

Effect of varying grasp on handwriting characteristics in Gujarati language

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Abstract

Handwriting characteristics are influenced by various factors, including pen grasp, which significantly impacts alignment, speed, spacing, line quality, and rhythm. This study examines the effect of varying pen grasps on handwriting in the Gujarati language among mature writers. Five distinct pen holds—dynamic tripod, static tripod, cross thumb, lateral tripod, and three-finger—were analyzed using 50 samples collected under controlled conditions. Each sample was evaluated based on parameters such as alignment, speed, rhythm, line quality, and specific Gujarati script formations (Hrasvai, Dirghai, Kano, etc.). The results reveal distinct variations in handwriting characteristics associated with different pen holds. These findings suggest that pen grasp plays a crucial role in identifying handwriting characteristics and can be an essential factor in forensic handwriting analysis. However, further research with a larger sample size is recommended to establish more comprehensive conclusions.

Keywords: Handwriting analysis, Gujarati script, pen grasp, pen position, forensic examination.

1. Introduction

In handwriting examination, both class and individual characteristics are meticulously analyzed to recognize, identify, and authenticate questioned or disputed handwriting [1–5]. Among these characteristics, pen position—referring to the manner in which a pen is held—is considered one of the most consistent writing habits, though it varies significantly between individuals. This variability makes it a crucial factor to examine in any handwriting investigation. Writers often hold the pen at varying angles relative to the paper, ranging from nearly vertical to as little as fifteen to twenty degrees from horizontal. The pen's orientation with respect to the line of writing can differ by as much as ninety degrees, extending from a position where the penholder is pointed directly toward the writer to one where the pen aligns almost parallel with the line of writing. Pen position, which encompasses the tool's orientation to the paper or document, is often conceptualized in relation to the line of writing. Another aspect is the angle formed between the instrument's axis and the paper surface. This factor is particularly relevant for ballpoint pens, roller pens, and other similar instruments, which may have specific angle limitations affecting how the pen's housing contacts the surface. These details can provide valuable evidence regarding a writer's pen grip and pen position, which may hold significance in certain cases. Writing executed with a flexible tool can produce distinct characteristics, making the instrument, grip, and manipulation methods key factors in handwriting examination [6]. Seven types of grip for tools have been identified [7], with the grip used for writing instruments influencing the kinds of strokes that can be produced. Writing development is a gradual process of improved control, with studies indicating that changes in pen grasp may continue until approximately 10.5 years of age. Pen position affects not only the characteristics of handwriting but also the writer's endurance and fatigue levels. While no significant differences in word count were observed, individuals using a lateral tripod grasp might experience quicker fatigue [8].

Earlier research on pen position primarily explored speed, legibility, and developmental aspects in children, with limited focus on the correlation between grip types and their resultant writing characteristics [9]. Pen grasp is determined first by the angle between the pen and the line of writing, which varies from 0 to 90 degrees, and second by the angle of the pen relative to the paper surface. Early studies emphasized pen pressure and shading as indicators of pen hold. However, with the increasing use of ballpoint pens, which lack shading, the focus has shifted [10]. Pen control and the forces applied are generally categorized into two main components [11]:

A. **Pen pressure:** The force exerted perpendicular to the instrument's axis.

B. **Directional component:** This includes two elements:

1. **Point load:** The vertical force responsible for indentation and shading (noted only with fountain pen nibs).
2. **Travel action:** The horizontal force responsible for creating lines—whether forward, sideward, drag, or backward.

Yakimishyn and Magill-Evans (2002) highlighted how a short writing tool and vertical surfaces can impact grasp in young children [12]. Mei Hui Tseng (1998) investigated the developmental progression of pencil grips in children [13]. Julie L. Dennis and Yvonne Swinith (2001) examined the influence of pencil grip on handwriting legibility among students [14]. However, these studies predominantly focused on children and English handwriting. Bladon and Elizabeth (2011) explored the prevalence of non-tripod grips in younger individuals during writing [15]. Colleen M. Schneck and Anne Henderson (1990) also studied the progression of pencil and crayon grips in non-dysfunctional children [15]. Most of this research pertains to English handwriting and young writers. In contrast, this paper focuses on Gujarati handwriting among mature writers.

2. Methodology

(I) Sample preparation

All 50 samples were obtained in Gujarati language in 5 different positions. Ten samples from each type of pen position were obtained. It is noted that all the writing samples should be written with the ballpoint pens provided to avoid handwriting variation due to the writing instrument. The thickness and type of pen may influence the grip of an individual, and variation may occur. With the help of a digital camera, photographs of the pen position of a writer while writing are taken, as shown in Figure 1. The following are various pen positions generally observed in mature writers and samples obtained accordingly.



Figure 1 Dynamic tripod



Figure 2 Fixed type (Static tripod)



Figure 3 Cross thumb



Figure 4 Lateral tripod



Figure 5 Broken type



Figure 6 Adaptive tripod



Figure 7 Three fingers

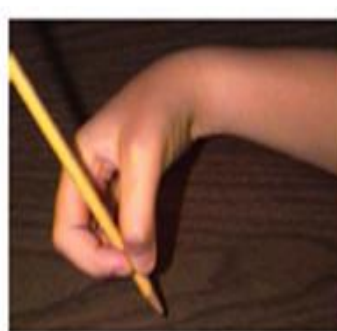


Figure 8 Hooked type

Table 1 shows different types of pen holds and the position of the pen.

