

VARIABILITY IN HANDWRITING PATTERNS AMONG ETHNIC GROUPS OF INDIA

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ABSTRACT

Writing is a complex act and highly developed skill. Variation in handwriting is the foremost principle of handwriting analysis. This paper presents an offline handwriting analysis method for English characters to see the variation in different Ethnic groups of India. Important features of handwriting were obtained and classified into Macro and micro features. These features were used to establish the discriminating power of handwriting for different Ethnic groups. In addition to this changes in handwriting patterns were also observed with respect to different factors like age, gender and education level etc. This approach provides impetus for identifying ethnicity with the help of handwriting features and assists in Forensic document examination.

KEYWORDS: Forensic Science, Handwriting Analysis, Ethnic Groups, Handwriting Variations, Document Examination

INTRODUCTION

Handwriting of a person has some unique features which can be used for personal identification. Just as no two people are exactly alike, the handwritings of no two people are exactly alike in their combination of characteristics. There are, of course, natural variations within the handwriting of each individual. Writer individuality rests on the hypothesis that each individual has consistent handwriting that is distinct from the handwriting of another individual.

Every person whose handwriting is developed and permanently formed had adopted certain more or less distinctive peculiarities in the formation of letters of which he is generally unaware. A peculiarity in handwriting is more often cultivated than controlled. There are many peculiarities in a handwriting text like specific shape of letters, e.g. their roundness or sharpness, regular or irregular spacing between letters, slope, pressure, average size of the letters, rhythmic repetition of the elements or arrhythmia and many others e.g. line quality, spacing and pen-lifts.

This paper presents an off-line analysis method for English handwritten characters among Delhi population, North India. The objective was to set a hypothesis that there are different handwriting patterns among different ethnic groups and to study the age, gender education and occupation differences with reference to handwriting among various ethnic groups in Delhi.

It has been observed that many studies have been conducted on the Handwriting identification and recognition. (Zhang & Srihari 2003, Schlapbach & Bunke 2004, Zheng et al 2004, Plamondon & Srihari 2000, Marti & Bunke 2002). These studies highlighted writer identification using different models and approaches like hidden Markov model (HMM), Markov Random Field-based (MRF) approach and binary vector dissimilarity measures etc. No study on the variability in handwriting patterns among different ethnic groups has been done so far, keeping the following aims, the present study was conducted.

Motivation

Identification through handwriting is very popular and widely used in forensic science. Though writer identification (signature verification) has been used for a long time, use of handwriting for automatic recognition has started few years ago. This technology has advanced to a much high level.

As an alternative, discriminating power of handwriting can also be used for variations among various ethnic groups in India. The present study is an effort to establish the variability in handwriting patterns of different ethnic groups in India.

Area and People

Delhi is a metropolitan region in India that includes the national capital city, New Delhi. Delhi city is one of India's most affluent urban centres. It is located in northern India on the banks of the River Yamuna in the area known as Delhi plains. New Delhi is a cosmopolitan city due to the multi-ethnic and multi-cultural presence of the vast Indian bureaucracy and political system. In India there are various population groups which are divided into caste groups, religious groups, scheduled tribes, scheduled castes and various ethnic groups. The various ethnic groups have been studied from holistic anthropological dimension viz. Kapoor et al, 2012 a, b, c; Malhotra et al, 1974,1980; Vidyarthi et al, 1976; Vijeta & Kapoor, 2012; Saini 2013 and many more. **Delhi's ethnic groups** may be sub-divided into two categories, indigenous and migrant. The indigenous people are those who belong to the Delhi-middle Yamuna basin, a region which spreads radially from the capital up to a distance of approximately 200 kilometres. Brahmin, Punjabi, Jat, Baniya and Ahir are considered indigenous people whereas Bengali Kayastha and Tamilians are considered as migrant populations. These groups are taken into consideration for the present study.

