iJournals: International Journal of Social Relevance & Concern (IJSRC)
ISSN:2347-9698, ijournals.in/ijsrc
Volume 13 Issue 6, June 2025

Comparative study of Devnagari script on porous and non-porous surfaces using unconventional writing instruments

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ABSTRACT

Handwriting analysis plays very important role in forensic investigations, offering insights into individual identity and crime scene circumstances. However, the surface on which handwriting appears whether porous or non-porous significantly influences its characteristics, especially when unconventional writing instruments are used. Most forensic examiners find it challenging to analyze the handwriting features of Devnagari script due to unconventional writing instruments and surfaces. Hence, a systematic study has been carried out on unconventional porous surface (i.e., cloth and wood) and non-porous (i.e., plastic and metal) surfaces using unconventional writing tools such as lipstick and kajal and evaluation has been done by comparing it with standard pen-paper. This present study illustrates how the physical properties of these surfaces affect the manifestation of handwriting characteristics. This study was carried out on 20 handwriting sample which were collected on porous surface (wood, cloth) and on non-porous surface (aluminium, plastic) using unconventional writing instruments (lipstick and kajal). Various handwriting features were reported and authorship were established by observing individual characteristics.

Keywords: Handwriting examination, Devnagari script, porous and non-porous surfaces, unconventional writing instruments, handwriting features.

1. INTRODUCTION

Handwriting is a difficult perceptual motor skill, also known as neuromuscular writing, distinguished by handwriting rather than typing or word processing, as well as a distinct individual's signature style. Handwriting evidence of an individual of the questioned document are based on the principle that no two individuals write exactly alike. Handwriting can be defined as the skill that is personal to individuals. Handwriting is based on the principle that it is a unique feature that distinguishes the individuals from one another. Handwriting of a person cannot change during a course of a persona [1]. The fundamental of handwriting is a threefold and a neuromuscular task. It is an acquired skill that is generally referred as an intricate perceptual motor task [2]. Handwriting analysis, also known as Graphology, is a scientific method used to understand a writer's personality through their handwriting patterns. It reveals persons personality traits such as emotional states, self-esteem, potential talents or tendencies, fear, anger honesty, etc. [3]. Generally, questioned document examiners are required to examine documents which are written on paper using ink as writing fluid and paper as the writing substrate. Document examination also involves cases for expert opinion where the questioned writings were executed on unusual surfaces such as metal, wall, mirror, cloth, doors, shoes, etc. Document examination cases have been reported in the literature, wherein writings examined were on unusual surfaces [4].

The utilization of unusual surfaces and instruments is more prominent in cases of suicide because the usual surface

(paper) and common writing instrument (pen) are not usually available in the vicinity. Thus, the individuals opt for the atypical surfaces, due to their easy availability and resistance to destruction. It is evident from earlier studies that the overall pictorial appearance of the handwriting on unfamiliar surfaces is influenced by the limited availability of the space and awkwardness faced by the writer while inscribing on the unique and unknown surface with the new writing instrument. [5]. Handwriting when found on unconventional surfaces like wall, skin of the human being, tree, mirror, table, window etc. may also reveal the circumstances under which the crime had happened. Forensic investigations of handwriting found on unusual surfaces is itself not an easy task for the investigators. This is mainly due to the fact that the pattern of the handwriting of an individual changes with the surfaces. In addition, criminal also tend to manipulate the handwriting evidences in order to escape from being caught. [6].

The Devnagari script uses combination of various sub-divisions which are called Akshara (letter) to form a Shabda (word) which are joined by a straight horizontal line called Shirorekha (head score). [7] classified the writing elements in Devnagari script. The characteristics of unconventional writing instruments and surfaces can significantly influence the appearance of handwriting. For example, a thick nib and a rough surface may obscure crucial details, making it challenging for an examiner to reach a definitive conclusion. If an examiner is unfamiliar with how different writing conditions affect handwriting traits, identifying the author of a questioned document may become even more difficult.