(II) Collection of samples:

It includes two things, i.e., handwritten original samples and photographs of writings and the pen position of a writer. The writer was asked to sit in a comfortable position for writing. Then, they were asked to write in their regular course of writing on plain white, unruled paper using a ballpoint pen given to them. By these, around 100 to 120 writing samples in the Gujarati script were collected. Five significant types of pen hold/positions were considered for examination, and 50 writing samples were extracted to match the number of writing samples of every kind of pen position/hold for examination to provide equivalent characters. Here, every type of pen hold/position has 10 writing samples. Writing was obtained based on education, occupation, and skill in Gujarati writing.

A. Description of person detail:

B. Name of a person

C. Occupation

D. Age

E. Education

F. Regular writing hour

G. Accustomed hand, i.e., right/ left

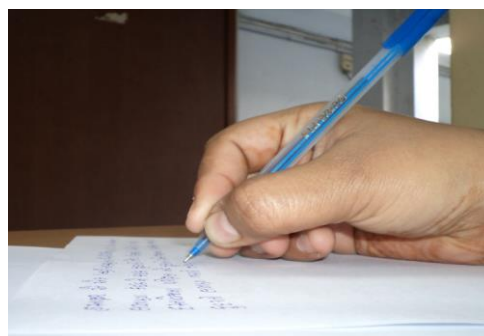
The paragraph is given for writing: One paragraph was given to writing containing Gujarati Script.

(III) Photography of pen hold/position of the writer while writing:

While writing, the writer's pen position and the way they hold the pen were photographed with different angles/positions of the camera to capture the pen position of the writer best. This photograph was done in two ways: (1) Pen position concerning the writing surface and (2) Pen position concerning the direction of writing. From these photographs, the angle of the pen concerning the line of writing and the paper surface in a particular type of pen hold/position were measured.



Pen position concerning the line of writing



Pen position concerning paper surface

(IV) Scanning of samples:

All the writing samples were scanned using VSC 6000 HS and converted into digitized images for a thorough examination.

(V) Extraction of writing characters from writing sample:

Each sample was examined thoroughly in enough light, with proper care and great attention to each writing character. Each sample required about 50-60 minutes for examination. From about 13 handwriting characters, five writing characters were extracted, which include alignment, speed, spacing, line quality, and rhythm, and other Gujarati script

characters like the formation of Hrasvai, Hrasvau, Dirghai, Dirghau, and particular letter formation (if any), etc., were extracted. All the 13 writing characters and other Gujarati script characters are discussed in the result.

3. Result and discussion-

The results obtained after the writing sample collection and photography are examined, and various writing characteristics are observed in the writing samples of all fifty subjects. The comparative percentage of all the characters studied obtained as follows-

1. Alignment: The process of adjusting parts of letters so that they are in the proper relative position. There are three types of alignment: incline, Decline, and straight.

દસ્તાકાર એ એક 'ન્યુનો-ગ્રસ્ક્યુલર કો-ઓર્ડિનેશન' છે. દરેક વ્યક્તિના લખાણ કંઈક ને કંઈક કુદરતી ભેદ (ફેરફાર) દર્શાવે છે. તકરારી દસ્તાવેજના પરીક્ષણ બારે કુદરતી અને નમૂનાના દસ્તાવેજો

1. Straight alignment

દસ્તાકાર એ એક 'ન્યુનો-ગ્રસ્ક્યુલર કો-ઓર્ડિનેશન' છે. દરેક વ્યક્તિના લખાણ કંઈક ને કંઈક કુદરતી ભેદ (ફેરફાર) દર્શાવે છે. તકરારી દસ્તાવેજના પરીક્ષણ બારે કુદરતી અને નમૂનાના

2. Decline alignment

દસ્તાકાર એ એક 'ન્યુનો-ગ્રસ્ક્યુલર કો-ઓર્ડિનેશન' છે. દરેક વ્યક્તિના લખાણ કંઈક ને કંઈક કુદરતી ભેદ (ફેરફાર) દર્શાવે છે. તકરારી દસ્તાવેજના પરીક્ષણ બારે કુદરતી અને નમૂનાના

3. Incline alignment

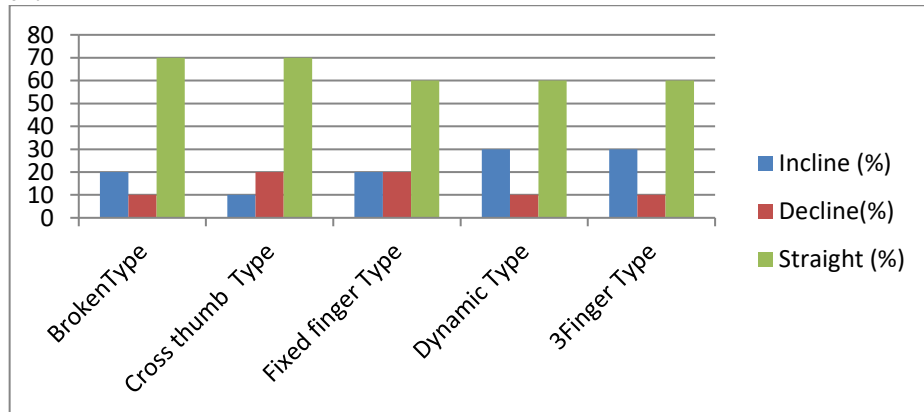


Chart 1. Showing alignment of writing in all the five types of pen holders and/or positions.