In Hindu society it is considered that Brahmins were born from *Mahapurush'smukh (mouth)*. These are considered as class of priests and scholars. The Brahmins are divided into two regional groups: Pancha-Gauda (Northern India) and Pancha-Dravida (Southern India). Panjabi is a heterogeneous ethnic group originated from Panjab region. Panjabi people are found among Hindu and Sikh. It was primarily a linguistic group regardless of any religious affiliations. Jat ethnic group belongs to non-elite tillers and herders of northern India. These people are also found among Hinduism, Sikhism and Islam. Baniya is an occupational ethnic group. These are Hindu by religion. Baniyas maintain intercommunity linkages with the Brahman, Valand, Soni and other communities through trade and service. Ahir is an ethnic group, whose traditional occupation is cow-herding. They are mainly concentrated in northern part of India. Bengali Kayasthaethnic group is basically from Bengal. This is a homogeneous group with heterogeneous origin. Tamilians group is a linguistic group from Tamilnadu, Srilanka and Maldives.

This study puts forward the natural variation in handwriting. The objective of this study was to establish the hypothesis that handwriting is population or ethnic group specific.

MATERIAL AND METHODS

There are two major points of concern when analyzing handwriting samples: First, to see the Variance within the handwriting patterns of different ethnic groups. Second, to see the changes in handwriting features with respect to different factors like age, education level etc. The present study consisted of three phases: data collection, feature extraction and statistical analysis to establish the classificatory power of handwriting. In the data collection phase, representative samples of handwriting were collected. In the second phase, certain peculiar characteristics of handwriting that would show the different patterns of handwriting was obtained. After that analysis part was done with the help of SPSS software.

Data Collection

An individual's handwriting changes over his or her lifetime. The most obvious changes take place from childhood through adolescence. Graphic maturity is generally reached towards the end of adolescence. Gradual changes will continue to occur. Although students learn the system of writing, each develops unique characteristics that distinguish his or her writing from all other writers. These are called individual characteristics, and they are either consciously created or subconsciously executed. The penmanship system taught in schools influences handwriting. Handwriting is also influenced by physiology, training, and other behavioural factors. (Srihari et al;2008)

To see the major variation in handwriting, samples from 12-18 yrs. School students were obtained. 8th-12th class was taken into consideration. Total 270 students were taken as representative sample from Delhi schools.

Standard Document

A standard document in English, which was to be copied by each subject, was designed for the present study. The source document was one page text on Global warming with certain handwriting characteristics of interest. The source document also contained punctuation marks like comma, brackets and semi-colon, numerals like 0,1,2,4, 9 and some italic written words.

Subjects were asked to copy the document two times in his/her natural handwriting on plain and ruled sheets. They were allowed to use the pen of their own choice. In case writing instrument was not available with the subject it was supplied to them. No other restriction was imposed on the writers.

In addition to the source document subjects were also asked to fill the proforma that encodes general information like Name, Age, Sex, Religion, Caste, Date and Place of examination. Certain close ended question related to handwriting e.g. relationship of handwriting with personality, mood, gender, time, handedness and resemblance of handwriting with parents were asked in the pro-forma. With the help of pro-forma knowledge of subject regarding forensic document examination was also examined. The field work was conducted from November 2012 to January 2013.

Feature Extraction

Each handwritten document was analyzed to study 19 features of handwriting. These features were divided into two classes: *Macro-features* and *Micro-features*. These characteristics or features were used to establish the discriminative power of handwriting among different ethnic groups. These features include

Macro- Features

- Margin
- Slant
- Size of the handwriting
- line Spacing
- Word spacing
- Letter spacing

Micro-Features

- Beginning Stroke

- Ending Stroke
- Lower case 't' analysis- t stem length, Bar pressure, Bar height and Bar length
- 'i' – dot
- lower case e loop
- 'o' analysis
- lower case 'm'
- lower case 'd'
- lower case 'g' and 'y' loop analysis

On the basis of different handwriting patterns obtained, these features can be divided into different types

S.No	Handwriting Features	Type
1.	Margin	i) Wide left margin ii) Wider to narrow left margin iii) Narrow to wider left margin iv) Even margins all around v) Wide upper margin vi) No upper margin vii) Narrow left margin viii) Narrow upper margin ix) Irregular margin x) No left margin
2.	Slant	i) Vertical slant ii) Moderate left slant iii) Extreme left slant iv) Moderate right slant v) Extreme right slant vi) irregular slant
3.	Beginning stroke	i) Long and curved ii) Unbending iii) Short curves from left to right iv) Long and below baseline stroke v) absent
4.	Ending stroke	i) Long, blunt and upward tending ii) Upward tending and tapered iii) High reaching iv) Below baseline v) Extended vi) Missing
5.	Lower case 't' analysis	i) Retraced ii) Looped iii) Inflexible beginning stroke iv) Separated
6.	't' stem length	i) Normal stem ii) Long stem iii) Short stem iv) Spread-out stem
7.	't' bar pressure	i) Normal pressure ii) Light pressure iii) Heavy pressure iv) Starts with heavy pressure but tapers

