and finding the number of the grid in which they fall. The average of both lower and upper zone is calculated and represented in its ratio. It can be divided into three categories values ranging from 0-3:0-1 are said to have a smaller letter size ratio, values ranging from 4-5:2-3 are said to have a medium letter-size ratio whereas values greater than 6: greater than 3 are said to have a large letter size ratio.

9. **Pen lifts and separations**-It means the person stops to form new letters and begin words. Forgeries may have lifts in unusual places.

10. **Speed**-It is the amount of time taken by a person to write. Speed is generally inversely proportional to the pen lifts i.e. the more the pen lift the less is the speed. In order to find out the speed, the average of the pen lifts in words were calculated. Speed can be observed as fast, medium, slow. It can be divided into three categories according to their ranges i.e. values ranging from1-3 were said to have fast speed, values ranging from 4-7 were said to have medium speed whereas values greater than 7 were said to have slow speed.

11. **Diacritic placement**-It generally tells how the t Are's crossed, how I's are and j's dotting is done.

12. **Pen pressure**- This is the amount of pressure applied by the writer to write which at a preliminary level is generally analysed by the amount of indentation on the backside of the writing.

Chi-square test

Chi-square is a statistical test commonly used to compare observed data with data we would expect to obtain according to a specific hypothesis Were the deviations (differences between observed and expected) the result of chance, or were they due to other factors. How much deviation can occur before you, the investigator must conclude that something other than chance is at work, causing the observed to differ from the expected. The chi-square test is always testing what scientists call the null hypothesis, which states that there is no significant difference between the expected and observed results.

The formula for calculating chi-square is –

$$X^2 = \sum (O-E)^2 / E$$

Where,
O = the frequencies observed
E = the frequencies expected
∑= the sum

P-Value

The p-value is the level of marginal significance within a statistical hypothesis test, representing the probability of the occurrence of a given event. The p-value is used as an alternative to rejection points to provide the smallest level of significance at which the null hypothesis would be rejected. For typical analysis, using the standard $\alpha = 0.05$ cut-off, a widely used interpretation is:

A small p-value (≤ 0.05) indicates strong evidence against the null hypothesis, so it is rejected.

A large p-value (≥ 0.05) indicates weak evidence against the null hypothesis (fail to reject).

P-values very close to the cut-off (~ 0.05) are considered to be marginal (need attention). So, the analysis must always report the p-value.

Results and Discussion

In this study, total 130 samples were collected from the 65 volunteers. Two samples have been collected from each volunteer out of which one was their genuine grip writing pattern and the other was their disguised grip writing pattern. The general handwriting characteristics of different grips were analysed and evaluated.

Evaluation of characteristic features for Dynamic tripod grip pattern

In this study, 27 samples of dynamic tripods were studied. The general characteristics features like slant, alignment, word spacing, letter size ratio and speed were observed and their chi-square values were calculated.

Table No. 1: Evaluation of general handwriting characteristics features for dynamic tripod grip pattern

Features	Category	Percentage	Chi square (x^c)	Tabulated value (x^t)	P value	Degree of freedom	Significant/ Nonsignificant
Slant	Left	11.11	11.55	5.99	0.0031	2	S
	vertical	25.925					
	Right	62.96					
Alignment	upward	77.77	24.88	5.99	0.00001	2	S
	downward	3.70					
	parallel	18.51					
Speed	Fast	55.55	9.55	5.99	0.00844	2	S
	medium	37.03					
	Slow	7.40					

Features	Category	Percentage	Chi square (x^c)	Tabulated value (x^t)	P value	Degree of freedom	Significant/ Nonsignificant
Spacing	minimum	11.11	9.55	5.99	0.00844	2	S
	medium	59.25					
	maximum	29.62					
Letter size ratio	Small	0	20.22	5.99	4.10E-05	2	S
	Medium	70.37					
	Large	29.62					