2. Speed: Speed in handwriting is identified by Pictorial effect, Rhythm, Style, Line quality, Tremors, Pen lift, Pen pause, Size

દસ્તાકાર એ એક 'ન્યુનો-ગ્રસ્ક્યુલર કો-ઓર્ડિનેશન' છે. દરેક વ્યક્તિના લખાણ કંઈક ને કંઈક કુદરતી ભેદ (ફેરફાર) દર્શાવે છે. તકરારી દસ્તાવેજના પરીક્ષણ બારે કુદરતી અને નમૂનાના

Slow speed Writing

હસ્તાક્ષર એ એક 'ન્યુરો-મસ્ક્યુલર કો-ઓર્ડિનેશન' છે. દરેક વ્યક્તિના લખાણ કંઈક ને કંઈક કુદરતી ભેદ (ફેરફાર) દર્શાવે છે. તકરારી દસ્તાવેજના પરીક્ષણ માટે કુદરતી અને નમૂનાના દસ્તાવેજો

Medium Speed writing

હસ્તાક્ષર એ એક 'ન્યુરો-મસ્ક્યુલર કો-ઓર્ડિનેશન' છે. દરેક વ્યક્તિના લખાણ કંઈક ને કંઈક કુદરતી ભેદ (ફેરફાર) દર્શાવે છે. તકરારી દસ્તાવેજના પરીક્ષણ માટે કુદરતી અને નમૂનાના દસ્તાવેજો

Fast speed Writing

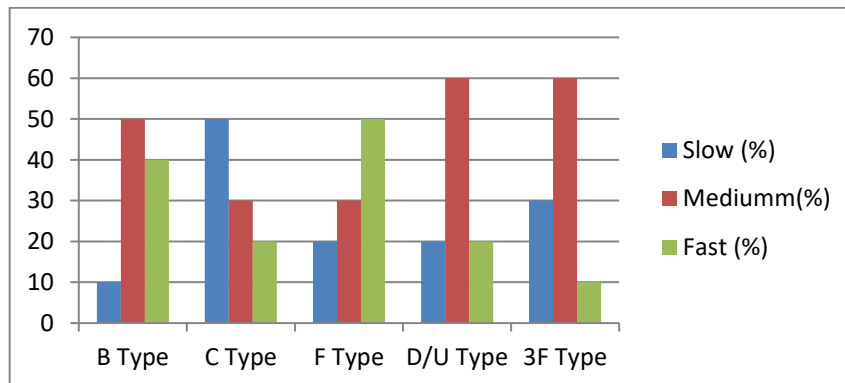


Chart 2. Showing speed in writing in all five types of pen holders and/or position

3. Line quality: The line written by an experienced writer is smooth and uniform. The starting, finishing, and embellishment strokes are natural and soft. Connecting strokes are uniform and continuous except where the writer habitually lifts the pen to complete or modify the letters. On the other hand, in simulated and traced forgeries, there are frequent pen pauses, pen lifts, and hesitation marks. The line looks labored and drawn, especially at the starting and finishing points, connecting, and embellishment strokes.

હસ્તાક્ષર એ એક 'ન્યુરો-મસ્ક્યુલર કો-ઓર્ડિનેશન' છે. દરેક વ્યક્તિના લખાણ કંઈક ને કંઈક કુદરતી ભેદ (ફેરફાર) દર્શાવે છે. તકરારી દસ્તાવેજના પરીક્ષણ માટે કુદરતી અને નમૂનાના દસ્તાવેજો

1. Smooth line quality

હસ્તાક્ષર એ એક 'ન્યુરો-મસ્ક્યુલર કો-ઓર્ડિનેશન' છે. દરેક વ્યક્તિના લખાણ કંઈક ને કંઈક કુદરતી ભેદ (ફેરફાર) દર્શાવે છે. તકરારી દસ્તાવેજના પરીક્ષણ માટે કુદરતી અને નમૂનાના દસ્તાવેજો

2. Average line quality

હસ્તાક્ષર એ એક 'ન્યુરો-મસ્ક્યુલર કો-ઓર્ડિનેશન' છે. દરેક વ્યક્તિના લખાણ કંઈક ને કંઈક કુદરતી ભેદ (ફેરફાર) દર્શાવે છે. તકરારી દસ્તાવેજના પરીક્ષણ માટે કુદરતી અને નમૂનાના દસ્તાવેજો

3. Tremulous line quality.

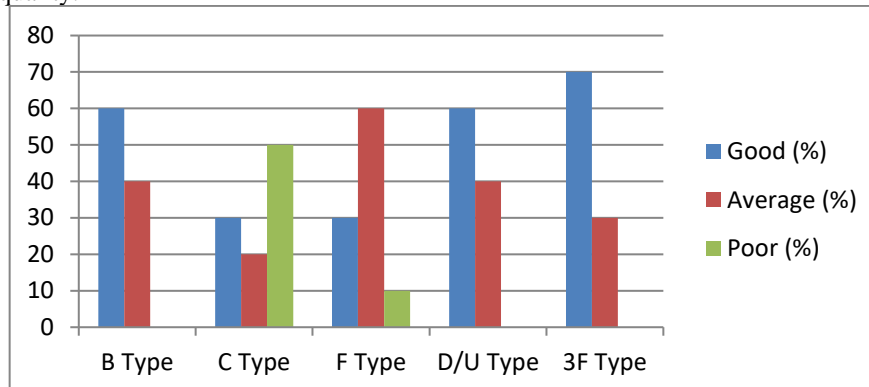
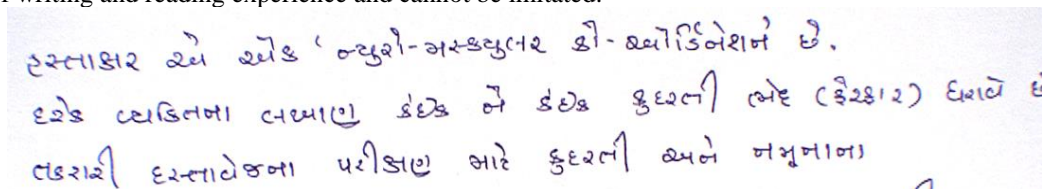
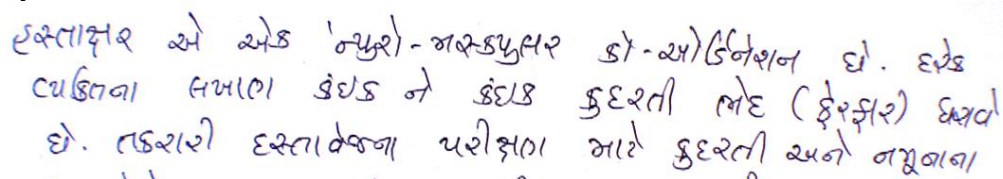