Table: Contd.,

8.	't' bar height	i)High above the stem ii) High bar iii) Balanced bar iv) Low bar v) No bar
9.	't' bar length of crossing	i)long ii) Short iii) Ascending bar iv) descending bar v) More to left vi) More to right vii) Absent
10.	'i'-dot analysis	i)Round and directly above the stem ii) Round and just above the stem iii) Round and high above the stem iv) Very light v) Left placed dot vi) Right placed dot vii) Circular dot viii) Smudged dot ix) Absent
11.	Lower case 'e' loop analysis	i) Narrow loop ii) Broad loop iii) No loop iv) Greek ε v) Normal loop
12.	Lower case 'm' analysis	i)Uphill humps ii) Downhill humps iii) Even humps iv) Rounded humps v) Sharp humps vi) Uneven humps
13.	Lower case 'o' analysis	i) Closed at the top with no loop ii) Open at the top iii) One inner loop
14.	Lower case 'd' analysis	i) Long ii) Short iii) Looped iv) split stem v) without extension
15.	Lower case 'g' and 'y' loop analysis	i)Triangular loop ii) Rounded full loop iii) Long and closed loop iv) Broad and full loop v) Small and cramped loop vi) Short and closed loop vii) Broad and full loop viii) Left arc ix) Open loop x)long down stroke

Statistical Analysis

The analysis work was done with the help of SPSS 16 software. Total 270 students, out of which 157 boys and 113 girls were taken between 12-18 age group from seven ethnic groups of India.

Table 1: Writer’s View on Relationship of Handwriting with Different Factors

Writer's Views on relationship of handwriting with different variables	Ethnic Groups																												
	Brahmin				Panjabi				Jat				Baniya				Ahir				Bengali (Kayastha)				Tamilian				
	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	
Does your handwriting related with your personality?	YES	21	55.3	15	75	19	65.5	21	65.6	16	64	10	90	10	50	6	66.7	11	73.3	7	53.8	6	60	7	100	14	70	9	42.9
	NO	17	44.7	5	25	10	34.5	11	34.4	9	36	1	9.1	10	50	3	33.3	4	26.7	6	46.2	4	40	-	-	6	30	12	57.1
Total	Total	38	100	20	100	29	100	32	100	25	100	11	100	20	100	9	100	15	100	13	100	10	100	7	100	20	100	21	100
Does your handwriting reflects your mood?	YES	24	63.2	19	95	22	75.9	28	27.5	17	68	11	100	14	70	8	88.8	9	60	8	61.5	7	70	7	100	12	60	16	76.2
	NO	14	36.8	1	5	7	24.1	4	12.5	8	32	-	-	6	30	1	11.1	6	40	5	38.5	3	30	-	-	8	40	5	23.8
Total	Total	38	100	20	100	29	100	32	100	25	100	11	100	20	100	9	100	15	100	13	100	10	100	7	100	20	100	21	100
Do you think your handwriting is good?	YES	26	68.4	14	70	18	62.1	23	71.9	17	68	10	90.9	11	55	9	100	10	66.7	10	76.9	6	60	7	100	11	55	16	76.2
	NO	12	31.6	6	30	11	37.9	9	28.1	8	32	1	9.1	9	45	-	-	5	33.3	3	23.1	4	40	-	-	9	45	5	23.8
Total	Total	38	100	20	100	29	100	32	100	25	100	11	100	20	100	9	100	15	100	13	100	10	100	7	100	20	100	21	100
Does your handwriting keep changing all the time?	YES	19	50	10	50	16	55.2	16	50	7	28	6	54.5	11	55	3	33.3	4	26.7	4	30.8	6	60	5	71.4	13	65	9	42.9
	NO	19	50	10	50	13	44.8	16	50	18	72	5	45.5	9	45	6	66.7	11	73.3	9	69.2	4	40	2	28.6	7	35	12	57.1
Total	Total	38	100	20	100	29	100	32	100	25	100	11	100	20	100	9	100	15	100	13	100	10	100	7	100	20	100	21	100
Do you think handwriting varies with age?	YES	25	65.8	18	90	25	86.2	25	78.1	15	60	11	100	15	75	9	100	12	80	10	76.9	5	50	7	100	9	45	19	90.5
	NO	13	34.2	2	10	4	13.8	7	21.9	10	40	-	-	5	25	-	-	3	20	3	23.1	5	50	-	-	11	55	2	9.5
Total	Total	38	100	20	100	29	100	32	100	25	100	11	100	20	100	9	100	15	100	13	100	10	100	7	100	20	100	21	100
Do you think handwriting varies with gender?	YES	16	42.1	10	50	13	44.8	10	31.2	15	60	3	27.3	9	45	2	22.2	7	46.7	5	38.5	4	40	5	71.4	7	35	9	42.9
	NO	22	57.9	10	50	16	55.1	22	68.8	10	40	8	72.7	11	55	7	77.8	8	53.3	8	61.5	6	60	2	28.6	13	65	12	57.1
Total	Total	38	100	20	100	29	100	32	100	25	100	11	100	20	100	9	100	15	100	13	100	10	100	7	100	20	100	21	100