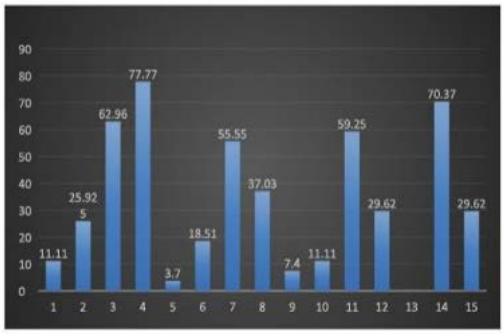


Figure No. 4: Bar graph for percentage evaluation general characteristics of dynamic tripod grip pattern

Figure No. 5: Dynamic Tripod grip pattern

1. **Slant**: It refers to the angle of inclination of writing or a letter of writing from the baseline of that writing. It may be forward and leaning to the right, or "backhand" if it leans to the left. The slant of writing may change from the beginning of a word to the end of a word, or from the beginning of a sentence, paragraph, or page to the end of that sentence, paragraph, or page. The SLANT of the writing indicates the Emotional Response. Letter slant can best be seen in letters containing upper loops: the b, d, h, 1, k, and t. the more the letter slant leans toward the right, the more emotional response can be expected. Most people write with a right slant the same was observed in the study as in 62.96 % samples had right slant were, 25.92 % samples had vertical slant and 11.11 % samples had left slant. The statistical analyses were carried out using Chi-square which is commonly used to compare observed data with expected data. The Chi-square value and the p-value calculated was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

2. **Alignment**: This is simply the relationship of the questioned writing to a baseline. It is the adherence of the writing to either a preformed (printed) or imaginary baseline. The writing may slant upward, downward, be concave or convex, or have a pattern of changes for different words, word portions, or signatures. It may follow the baseline, or go through the baseline, or be irregular with regard to the baseline. It was found that most writers had upward alignment i.e. 77.77%, 18.51 % writers had parallel alignment while 3.70 % writers had downward alignment. The statistical analyses were carried out using Chi-square which is commonly used to compare observed data with expected data. The Chi-square value and the p-value calculated was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

3. **Speed**: Speed is found in the flow of the writing and indicates the speed of thought, action and perception. Additionally, writing that has few or no beginning strokes shows the stripping away of unnecessary details contributing to the applicant's efficiency in handwriting. It is related to the pen lifts by the writer. The more the pen lifts the less is the speed. It was noted that the speed of most of the writers was fast, 55.55% writers speed was fast which is because most of the writers were experienced and skilled. 37% writers had medium speed while 7.5% writers speed was observed slow. The statistical analyses were carried out using Chi-square which is commonly used to compare observed data with expected data. The Chi-square value and the p-value calculated was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

4. **Letter Size Ratio**: Every letter takes up space, too. Some letters extend into the upper area of the writing and are referred to as upper-zone letters: b, d, h, k, /, and t. The lower-zone letters are the g, j, p, q, y, and z. Most letters are found in the middle zone of writing. The size of the middle zone is the major factor considered in handwriting analysis. Almost all other signs are compared to it. f is the only letter that reaches all three zones. Most people's script falls somewhere in medium size. According to the observations from the study, most writer's letters size was of medium size i.e. 70% and 30% writer's letter-size ratio was large while none of the writer's letter-size ratio was observed small. The parameters for the measurement of letter-size ratio were mentioned in material

methods. The statistical analyses were carried out using Chi-square which is commonly used to compare observed data with expected data. The Chi-square value and the p-value calculated was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

5. **Spacing**: Spaces are found around the whole page of writing in the amount of room that the letters take up in the generous or compressed usage of space between letters, lines, and words. The spacing between words was calculated in this study according to the method mentioned in the material and methods. It was found that in 59.25% writers sample spacing was medium while in 29.62% samples spacing was maximum and spacing in 11.11% samples were minimum. The statistical analyses were carried out using Chi-square which is commonly used to compare observed data with expected data. The Chi-square value and the p-value calculated was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

Evaluation of characteristics features for Dynamic Quadrupod grip pattern

In this study, 18 samples of dynamic quadrupod were studied. The general characteristics features like slant, alignment, word spacing, letter size ratio and speed were observed and their Chi-square values were calculated.

