

Sex determination from handwritten documents using Conventional method

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Even in the era of digitalization, appreciation of hand written documents stands as a major proof in cases of fraud or crime. Instances of disputes regarding property will, suicidal notes needs to identify the individual. Handwriting being the unique feature of an individual reflects the personality and state of mind. Efforts to determine the gender on the basis of handwriting help forensic experts minimizing the suspect pool to an appreciable extent. Many online and offline studies were conducted on handwriting analysis. Use of offline handwritten documents simplifies the task. With this thought several macro and micro-features were assessed from the written documents to find out the more significant ones in gender determination. This study was conducted on 150 medical students where 75 males and 75 females were included. A short paragraph including the entire English alphabet was chosen for this study. Out of all the macrofeatures considered in this study difference in cursive and printed writing showed a significant gender difference. Among the microfeatures analysed, Small letter 'r' (parochial/arcade), flourish at the start of small letter 'c' and loop at the end of small letter 'u' were the three features exhibiting gender differences. Thus rejecting the null hypothesis, this study stands in favor with the statement 'Gender differentiation is possible from handwritten documents.

KEY WORDS: Handwriting analysis, Gender, Forensic investigation

INTRODUCTION

Gender determination from hand written documents is an interesting research problem of forensic as well as psychological interest. Handwriting is an acquired dynamic skill of an individual. It is a complex blend of expression and motor skill that requires neuromuscular coordination. Among subjects, it shows differing degrees of natural variation. Handwriting is a unique feature of every individual that depends on adaptation of an individual. No two handwritings can be alike, as no two persons are alike. It is one

of the most advanced achievements of the human hand that can determine the individuality of a person. Culture shows a significant impact on the nature of handwriting pattern. Its evidence of dependence manifests in class, system, or national characteristics.

Graphology is the study of the art of handwriting and its analysis which is currently applicable in the assessment of people in industries.^[1]

Even in the era of digitalization, handwriting plays a major role in documentation, medium of communication, etc. Handwriting analysis is known to understand behavioral aspects of an individual. These studies are gaining popularity in the recent years due to widespread applications across diverse fields such as psychology, education, medicine, criminal detection, marriage guidance, commerce, and recruitment.^[2] Not necessarily all the samples collected will be from desired conditions. There are various studies that tried to interpret the handwritings found on

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unusual surfaces specially during conditions of suicidal attempts, fraud and robbery. Singh *et al.* in their review article, analyzed both qualitative and quantitative features of handwriting depicted on unusual surfaces.^[3]

Handwriting analysis reflects on behavior and personality of an individual.^[4] Thus, graphology remains a great tool for many industrial activities such as recruitment, selection, cancelling, interviewing, career planning, and team building. According to Bradley, there are 300 distinct characteristics of handwriting that would help in investigation.

A strong coordination exists among positions of arm, hand, and fingers while writing. Group of intrinsic muscles in hand, especially lumbricals cause flexion at the metacarpophalangeal joints and extension at proximal interphalangeal joints and distal interphalangeal joints. Combination of many elements, rather than a single feature brings better understanding about this complex activity. The motor activity of handwriting pattern represented in memory may not be muscle specific.^[5] This skillful act needs structured sequence of coordinated movements smoothly executed at its proper time and place. They constitute the habitual aspects of writing that are peculiar to each individual. These writing habits may become more automatic with gradual practice.

Males are more heroic while females are softer in nature, so as these qualities even reflect in their handwritings. Females do not undermine the minute details whereas males show plainness in writing patterns.

Aim of the Study

This study aims at analyzing handwriting patterns to determine gender differences.

H_0 : Gender differentiation is not possible from handwritten documents.

RATIONALE

Handwriting is an acquired skill and is unique for every individual. It even cannot be recreated by the same individual. However, it shows a continuous flow even though not appreciated as an inked line that helps in identification of an individual. This study may provide relevant parameters that can differentiate offline written documents.

Study Subjects

This was 18–24-year-old MBBS students which include both males and females.

Sample Size

This was 150 participants.

Sampling Method

This was convenience sampling.

Study Area

This was Rohilkhand Medical College and Hospital, Bareilly International University.

Consent

Informed consent from the study subjects was attained after well explaining the purpose of the study conducted.

METHODOLOGY

One hundred and fifty handwritten samples were collected. The written document was a short paragraph that included the entire alphabet.

Inclusion Criteria

The following criteria were included in the study:

- Normal healthy subjects
- Right handed subjects.

Exclusion Criteria

The following criteria were excluded from the study:

- Injury to the writing hand
- Unwillingness to participate
- Habitual persons to write using mouth or foot.

Parameters Involved in Assessment of Handwriting

All the features were classified into macro-features and micro-features. All the qualitative data was converted into quantitative data set by giving codes for statistical analysis.

A) Macro-features

1. Slant: It has been classified into three types using 1–3 codes.
 - Forward – 1
 - Backward – 2
 - Vertical – 3.
2. Margins: It has been classified into three types using 1–2 codes
 - Even – 1
 - Irregular – 1.
3. Type of handwriting:
 - Cursive writing – 1
 - Printed – 2.
4. Writing quality:
 - Smooth – 1
 - Shaky – 2.
5. Pen pressure: It has been classified into three types using 1–3 codes
 - Light – 1
 - Medium – 2
 - Heavy – 3.