Chart 3. Showing the line quality of writing in all five types of pen holders and/or positions.

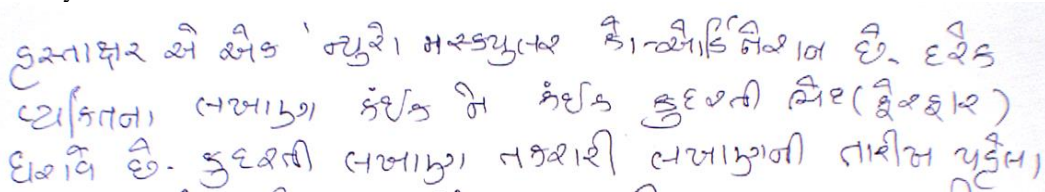
4. Rhythm: Rhythm is found in the handwriting of educated persons with ample writing experience only. The flow of the writing indicates rhythm, correct line quality and punctuation, and proportionate formation of letters and figures. It is a product of writing and reading experience and cannot be imitated.



1. Smooth Rhythm



2. Intermittent Rhythm



3. Jerky Rhythm

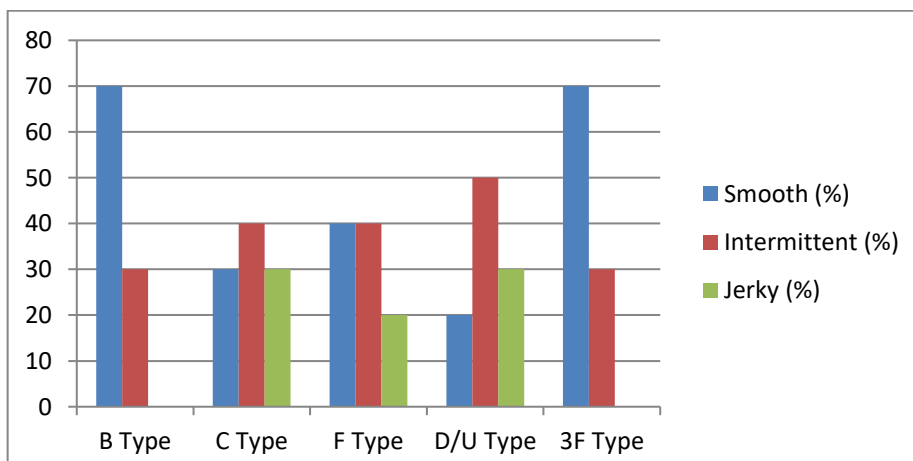


Chart 4. Showing the Rhythm of the writing of all five types of pen holders and/or positions.

4. Spacing between letters and words: The spacing between the words/letters is divided into three categories: large, medium, and trim.

હસ્તાક્ષર એ એક 'ન્યૂરી-મસ્ક્યુલર કી-ઓર્ગેનિઝેશન' છે
દરેક વ્યક્તિના લખાણ કંઈક ને કુદરતી ભેદ (ફેરફાર)
દર્શાવે છે. તકરારી દસ્તાવેજના પરીક્ષામાં મોટે કુદરતી
અને નમૂનાના દસ્તાવેજની આવશ્યક છે. કુદરતી

1. Large spacing

હસ્તાક્ષર એ એક 'ન્યૂરી-મસ્ક્યુલર કી-ઓર્ગેનિઝેશન' છે. દરેક વ્યક્તિના
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દસ્તાવેજના પરીક્ષામાં મોટે કુદરતી અને નમૂનાના દસ્તાવેજની આવશ્યક છે.

2. Medium spacing

તકરારી દસ્તાવેજના પરીક્ષામાં મોટે કુદરતી અને નમૂનાના
દસ્તાવેજની આવશ્યક છે. કુદરતી લખાણ તકરારી લખાણની
તારીખ પ્રમાણ વ્યક્તિના રોજબરોજની ક્રીની પ્રમાણ લખાણમાં છે.