Table No. 2: Evaluation of general handwriting characteristics features for dynamic quadruped grip pattern

Features	Category	Percentage	Chi square (x^2)	Tabulate d value (x^2)	P value	Degree of freedom	Significant/ Non-significant
Slant	Left	16.66	6.33	5.99	0.0421	2	S
	Vertical	22.22					
	Right	61.11					
Alignment	Upward	72.22	14.33	5.99	0.0007 7	2	S
	Downward	0					
	Parallel	27.77					
Speed	Fast	66.66	9	5.99	0.0111	2	S
	Medium	16.66					
	Slow	16.66					
Spacing	Minimum	16.66	6.33	5.99	0.0042 2	2	S
	Medium	61.11					
	Maximum	27.77					
Letter size ratio	Small	0	14.33	5.99	0.0007 7	2	S
	Medium	72.22					
	Large	27.77					

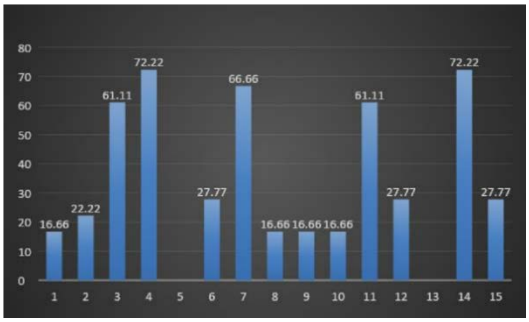


Figure No. 6: Bar graph for percentage evaluation of general characteristics for dynamic quadrupod grip pattern

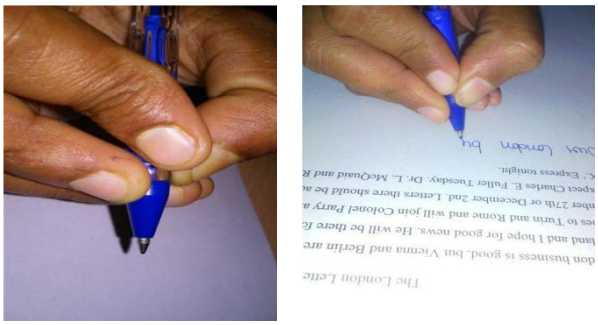


Figure No. 7: Dynamic quadrupod grip

1. **Slant:** In the study it is observed that 61.11 % samples had a right slant, 22.22 % samples had vertical slant and 16.66% samples had left slant. The statistical value was calculated for Chi-square and the p-value was more than the tabulated value. There accept the alternate hypothesis which states that there is a significant difference between the expected and observed results.

2. **Alignment**: In the study it was found that most writers had upward alignment i.e. 72.22%, 27.77% writers had parallel alignment while none of the writers had downward alignment. . The statistical value calculated for Chi-square and the p-value was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

6. **Speed**: In the study it was observed that the speed of most of the writers was fast, 66.66% writers speed was fast which is because most of the writers were experienced and skilled 16.66%writers had medium speed while 16.66% writers speed was observed slow. The statistical value calculated for Chi-square and the p-value was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

7. **Letter Size Ratio**: In the study, it was found that most writer's letters size were of medium size i.e. 72.22% and 27.77% writer's letter-size ratio were large while none of the writer's letter-size ratio was observed small. The statistical value was calculated for Chi-square and the p-value was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

8. **Spacing**: In the study, it was found that in 61.11% of writers sample spacing were medium while in 27.77% samples spacing was maximum and spacing in 16.66% samples were minimum. The statistical value was calculated for Chi-square and the p-value was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

Evaluation of characteristics features for lateral quadrupod grip pattern

In this study 15 samples of lateral quadrupod were studied. The general characteristics features like slant, alignment, word spacing, letter size ratio and speed were observed and their chi-square values were calculated.