Table 1 shows writer’s view on relationship of handwriting with personality, mood, time, age and gender. Among all the seven ethnic groups majority of the subjects admitted that their handwriting is related with personality and reflects mood. All the female writers among Bengali ethnic group admitted relationship of handwriting with personality. Among Brahmin ethnic group 50% males and females admitted that their handwriting changes with time. Among Punjabis 55.2% males and 50% females responded positively with reference to handwriting change with time whereas 100% Jat, Baniya and Bengali females agreed for the same with age. Among Baniya ethnic group 77.8% females think that handwriting varies with gender.

Table 2: Different Factors that Makes Writer’s Handwriting Good

Different Factors that makes writer's handwriting good	Ethnic Groups																											
	Brahmin				Panjabi				Jat				Baniya				Ahir				Bengali (Kayastha)				Tamilian			
	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%
Pen Used	7	18	1	5	7	24	7	22	6	24	3	27	6	30	2	22	2	13	2	15	1	10	1	14	7	35	5	24
Hard Practice	3	7.9	2	10	4	14	4	13	2	8	4	36	4	20	2	22	1	6.7	2	15	1	10	1	14	-	-	1	4.8
Mood & Concentration	8	21	11	55	5	17	10	31	3	12	2	18	4	20	3	33	2	13	4	31	2	20	3	43	4	20	6	29
Writing style	6	16	2	10	8	28	4	13	8	32	-	-	3	15	-	-	5	33	-	-	4	40	1	14	6	30	4	19
Neatness & Clarity	12	32	4	20	3	10	7	22	4	16	2	18	3	15	2	22	4	27	5	39	2	20	1	14	2	10	5	24
Time	2	5.3	-	-	2	6.9	-	-	2	8	-	-	-	-	-	-	1	6.7	-	-	-	-	-	-	1	5	-	-
Total	38	100	20	100	29	100	32	100	25	100	11	100	20	100	9	100	15	100	13	100	10	100	7	100	20	100	21	100

Table 2 depicts different factors that makes writer’s handwriting good. Mood and concentration was one of the major factors for making handwriting good among Brahmin, Bengali, Baniya, Punjabi and Tamilian females with 55.0%, 42.9%, 33.3%, 31.2% and 28.6% respectively whereas Bengali, Ahir, Jat and Panjabi ethnic group males added writing style as good handwriting factor with 40.0%, 33.3%, 32.0% and 27.6%. Among Brahmin males and Ahirfemales majority of the writers considered neatness and clarity for making their handwriting good. Male writers in Tamilian and Baniya ethnic group said pen as good handwriting factor with 35.0% and 30.0%. Majority of Jat females considered hard practice for making their handwriting good with 36.4% followed by pen used (27.3%).