3. Small spacing

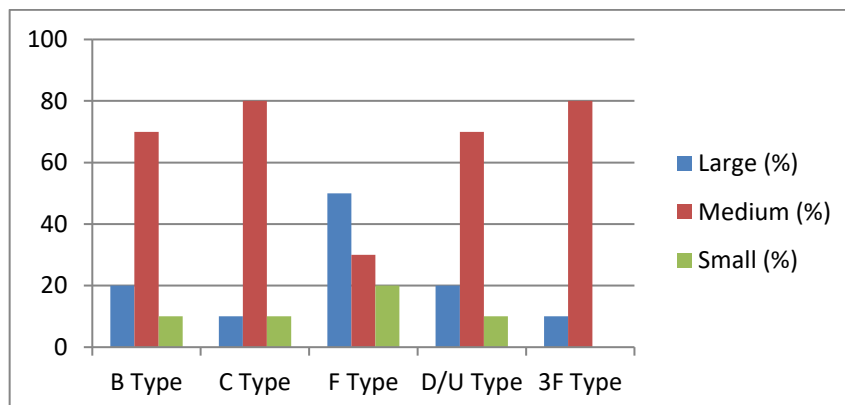


Chart 5. Showing spacing between words and letters in writing of all five types of pen holders and/or positions.

5. Kano:

Smaller kano Bigger kano Equal kano

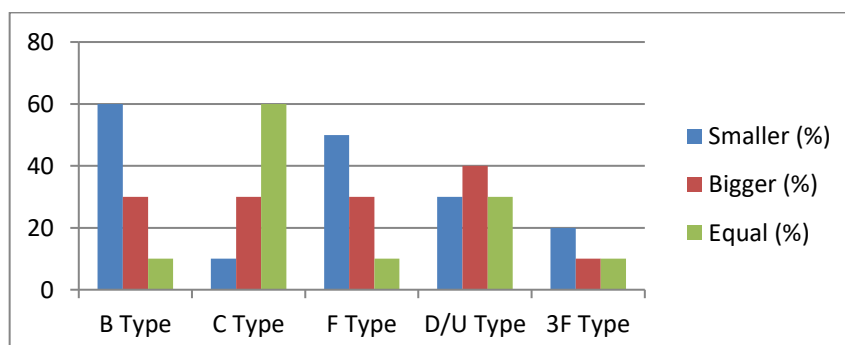


Chart 6. Showing the type of Kano formed in writing of all five types of pen holders and/or positions.

6. Matras:

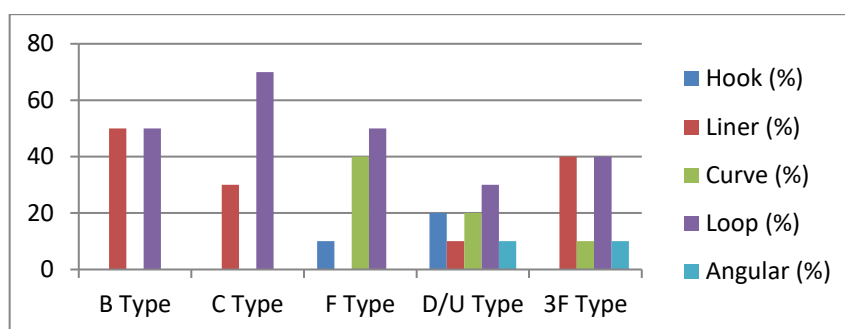
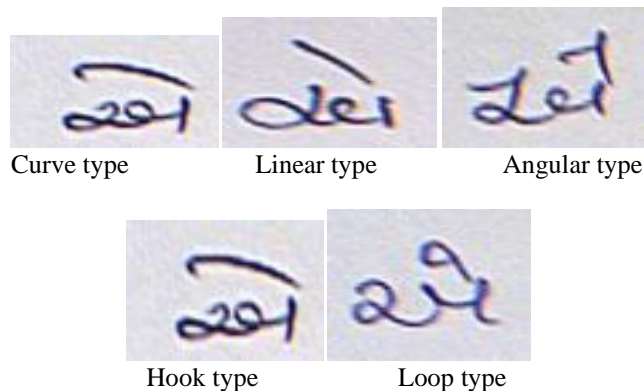


Chart 7. Showing the type of Matra formed in all five types of pen holders and/or positions.

7. Hrasvau:

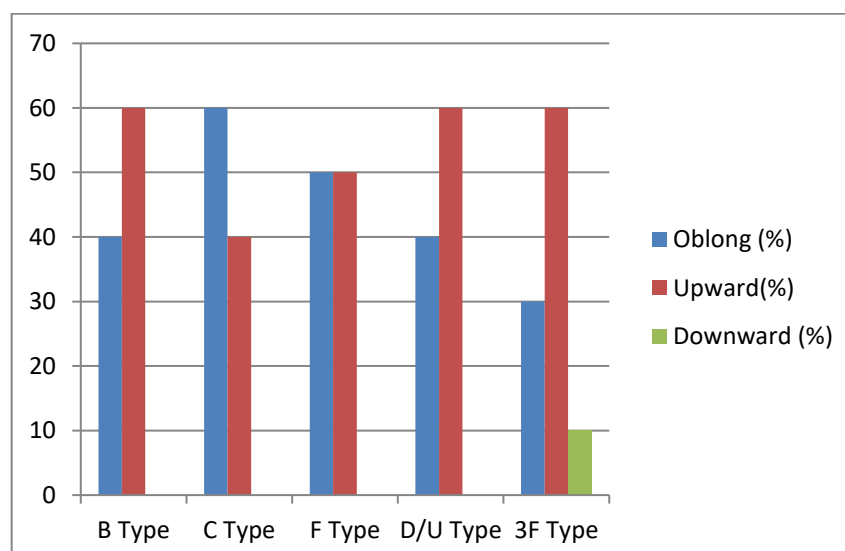


Chart 8. Showing the type of Hrasvau formed in writing of all five types of pen holders and/or positions.