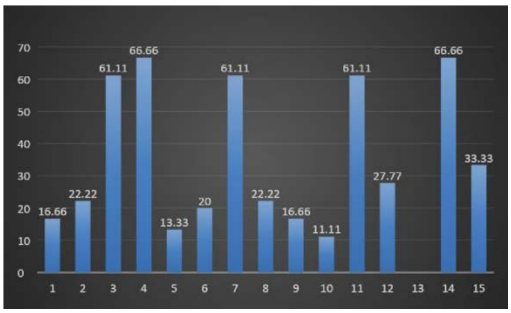


Figure No. 8: Bar graph for percentage evaluation of general characteristics for lateral quadrupod grip pattern

Figure No. 9: Lateral quadrupod

Table No. 3: Evaluation of general handwriting characteristics features for lateral quadrupod grip pattern

Features	Category	Percentage	Chi square (x^2)	Tabulated value (x^2)	P value	Degree of freedom	Significant/ Non-significant
Slant	Left	16.66	8.2	5.99	0.0166	2	S
	Vertical	22.22					
	Right	61.11					
Alignment	Upward	66.66	10.33	5.99	0.0057	2	S
	Downward	13.33					
	Parallel	20					
Speed	Fast	61.11	6.33	5.99	0.0421	2	S
	Medium	22.22					
	Slow	16.66					
Spacing	Minimum	11.11	7	5.99	0.0302	2	S
	Medium	61.11					
	Maximum	27.77					
Letter size ratio	Small	0	12	5.99	0.0025	2	S
	Medium	66.66					
	Large	33.33					

1. **Slant**: In the study, it was observed that 61.11 % samples had right slant were 22.92 % samples had vertical slant and 16.22 % samples had left slant. The statistical value was calculated for Chi-square and the p-value was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

2. **Alignment**: In the study, it was found that most writers had upward alignment i.e. 66.66 %, 20 % writers had parallel alignment while 13.33 % writers had downward alignment The statistical value calculated for Chi-square and the p-value was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

3. **Speed**: In the study it was found that the speed of most of the writers was fast, 61.11% writers speed was fast which is because most of the writers were experienced and skilled. 22.22% writers had medium speed while 16.66% writers speed was observed slow. The statistical value calculated for Chi-square and the p-value was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

4. **Letter Size Ratio**: In the study, it was observed that most writer's letters size was of medium size i.e. 66.66 and 13.33 writers letter-size ratio was large while none of the writer's letter-size ratio was observed small. The statistical value was calculated for Chi-square and the p-value was more than the tabulated value. There accept the alternate hypothesis which states that there is a significant difference between the expected and observed results.

5. **Spacing:** In the study, it was found that in 61.11% writers sample spacing were medium while in 27.77% samples spacing were maximum and spacing in 11.11% samples were minimum The statistical value calculated for Chi-square and the p-value was more than the tabulated value. There accepting the alternate hypothesis which states that there is a significant difference between the expected and observed results.

Evaluation of characteristics features of adaptive grip pattern

In this study, 5 samples of adaptive grip were studied. The general characteristics features like slant, alignment, word spacing, letter size ratio and speed were observed and their percentage was calculated. The statistical analysis could not be carried out due to a lack of the minimum requirement of samples.

Table No. 4: Evaluation of general handwriting characteristics features for adaptive grip pattern

Features	Category	Percentage
Slant	Left	0
	Vertical	40
	Right	60
Alignment	Upward	60
	Downward	20
	Parallel	20
Speed	Fast	80
	Medium	20
	Slow	0
Spacing	Minimum	40
	Medium	20
	Maximum	40
Letter size ratio	Small	0
	Medium	60
	Large	40

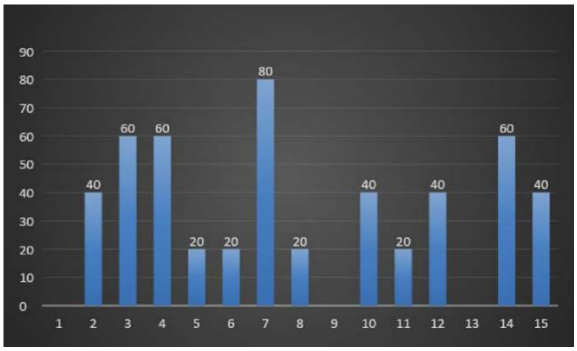


Figure No.10: Bar graph for percentage evaluation of general characteristics for adaptive grip pattern

Figure No. 11: Adaptive grip

1. **Slant:** In the study it is observed that 60 % samples had right slant were, 40 % samples had vertical slant and none of the samples had left slant. The statistical analysis cannot be carried out for this grip since the numbers of samples found were less in numbers in order carry out their chi-square and p-value analysis.