2. MATERIALS AND METHOD

In present study 180 handwriting samples of 20 individuals between age group of 20 to 35 from SHUATS Campus, Prayagraj, who have good knowledge of Hindi varnamala and have good writing skills in Hindi. Each individual was asked to write "गली में चलते वक्त नकाबपोश ने चाकू दिखाकर पर्स, मोबाइल छीना और भाग गया।" on four unconventional writing surfaces i.e., aluminium, plastic (non-porous) and wood, cloth (porous) with unconventional writing instruments i.e., lipstick and kajal (figure 1) and one sample is collected using pen on paper for standard, which means total of 9 handwriting samples are collected from each individual. Thus, 180 samples were collected by all 20 individuals.

Figure 1. Writing instruments

All collected sample were photographed immediately in day light using smartphone camera of focal length 4.733mm, aperture f1.7 and dimensions of 3468×4624 pixels to preserve it from smudging and protect its evidential value for better analysis. The photographed samples were then compared with standard for identification of handwriting features and their authorship identification.

3. RESULT

180 handwriting samples were collected and examined for different handwriting features under two different parameters:

1. Surfaces
2. Instruments

After examination and interpretation, the percentage tables of similarities and dissimilarities in handwriting

features were observed. After a thorough analysis of all collected handwriting samples, including both conventional and unconventional types, statistical results were derived to assess whether there was a significant or non-significant difference between the percentage of similarities and dissimilarities in class characteristics of collected handwriting samples. This evaluation was conducted using the "Two-Way ANOVA without replication."

Table.3.1. Percentage (%) of similarities and dissimilarities in class characteristics of handwriting on Non-Porous (Aluminium) surface

S.No.	Class characterstics	Frequency	% Similarities	% Dissimilarities
1	Slant	20	95%	5%
2	Line Quality	20	100%	0%
3	Spacing	20	90%	10%
4	Letter Size	20	20%	80%
5	Alignment	20	35%	65%

As shown in Table 3.1, the percentage of similarities exceeds that of dissimilarities in most handwriting characteristics, with the exception of letter size (20%) and alignment (35%). The graphical representation shown in fig 3.1, further illustrates that an individual's handwriting remains largely consistent despite changes in the writing surface.

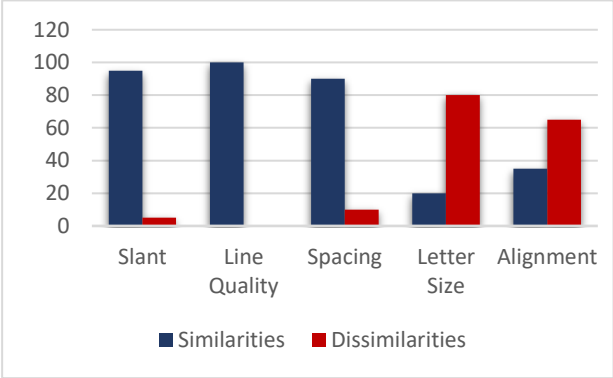

Figure.3.1 Comparison of similarities and dissimilarities in class characteristics of handwriting on unconventional surface (Aluminium)

Table.3.2 Percentage (%) of similarities and dissimilarities in class characteristics of handwriting on Non-Porous (Plastic) surface

S.No.	Class characterstics	Frequency	% Similarities	% Dissimilarities
1	Slant	20	95%	5%
2	Line Quality	20	100%	0%
3	Spacing	20	90%	10%
4	Letter Size	20	15%	85%
5	Alignment	20	20%	80%

As shown in Table 3.2, the percentage of similarities exceeds that of dissimilarities in most handwriting

characteristics, with the exception of letter size (15%) and alignment (20%). The graphical representation shown in fig 3.2, further illustrates that an individual's handwriting remains largely consistent despite changes in the writing surface.

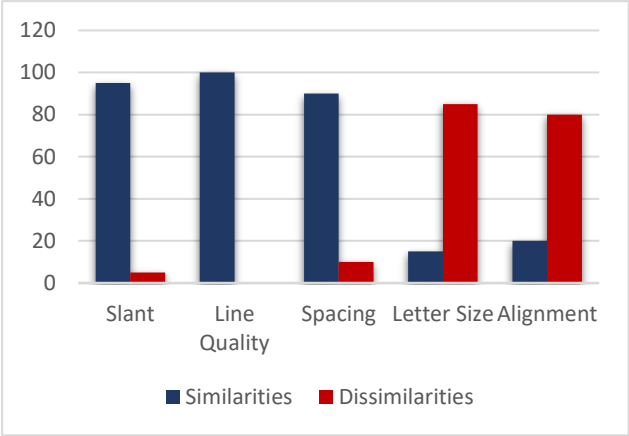

Figure.3.2 Comparison of similarities and dissimilarities in class characteristics of handwriting on unconventional surface (Plastic)