8. Dirghau:



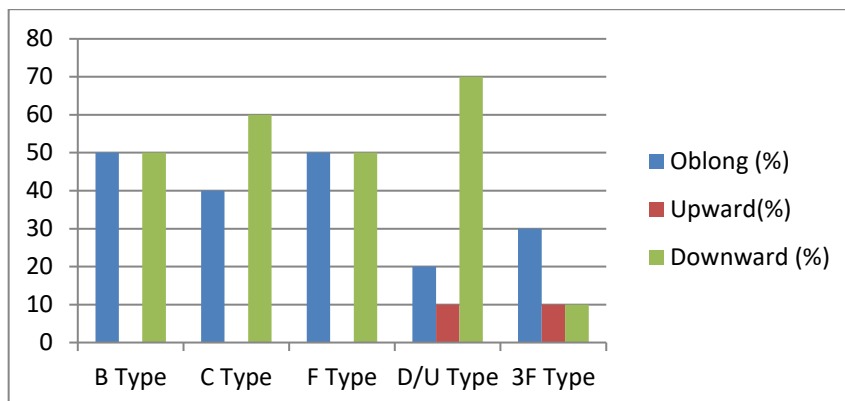


Chart 9. Showing the type of Dirghau formed in writing of all five types of pen holders and/or positions.

9. Hrasvai:

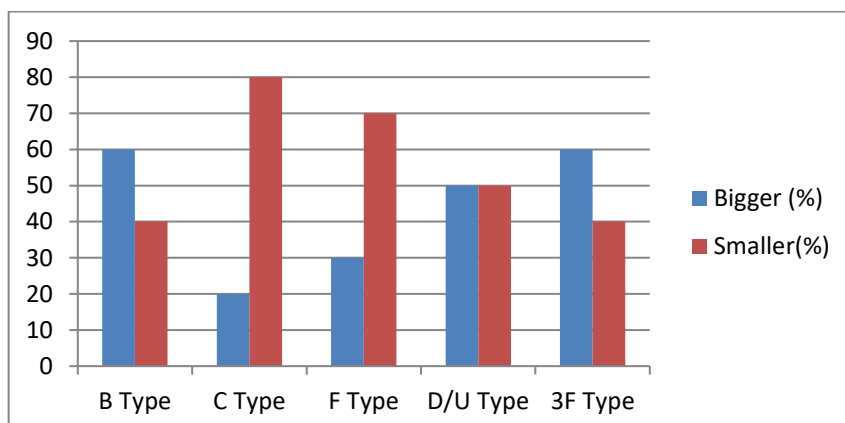


Chart 10. Showing Dirghai formation in writing of all five types of pen holders and/or positions.

10. Dirghai:

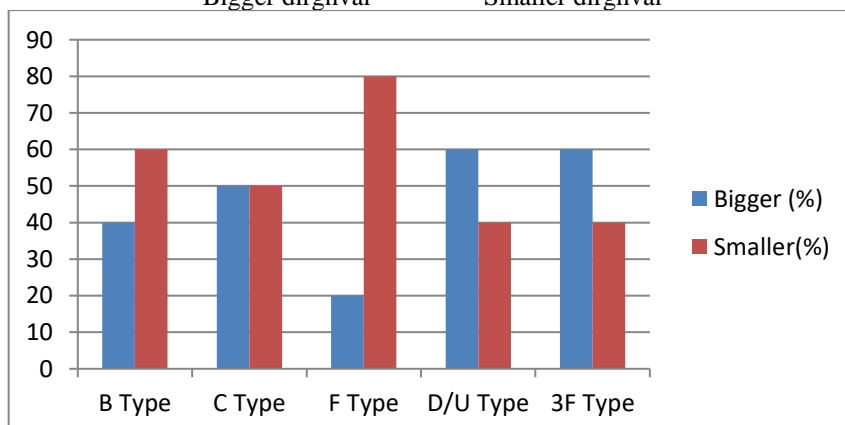
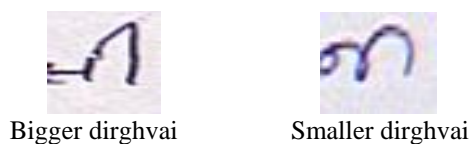


Chart 11. Showing formation of Dirghai in writing of all five types of pen holders and/or positions.

13. Pen position concerning the line of writing and paper surface:

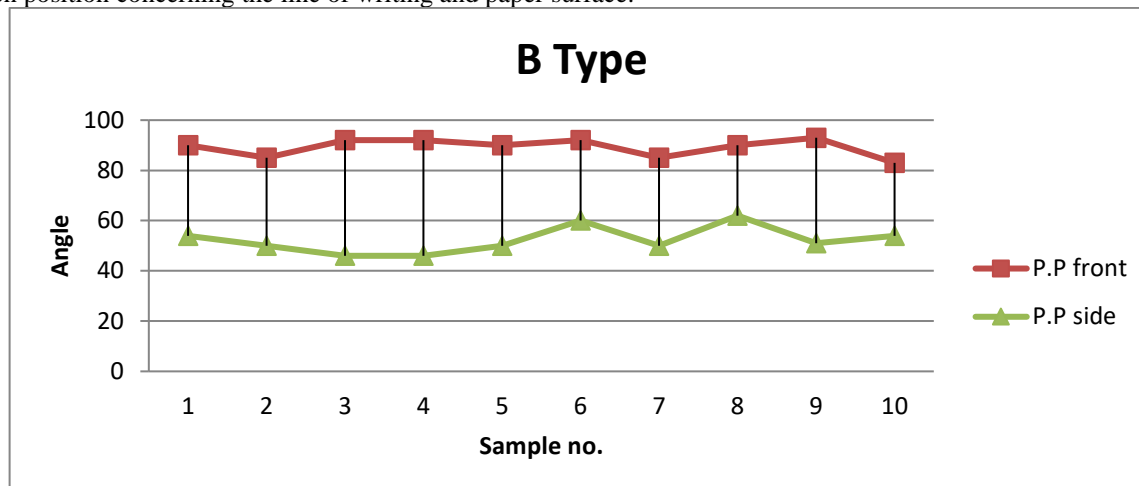


Chart 12. The pen position of the line of writing is between 850 and 950, and the pen position with respect to the paper surface is between 450 and 650, which is a broken type of pen hold.