2. **Alignment:** In the study It was observed that most writers had upward alignment i.e. 60%, 20 % writers had parallel alignment while 20% writers had downward alignment. The statistical analysis cannot be carried out for this grip since the numbers of samples found were less in numbers in order to carry out their chi-square and p-value analysis.

3. **Speed:** In the study it was observed that speed of most of the writers was fast, 80% writers speed was fast which is because most of the writers were experienced and skilled. 20% writers had medium speed while none of the writers speed was observed slow. The statistical analysis cannot be carried out for this grip since the numbers of samples found were less in numbers in order to carry out their chi-square and p-value analysis.
4. **Letter Size Ratio:** In the study, it is observed that most writer's letters size was of medium size i.e. 60% and 40% writer's letter-size ratio was large while none of the writer's letter-size ratio was observed small. The parameters for measurement of letter-size ratio were mentioned in material methods. The statistical analysis cannot be carried out for this grip since the numbers of samples found were less in numbers in order carry out their chi-square and p-value analysis.

5. **Spacing:** In the study, it was observed that in 20% writers sample spacing was medium while in 40% samples spacing was maximum and spacing in 40% samples were minimum. The statistical analysis cannot be carried out for this grip since the numbers of samples found were less in numbers in order carry out their chi-square and p-value analysis.

Comparison of the handwriting features of disguised grip pattern with the genuine grip pattern

Dynamic tripod grip

In this study 27 disguised grip samples of dynamic tripod were studied. The general characteristics features like slant, alignment, word spacing, letter size ratio and speed were observed and evaluated and compared with the genuine grip pattern in order to find the percentage of similarities and differences that occurred due to the changing of grip pattern.

Table No. 5: Comparison of general handwriting characteristics features between genuine dynamic tripod grip pattern and other disguise grip patterns

Features	Sample number (N)	Similarity	Differences
Slant	27	74.04%	25.92%
Alignment	27	77.77%	22.22%
Speed	27	81.48%	18.51%
Spacing	27	85.18%	14.81%
Letter size ratio	27	92.59%	7.40%

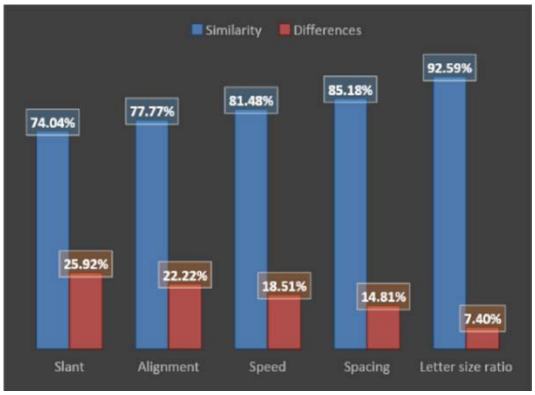


Figure No. 12: Bar graph for percentage comparison of general characteristics for genuine dynamic tripod grip pattern with other disguise grip patterns

The observations clearly showed that for the dynamic tripod grip the general characteristics features i.e. slant, alignment, speed, spacing, letter size ratio shows differences in the sample as 25.92%, 22.22%, 18.51%, 14.81% and 7.40% respectively which are very slight changes as compared to the similar characteristics. Slant and alignment showed the maximum differences in characteristics after disguising the grip. The most frequent grip disguised by the dynamic tripod writer observed was the Dynamic quadrupod grip since out of 27 samples 19 samples disguised in dynamic quadrupod.