Table.3.3 Percentage (%) of similarities and dissimilarities in class characteristics of handwriting on Porous (Wood) surface

S.No.	Class characterstics	Frequency	% Similarities	% Dissimilarities
1	Slant	20	95%	5%
2	Line Quality	20	100%	0%
3	Spacing	20	85%	15%
4	Letter Size	20	15%	85%
5	Alignment	20	20%	80%

As shown in Table 3.3, the percentage of similarities exceeds that of dissimilarities in most handwriting characteristics, with the exception of letter size (15%) and alignment (20%). The graphical representation shown in fig 3.3, further illustrates that an individual's handwriting remains largely consistent despite changes in the writing surface.

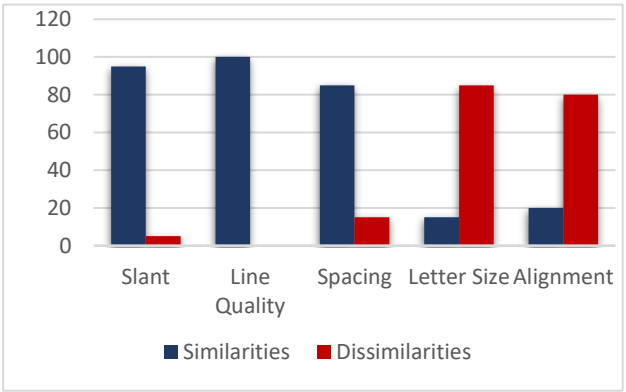

Figure.3.3 Comparison of similarities and dissimilarities in class characteristics of handwriting on unconventional surface (Wood)

Table.3.4 Percentage (%) of similarities and dissimilarities in class characteristics of handwriting on Porous (Cloth) surface

S.No.	Class characterstics	Frequency	% Similarities	% Dissimilarities
1	Slant	20	90%	10%
2	Line Quality	20	100%	0%
3	Spacing	20	90%	10%
4	Letter Size	20	20%	80%
5	Alignment	20	30%	70%

As shown in Table 3.4, the percentage of similarities exceeds that of dissimilarities in most handwriting characteristics, with the exception of letter size (20%) and alignment (30%). The graphical representation shown in fig 3.4, further illustrates that an individual's handwriting remains largely consistent despite changes in the writing surface.

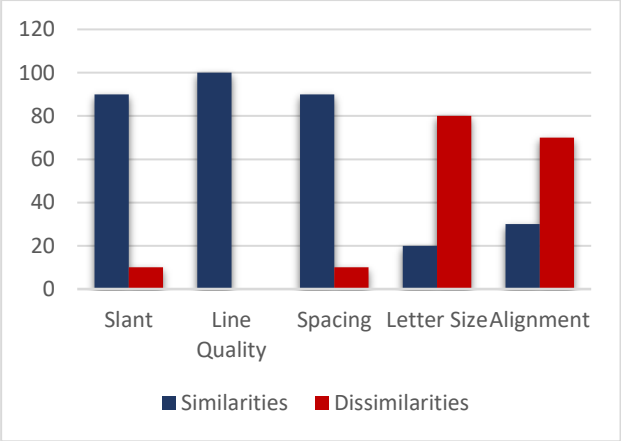

Figure3.4 Comparison of similarities and dissimilarities in class characteristics of handwriting on unconventional surface (Cloth)

After a thorough analysis of all collected handwriting samples, including both conventional and unconventional types, statistical results were derived to assess whether there was a significant or non-significant difference between the percentage of similarities and dissimilarities. This evaluation was conducted using the "Two-Way ANOVA" method, as presented in Tables 1, 2, 3, and 4.