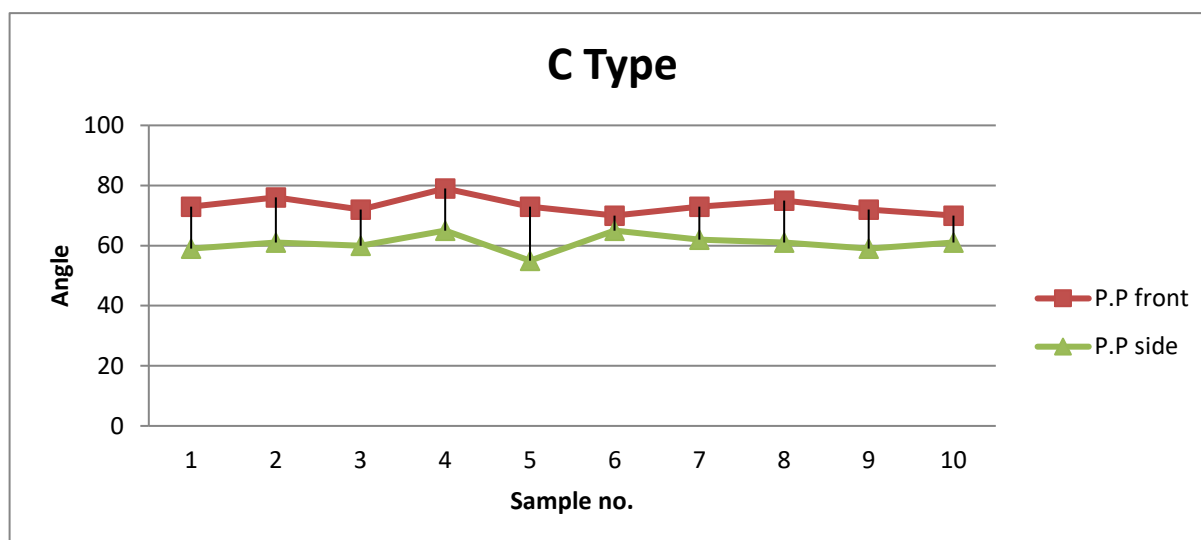


Chart 13. The pen position w.r.t line of writing is between 700- 800, and the pen position concerning the paper surface is between 550- 650 of the cross thumb type of pen holder.

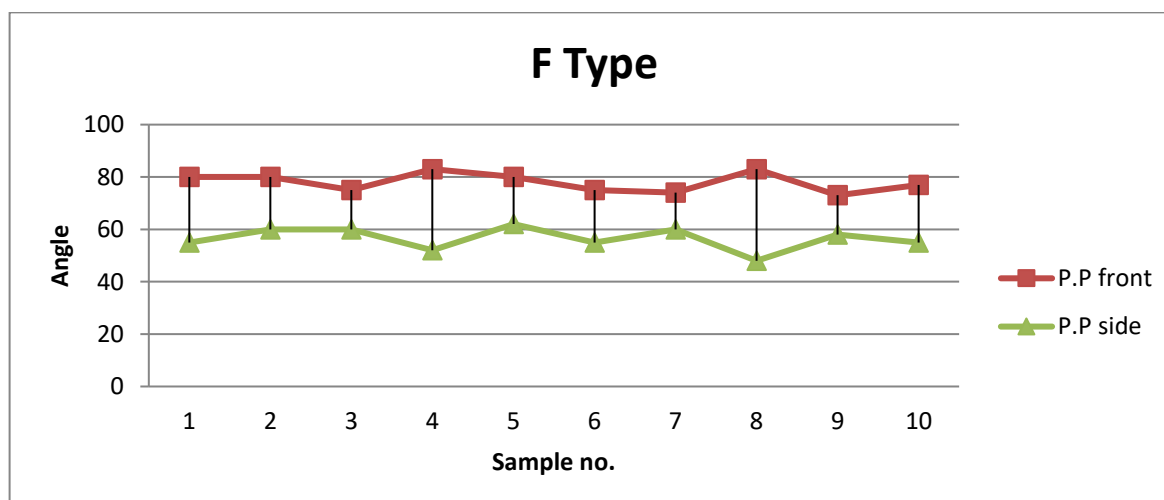


Chart 14. The pen position w.r.t. to the line of writing is between 750- 850, and the pen position concerning the paper surface is between 450- 600 in a fixed type of pen holder.