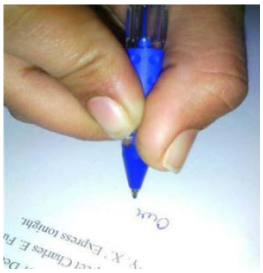


Figure No. 13: Dynamic tripod

Figure No. 14: Dynamic quadrupod

Dynamic quadrupod grip

In this study, 18 disguised grip samples of dynamic quadrupod were studied. The general characteristics features like slant, alignment, word spacing, letter size ratio and speed were observed and evaluated and compared with the genuine grip pattern in order to find the percentage of similarities and differences occurred due to the changing of grip pattern.

Table No. 6: Comparison of general handwriting characteristics features between genuine dynamic quadrupod grip pattern and other disguise grip patterns

Features	Sample number (N)	Similarity	Differences
Slant	18	77.77%	22.22%
Alignment	18	77.77%	22.22%
Speed	18	72.22%	27.77%
Spacing	18	83.38%	16.66%
Letter size ratio	18	88.88%	11.11%

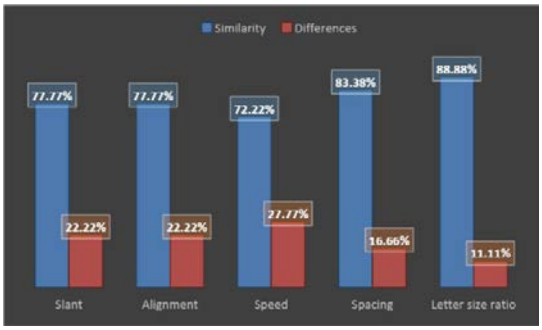


Figure No. 15: Bar graph for percentage comparison of general characteristics for genuine dynamic quadrupod grip pattern with other disguise grip patterns

The observations clearly showed that for the dynamic quadrupod grip the general characteristics features i.e. slant, alignment, speed, spacing, letter size ratio shows differences in sample as 22.22%, 22.22%, 27.77.%, 16.66% and 11.11% respectively which are very slight changes as compared to the similar characteristics. Slant, alignment and slant showed the maximum differences in characteristics after disguising the grip. The most frequent grip disguised by the dynamic quadrupod writer observed was the Dynamic tripod grip since out of 18 samples 16 samples were disguised in dynamic tripod.

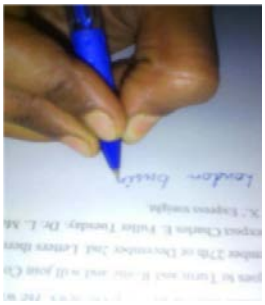


Figure No. 16: Dynamic quadrupod

Figure No. 17: Dynamic tripod

Lateral quadrupod

In this study 15 disguised grip samples of dynamic quadrupod were studied. The general characteristics features like slant, alignment, word spacing, letter size ratio and speed were observed and calculated and compared with the genuine grip pattern in order to find the percentage of similarity and difference occurred due to the changing of grip pattern.

Table No. 7: Comparison of general handwriting characteristics features between genuine lateral quadrupod grip pattern and other disguise grip patterns

Features	Sample number (N)	Similarity	Differences
Slant	15	60%	40%
Alignment	15	73.33%	26.66%
Speed	15	73.33%	26.66%
Spacing	15	80%	20%
Letter size ratio	15	88.88%	13.33%

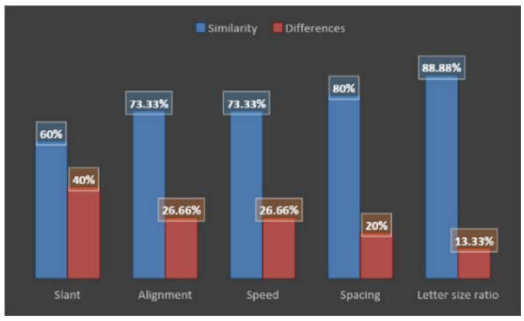


Figure No. 18: Bar graph for percentage comparison of general characteristics for genuine lateral quadrupod grip pattern with other disguise grip patterns

The observations clearly showed that for the Lateral quadrupod grip the general characteristics features i.e. slant, alignment, speed, spacing, letter-size ratio shows differences in sample as 40%, 26.66.%, 26.66%, 20% and 13.33% respectively which are very slight changes as compared to the similar characteristics. Slant, alignment and speed showed the maximum differences in characteristics after disguising the grip. The most frequent grip disguised by the Lateral quadrupod writer observed was the Dynamic tripod grip since out

of 15 samples 10 samples were disguised in dynamic tripod.