Table 1: Observation table on the basis of Similarities for ANOVA Analysis (Surfaces)

Surfaces	Features				
	F1	F2	F3	F4	F5
S1	95	100	90	20	35

S2	95	100	90	15	20
S3	95	100	85	15	20
S4	90	100	90	20	30

Table.2 ANOVA Table on the basis of similarities (surfaces)

Source of variation	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	Result	S. Ed. (±)	C.D. at 5%	F. Tab. 5%	SE(m)
Features	4	25492.500	6373.125	485.57143	3.26	S	2.562	5.124	5.41	-
Surfaces	3	73.750	24.583	1.8730159	3.49	NS	2.291	4.583	5.95	2.092
Error	12	157.500	13.125	-	-	-	-	-		
TOTAL	19		-	-	-	-	-	-		

Table 2 indicates that the calculated F-values for surface variation are lower than the critical F-values at the 5% significance level. Therefore, the null hypothesis is accepted, suggesting that surface variation does not cause a significant difference in handwriting. In contrast, the calculated F-values for handwriting features exceed the critical values at the 5% significance level. Hence, the null hypothesis is rejected, indicating that handwriting differs significantly with respect to features.

Figure.2 Smooth line formation on non-porous surface (aluminium, plastic)

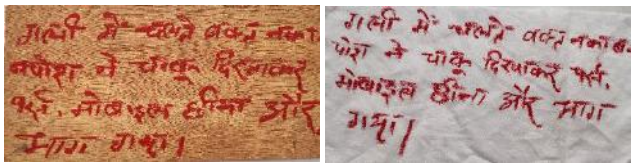

Figure.3 Irregular line formation on porous surface (wood, cloth)

During the course of this study, it was found that the handwriting on porous surfaces have irregular line formation, due to inconsistent absorption of writing material (lipstick, kajal) shown in fig.3 whereas on non-porous surfaces the line formation of the alphabets is very smooth and are consistent as we can see in fig.2 But it is also observed that non-porous surfaces retain smudges along with the handwriting very easily and are more vulnerable, hence requires immediate attention and preservation of sample by taking photographs.

Strokes in non-porous surfaces are relatively sharper than that of porous surfaces as the surface is smooth whereas in porous surface the strokes appear softer and are less defined due to rough surface which alters letter forms and distorts the intended shapes of alphabets, hence the general characteristics of handwriting are likely to be less appeared in porous surface in comparison to non-porous surfaces.

It is also observed that the kajal and lipstick used as writing instruments for taking the sample takes more time in drying on non-porous surface, as the components of kajal and lipstick stick over the surface and do not get absorbed whereas in porous surface it gets dried easily and quickly as compared to non-porous surface due to its absorbing nature.

Table.3.5 Percentage (%) of similarities and dissimilarities of handwriting features due to Lipstick

S.No.	Class characterstics	Frequency	% Similarities	% Dissimilarities
1	Slant	20	95%	5%
2	Line Quality	20	100%	0%
3	Spacing	20	85%	15%
4	Letter Size	20	15%	85%
5	Alignment	20	35%	65%

As shown in Table 3.5, the percentage of similarities exceeds that of dissimilarities in most handwriting characteristics, with the exception of letter size (15%) and alignment (35%). The graphical representation shown in fig 3.5, further illustrates that an individual's handwriting remains largely consistent despite changes in the writing instrument.

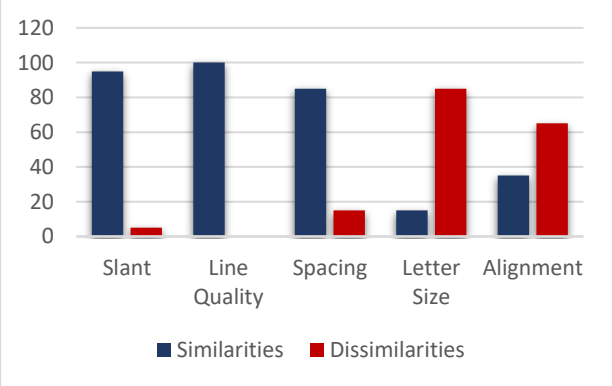

Figure.3.5 Comparison of similarities and dissimilarities in class characteristics of handwriting using unconventional instrument (Lipstick)

Table.3.6 Percentage (%) of similarities and dissimilarities of handwriting features due to Kajal

S.No.	Class characterstics	Frequency	% Similarities	% Dissimilarities
1	Slant	20	90%	10%
2	Line Quality	20	100%	0%
3	Spacing	20	85%	15%
4	Letter Size	20	15%	85%
5	Alignment	20	40%	60%

As shown in Table 3.6, the percentage of similarities exceeds that of dissimilarities in most handwriting characteristics, with the exception of letter size (15%) and alignment (40%). The graphical representation shown in fig 3.6, further illustrates that an individual's handwriting remains largely consistent despite changes in the writing instrument.