B) Micro-features

1. Shape of small letter “r”:

- Parochial – 1.
- Arcade – 2.
- 2. Dot on small letter i
 - Solid dot – 1
 - Circular – 2
- 3. Loop in stem of small letter “b”
- 4. Loop in the stem of small letter “l”
- 5. Flourish at the start of letter “d”
- 6. Flourish at the start of “a”
- 7. Flourish at the start of “c”
- 8. Hook at the end of u.

Many incidences such as suicides, threats, robbery, and rape are some serious issues where a piece of handwriting available in the scene can help rule out a problem. Males and females are equal but not the same. Development of brain occurs during 8–24 weeks of intrauterine life (critical period). Between 7 and 12 weeks of IUL, the levels of fetal testosterone widely impact the cortical volume and thickness in males. Testosterone has huge impact on brain during 4–12 weeks of post natal life (mini puberty).^[6] Handwriting is an impulsive activity where the brains impulse to the hand which then manipulates the hand writing.

RESULTS AND DISCUSSION

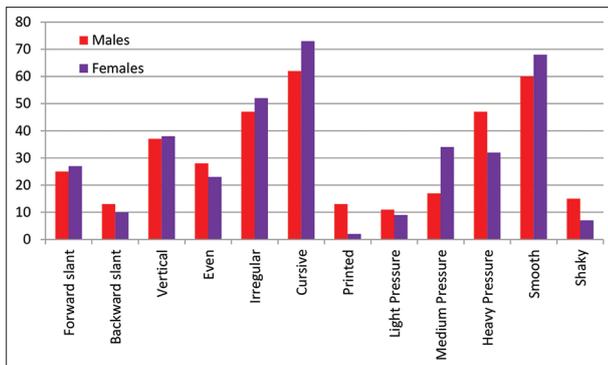


Figure 1: Graph showing frequency distribution of various handwriting macro-features in males and females

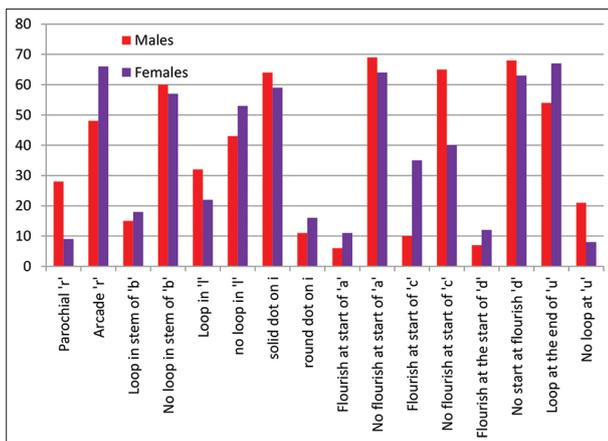


Figure 2: Graph showing frequency distribution of various handwriting micro-features in males and females

A common form of supplementary proof in cases of criminal justice may be a written document. Many studies proved that handwriting of an individual reflects their personality, while some strongly deny it.^[7] Using binarization algorithm method, Srihari *et al.* studied individuality of handwriting on 1500 US individuals.^[8] Bansal *et al.* strongly believe that handwritten documents are a major source for sex identification in case of civil and criminal verifications.^[9] Several studies used various feature extraction methods for analyzing written documents using software programs.^[10] According to them, the use of unusual surfaces at crime scenes for handwriting may complicate the investigations. Some studies concluded that online prediction of handwriting is much more reliable than offline techniques.^[11]

Table 1: Independent t-test showing gender differences among macroscopic features

Sl. no.	Macro-features	Gender	Mean	SD	t-value	df	Sig
1	Slant	Male	2.15	0.896	0.000	148	1.000
		Female	2.15	0.926			
2	Margins	Male	1.63	0.487	-0.858	148	0.392
		Female	1.69	0.464			
3	Pattern	Male	2.48	0.381	3.067	148	0.003
		Female	2.31	0.162			
4	Pen pressure	Male	2.48	0.742	1.494	148	0.137
		Female	2.31	0.677			
5	Writing quality	Male	1.20	0.403	1.855	148	0.066
		Female	1.09	0.293			

SD: Standard deviation, p=0.00 is considered as statistically significant

Table 2: Frequency distribution table for various macro-features of handwriting in males and females

Sl. no.	Parameters (macrofeatures)	Male		Female	
		n=75	Percentage	n=75	Percentage
1	Slant				
	Forwards	25	33.3	27	36
	Backwards	13	18.7	10	13.3
2	Vertical	37	48	38	50.7
	Even	28	37.3	23	30.7
	Irregular	47	62.7	52	69.3
3	Pattern				
	Cursive	62	82.7	73	97.3
	Printed	13	17.3	02	2.7
4	Pen pressure				
	Light	11	14.7	09	12
	Medium	17	22.7	34	45.3
5	Heavy	47	62.7	32	42.7
	Writing quality				
	Smooth	60	80	68	90.7
Shaky	15	20	7	9.3	