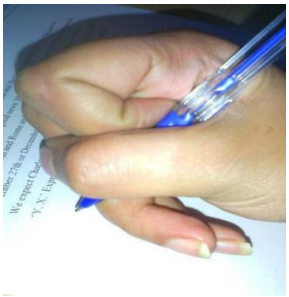


Figure No. 19: Lateral quadrupod

Figure No. 20: Dynamic tripod

Adaptive grip

In this study, 5 disguised grip samples of Adaptive grip were studied. The general characteristics features like slant, alignment, word spacing, letter size ratio and speed were observed and calculated and compared with the genuine grip pattern in order to find the percentage of similarity and difference occurred due to the changing of grip pattern.

Table No. 8: Comparison of general handwriting characteristics features between genuine adaptive grip pattern and other disguise grip patterns

Features	Sample number (N)	Similarity	Differences
Slant	5	60%	40%
Alignment	5	60%	40%
Speed	5	60%	40%
Spacing	5	80%	20%
Letter size ratio	5	80%	20%

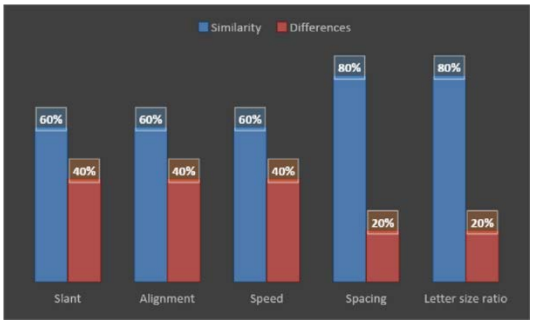


Figure No. 21: Bar graph for percentage comparison of general characteristics for genuine adaptive grip pattern with other disguise grip patterns

The observations clearly showed that for the Adaptive grip the general characteristics features i.e. slant, alignment, speed, spacing, letter-size ratio shows differences in the sample as 40%, 40%, 40%, 20% and 20% respectively which are very slight change as compared to the similar characteristics. Slant, alignment and speed showed the maximum differences in characteristics after disguising the grip. The most frequent grip disguised by the adaptive grip writer observed was the Dynamic tripod grip since out of 5 samples 4 samples were disguised in dynamic tripod.

Figure No. 22: Adaptive grip

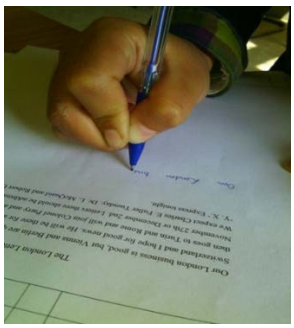


Figure No. 23: Dynamic tripod

Discussion

The results were observed after the analysis of the general handwriting characteristics of different grip patterns. The characteristics features were further evaluated. The result shows slight variations in the characteristics features of genuine grip patterns when compared to their respective disguised grip pattern. The results were represented in both tabular and graphical forms. There are very few numbers of studies conducted by different researchers for analysis of grips.

Ziviani and Elkins (1986) described how the speed and legibility of fourth grader's handwriting was affected by type of pencil grip on the evaluation tool of children's handwriting. It described that out of 99 student 38 students have dynamic tripod grip,22 have lateral tripod grip and 21 have lateral quadrupod grip which concluded that lateral quadrupod and four-finger grips to be as functional as dynamic tripod, dynamic quadrupod and lateral tripod.