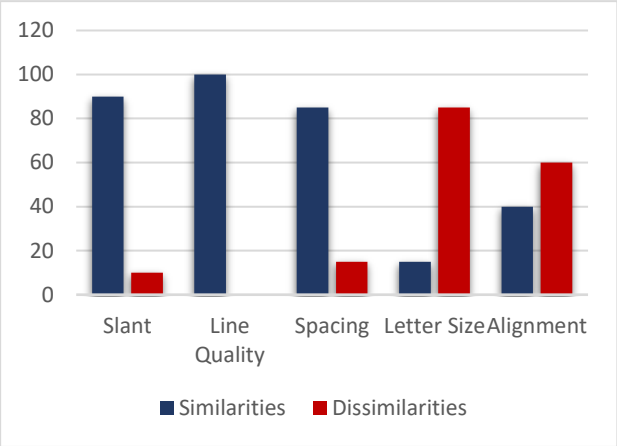

Figure.3.6 Comparison of similarities and dissimilarities in class characteristics of handwriting using unconventional instrument (Kajal)

Table 3: Observation table on the basis of Similarities for ANOVA Analysis (Instruments)

Instruments	Features				
	F1	**F2**	**F3**	**F4**	**F5**
I1	95	100	85	15	35
I2	90	100	85	15	40

Table 4: ANOVA Table on the basis of Similarities (Instruments)

Source of variation	d. f.	S.S.	M.S.S.	F. Cal.	F. Tab. 5%	**Result**	S. Ed. (±)	C.D. at 5%	F. Tab. 5%	SE(m)
Features	4	11265.000	2816.250	450.6	6.39	**S**	2.500	5.001	15.98	-
Instruments	1	0.000	0.000	0	7.71	**NS**	1.581	3.163	21.20	1.443
Error	4	25.000	6.250	-	-	-	-	-		
TOTAL	9		-	-	-	-	-	-		

Table 4 shows that the calculated F-values for different instruments are less than the tabulated F-value at the 5% significance level. This indicates that the null hypothesis is accepted, suggesting that there is no significant difference in handwriting due to variations in writing instruments. However, the calculated F-value for different handwriting features exceeds the tabulated F-value at the 5% level. This leads to the rejection of the null hypothesis, indicating a significant difference in handwriting with respect to the selected features.

4. DISCUSSION

The study showed that every individual shows similar handwriting features on both porous and non -porous surfaces except their letter size and alignment due to change in the writing surfaces and writing instruments. Due to change in the writing instruments and writing surfaces the class characteristics of handwriting i.e., slant, spacing, line quality, etc., shows variation while individual characteristics of the person remain unchanged. For examining this point, we applied statistics for the same, as a result it was found that F values of surface variation (i.e. porous and non-porous) and writing instrument was lower than critical F value on the other

hand F value of different writing features exceeds which explains that no significant change was observed in handwritings on multiple unconventional surfaces which further can create difficulty in establishing authorship of a person.

The purpose of selecting multiple surfaces under the category of porous and non-porous was to check what are the possible variations one can have while writing on smooth shiny non porous surface where ink flow is smooth and also prone to slippery ink strokes and porous rough surface which easily feathers the ink.

Comparative study of handwriting on porous and non-porous surfaces using unconventional writing instruments is a scarce research topic when talking about hindi language. Study was performed on Comparison of various writing characteristics of Hindi and Marathi languages of Devanagari origin, where they determine the authorship of handwriting of different language of same script [8].

5. CONCLUSION

The percentage of similarities exceeds that of dissimilarities in most handwriting characteristics, in class characteristics, and individual characteristics of handwriting remains largely consistent despite changes in the writing surface and writing instruments, which makes it clear that authorship identification can be done easily on handwritings on different surfaces or by using different writing instruments, only if the handwriting's class or individual characteristics changes prominently it can lead to false rejection in the authorship identification of a person.

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