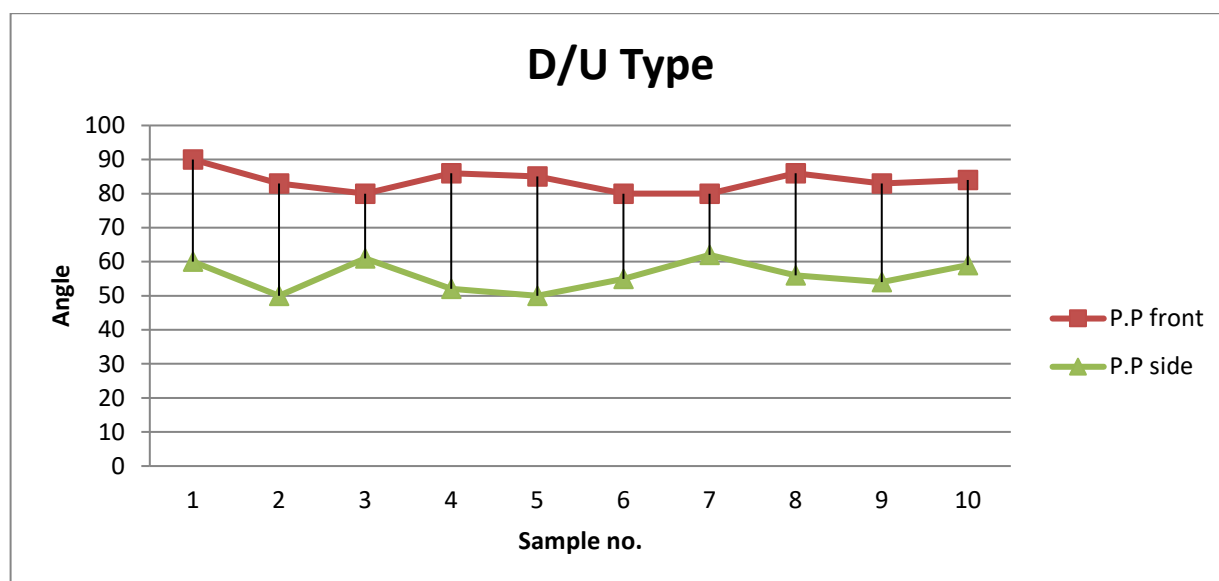


Chart 15. Showing pen position w.r.t. to the line of writing between 80° - 90° and pen position concerning paper surface is between 50° - 65° in a Fixed type of pen holder.

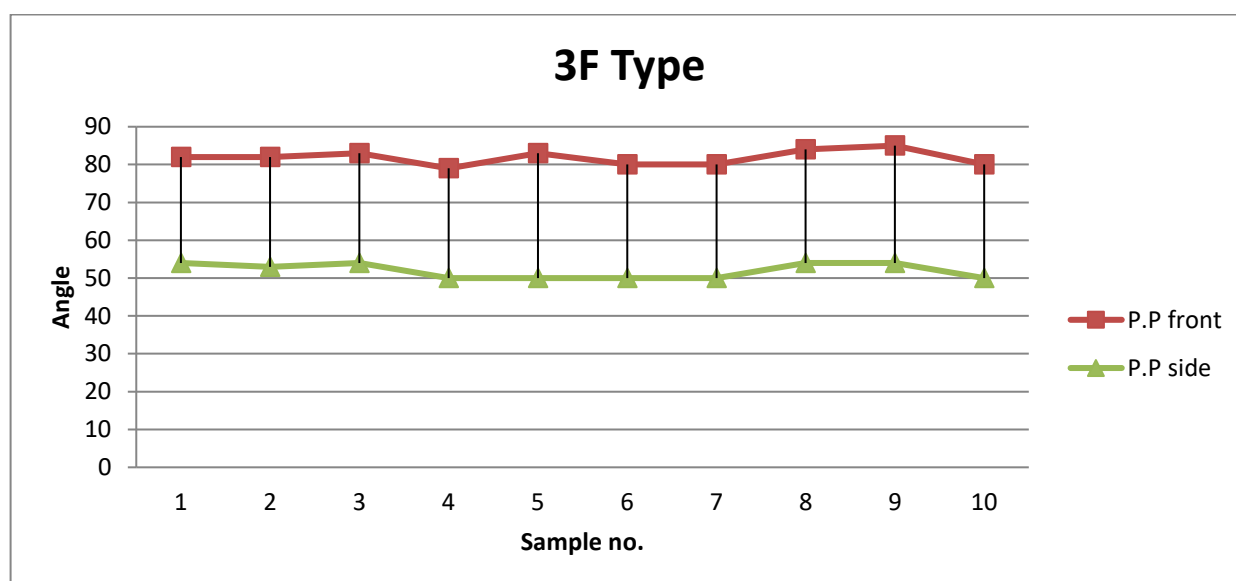


Chart 16. The pen position w.r.t. to the line of writing is between 800° - 850° , and the pen position with respect to the paper surface is between 500° - 550° in the Three-finger type of pen hold.

4 . Conclusion

The study reveals that different pens significantly impact Gujarati handwriting characteristics. Broken pen hold positions ranged between 850° - 950° (line of writing) and 450° - 650° (paper surface), cross thumb between 700° - 800° and 550° - 650° , fixed type between 750° - 850° and 450° - 600° , dynamic type between 800° - 900° and 500° - 650° , and three-finger type between 800° - 850° and 500° - 550° . Slow writing speed was observed in the cross-thumb hold, while medium speed appeared in the broken, dynamic, and three-finger holds. Good line quality was evident in broken, dynamic, and three-finger holds, with average quality in the fixed type and poor quality in the cross thumb. The formation of small Kano was seen in broken holds, bigger Kano in dynamic holds, and equal Kano in cross thumb, fixed, and three-finger types. Larger Hrasvai and Dirghai were prominent in broken and three-finger holds, while smaller formations were observed in the cross-thumb, fixed, and dynamic types. These findings provide preliminary insights into recognizing handwriting differences based on pen positions, requiring larger sample sizes and extended studies for conclusive results.

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