Jacobson and Sperling (1976) developed a method of classification by which hand grips can be verbally described in great detail, thus enabling small differences between types of grip which are similar in principle. By means of a code system, each handgrip can be described in the form of a code consisting of designations for the different variables which together define the handgrip. The method has been tested in a pilot study in which six subjects with normal hand function participated. The experiments were filmed and the handgrips coded; the coded material was then submitted to automatic data processing. The study showed that using the method described it is possible to classify and evaluate a large quantity of information concerning the function of the healthy and injured hand. None of the researchers till now have classified and evaluated the general characteristics of different grip patterns and also the comparison between genuine and disguised grips in order to draw a conclusion about the identity of the writer up to a certain extent which can help the forensic document expert to eliminate suspect or group of suspects on the preliminary level.

The chi-square and the p-value test results in Table No. 1, 2, 3 show that there is a significant variation in the general characteristics features of different grip patterns. Table No. 5 to 8 also shows that there is very less or slight differences in the handwriting characteristics when genuine grip handwriting features are compared with the disguised grip writing features facilitating to establish the identity of the writer up to some extent. The study also suggests that the most frequently used disguise grip pattern is the dynamic tripod grip pattern for grips like dynamic quadrupod, lateral quadrupod and the adaptive grip whereas for dynamic tripod the disguise grip pattern used is the dynamic quadrupod. The study shows that the grip of an individual also play a role in an individual handwriting formation which can be used for the forensic examination of documents for writer's identity or for the elimination of suspects and thus supporting the rule of forensic science examination where the innocent suspects can be set free and guilty can be punished further.

Summary

The present study entitled **"Variations in handwriting characteristics due to different grip patterns"** was carried out at the Department of Forensic Science, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, with the following objectives: to analyse the general handwriting characteristics of different grip pattern, to evaluate characteristics features with in different grip patterns, to compare the handwriting features of disguised grip pattern with the genuine grip pattern.
For the present study, 130 handwriting samples were collected from 65 volunteers i.e. two from each one out of which one is their genuine grip and the other is their disguised grip. It has been collected from different places according to the availability of different grips.

This study is to find out the variation in handwriting characteristics due to different grip patterns. 130 samples are examined for their characteristics features successfully, and the results were analysed statistically using chi-square and p test. Table No. 1, 2, 3, shows the variation in the handwriting features of different grip patterns. The Table No. 1, 2, 3 shows the calculated and tabulated chi square and p value for characteristic features of handwriting samples of different grip patterns. Since the calculated value of chi square and p value at 5.99% significance for each feature of different grip patterns was greater than the tabulated value of chi square and p value at 5.99% significance, rejecting the null hypothesis that there are no significant variations in the handwriting characteristics due to different grip patterns.

The results show that that grip of an individual also plays a role in individual handwriting formation The results show that that grip of an individual also plays a role in an individual handwriting formation which can be used for the forensic examination of documents for establishing the writer's identity. The study show there is a significant variation in the general characteristics features of different grip patterns. The table 5 to 8 also shows that there is very less or slight differences in the handwriting characteristics when genuine grip handwriting features are compared with the disguised grip writing features facilitating to establish the identity of the writer up to some extent and thus can help the forensic document examiner to eliminate the suspect at preliminary level. The study also suggests that the most frequently used disguise grip pattern is the dynamic tripod grip pattern

Conclusion

The general handwriting characteristic features were analysed and evaluated. The characteristics features for both genuine and their disguised grip were compared and calculated for the similarity and differences.

According to Tables 1 to 3, it can be concluded that

- There is a significant variation in the general characteristics features of different grip patterns which can be used for the forensic examination of documents for establishing the writer's identity.

According to Tables 5 to 8, it can be concluded that

- There is very less or slight differences in the handwriting characteristics when genuine grip handwriting features are compared with the disguised grip writing features facilitating to establish the identity of the writer up to some extent and thus can help the forensic document examiner to eliminate the suspect at preliminary level.

Recommendation for Future Research Scope

Since the principle of handwriting states that no two people write exactly alike in an extended handwriting samples. Every individual has its own features and characteristics of handwriting. The number of samples can be taken more for each grip for further research which can give more and more accurate results about the specific characteristics of each grip which can differ with the others in one or more way ultimately it can also lead to establish the authorship of writing in a more significant way.

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