Table 3: Frequency distribution table for various micro-features of handwriting in males and females

Sl. no.	Parameters (micro-features)	Male		Female	
		n=75	Percentage	n=75	Percentage
1	Small letter "r"				
	Parochial	28	37.3	09	12
	Arcade	48	62.7	66	88
2	Small letter "b"				
	Loop in the stem	15	20	18	24
	No loop	60	80	57	76
3	Small letter "l"				
	Loop in the stem	32	42.7	22	29.3
	No loop	43	57.3	53	70.7
4	Small letter i				
	I (solid)	64	85.3	59	78.7
	î (round)	11	14.7	16	21.3
5	Small letter "a"				
	Flourish at the start	6	8%	11	14.7
	No	69	92	64	85.3
6	Small letter "c"				
	Flourish at the start	10	13.3	35	46.7
	No flourish	65	86.7	40	53.3
7	Small letter "d"				
	Flourish at the start	07	9.3	12	16
	No flourish	68	90.7	63	84
8	Small letter "u"				
	Loop at the end	54	72	67	89.3
	No flourish	21	28	08	10.7

Table 4: Independent t-test showing gender differences among microscopic features

Sl. no.	Micro-features	Gender	Mean	SD	t-value	df	Sig
1	Small letter r	Male	1.63	0.487	-3.740	148	0.000*
		Female	1.68	0.327			
2	Loop in the stem of b	Male	1.8	0.43	0.588	148	0.557
		Female	1.76	0.430			
3	Loop in the stem of "l"	Male	1.57	0.498	-1.706	148	0.090
		Female	1.71	0.458			
4	Dot over "i"	Male	1.15	0.356	-1.062	148	0.299
		Female	1.21	0.412			
5	Flourish at the start of "a"	Male	1.92	0.273	1.933	148	0.055
		Female	1.81	0.392			
6	Flourish at the start of "c"	Male	1.87	0.342	4.750	148	0.000*
		Female	1.53	0.502			
7	Loop at the end of "u"	Male	1.89	0.311	2.737	148	0.007*
		Female	1.72	0.452			
8	Flourish at the start of "d"	Male	1.91	0.292	1.225	148	0.222
		Female	1.84	0.369			

SD: Standard deviation, * is considered as statistically significant for $p < 0.05$

This article was an attempt to find out gender differences among various parameters using handwritten documents. All

the parameters were broadly categorized into macro-features and micro-features. Among all the macro-features studied, only

pattern of handwriting categorized into cursive and printed type was found to be significantly different among males and females at $P < 0.05$ [Table 1]. Cursive handwriting was depicted more by females (97.3%) than males (82.7%). Printed handwriting was seen more in males (17.3%) than in females (2.7%). Among males forward slant, backward slant and vertical type of handwritings were noticed in 33.3%, 18.7% and 48%, respectively [Figure 1]. In females, forward slant, backward slant, and vertical type of handwritings were noticed in 36%, 13.3% and 50.7%, respectively [Table 2]. Independent t-test showed no significant gender differences in this parameter. In contrast to this study, Shaus *et al.* noted slant in handwriting as one of the gender differentiating feature.^[12] According to Meena *et al.*, slant in signatures can be used as a sex determining factor.^[13]

According to Kiran and Sridhar, pen lifts had a greater correlation among parents and children rather than the pressure applied while writing. In this study, no significant gender differences were noticed regarding pen pressure.^[14] These variations among studies might be due to of difference in analyzing techniques.

Out of eight micro-features studied, three of them showed characteristically significant gender differences (at $P < 0.05$). Small letter “r” (parochial/arcade), flourish at the start of small letter “c,” and loop at the end of small letter “u” were the three features exhibiting gender differences. Parochial shape of “r” was exhibited by 37.3% and 12% males and females, respectively, while arcade pattern of “r” was demonstrated by 62.7% males and 88% females [Figure 2]. Flourish at the start of small letter “c” was represented by 13.3% males and 46.7% females, while no flourish was depicted by 86.7% males and 53.3% of females [Figure 2]. Loop at the end of “u” was noticed among 72% and 89.3% males and females, respectively, while 28% males and 10.7% females did not show the same [Tables 3 and 4]. A study conducted by Azab *et al.*^[15] did not find any gender differences in Arabic handwriting, while a case scenario presented by Gupta and Ravi strongly affirms the significance of handwriting analysis used in criminal case investigation.^[16]

CONCLUSION

Handwriting analysis has recently gained much attention in the research field. This study investigated the potential of visual attributes of handwriting in gender prediction. This study does not deny on online assessment of handwriting, but it establishes significant evidence that certain parameters can be effectively used in sex determination by manual examination of written documents. This article is an attempt to ease the detection process by ruling out sex from the suspected handwritten documents. This study finally rejects the null hypothesis by saying “Gender differentiation is possible from handwritten documents.” Future studies of this kind on large sample size are recommended for generalizing the results.

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