Table 3: Forgery Ability among Ethnic Groups

	Ethnic Groups																												
	Brahmin				Panjabi				Jat				Baniya				Ahir				Bengali (Kayastha)				Tamilian				
	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	
Forgery Ability of the writer	Yes	9	24	7	35	9	31	10	31	7	28	6	55	5	25	5	56	6	40	3	23	3	30	1	14	6	30	11	
	No	29	76	13	65	20	69	22	69	18	72	5	46	15	75	4	44	9	60	10	77	7	70	6	86	14	70	10	
	Total	38	100	20	100	29	100	32	100	25	100	11	100	20	100	9	100	15	100	13	100	10	100	7	100	20	100	21	

Table 3 displays the forgery ability among seven ethnic groups. Most of the male and female writers among Brahmin, Panjabi, Ahir and Bengali ethnic group do not have the ability to forge. 85.7% Bengali females responded negative for the forgery ability followed by 76.9% females among Ahir ethnic group. Majority of females among Baniya, Jat and Tamilian ethnic group have forgery ability with 55.6%, 54.5% and 52.4% respectively.

Table 4: Patterns of Slant among Ethnic Groups

Slant (Handwriting Feature)	Ethnic Groups																											
	Brahmin				Panjabi				Jat				Baniya				Ahir				Bengali (Kayastha)				Tamilian			
	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%
Vertical slant	4	11	10	50	6	21	16	50	6	24	7	64	4	20	3	33	3	20	7	54	2	20	3	43	7	35	12	57
Moderately left slant	8	21	2	10	5	17	4	13	5	20	1	9.1	5	25	-	-	1	6.7	2	15	2	20	1	14	3	15	1	4.8
Extremely left slant	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Moderately right slant	10	26	8	40	6	21	9	28	6	24	2	18	5	25	5	56	5	33	4	31	-	-	3	43	5	25	6	29
Extreme right slant	8	21	-	-	4	14	1	3.1	3	12	-	-	-	-	-	-	1	6.7	-	-	-	-	-	-	-	-	-	-
Irregular slant	8	21	-	-	8	28	2	6.2	5	20	1	9.1	6	30	1	11	5	33	-	-	6	60	-	-	5	25	2	9.5
Total	38	100	20	100	29	100	32	100	25	100	11	100	20	100	9	100	15	100	13	100	10	100	7	100	20	100	21	100

Table 4 represents patterns of slant among seven ethnic groups. Vertical slant was prevalent among females of Jat, Tamilian, Ahir, Brahmin Panjabi and Bengali ethnic group with 63.6%, 57.1%, 53.8%, 50.0%, 50.0% and 42.9%. It was also found to be maximum among Tamilian and Jat males with 35.0% and 24.0%. Males among Brahmin, Jat and Ahir used to leave moderately right slant with 26.3%, 24.0% and 33.3% which is maximum. Under moderately right slant, 55.6% Baniya and 42.9% Bengali females were found to be maximum. Irregular slant was common among males of Panjabi, Baniya, Ahir and Bengali ethnic group. It was found to be highest among among Bengali males with 60.

Table 5: Line Spacing (Handwriting Feature) among Ethnic Groups

Line Spacing in c.m. (Handwriting Feature)	Ethnic Groups																											
	Brahmin				Panjabi				Jat				Baniya				Ahir				Bengali (Kayastha)				Tamilian			
	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%
0.10-0.20	7	18	2	10	6	21	5	16	8	32	3	27	8	40	2	22	6	40	6	46	3	30	-	-	6	30	8	38
0.20-0.30	15	40	7	35	10	35	8	25	8	32	6	55	2	10	2	22	7	47	5	39	3	30	1	14	2	10	5	24
0.30-0.40	5	13	6	30	9	31	14	44	2	8	1	9.1	3	15	3	33	1	6.7	-	-	2	20	5	71	6	30	3	14
0.40-0.50	7	18	3	15	3	10	4	13	5	20	-	-	4	20	1	11	-	-	1	7.7	-	-	-	-	2	10	4	19
0.50-0.60	2	5.3	2	10	-	-	-	-	1	4	1	9.1	-	-	1	11	1	6.7	1	7.7	2	20	1	14	1	5	-	-
0.60-0.70	1	2.6	-	-	1	3.4	1	3.1	-	-	-	-	1	5	-	-	-	-	-	-	-	-	-	-	1	5	1	4.8
0.70-0.80	-	-	-	-	-	-	-	-	1	4	-	-	1	5	-	-	-	-	-	-	-	-	-	-	1	5	-	-
0.80-0.90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	-	-
0.90-1.00	1	2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00-1.10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.10-1.20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.20-1.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.30-1.40	-	-	-	-	-	-	-	-	-	-	-	-	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	38	100	20	100	29	100	32	100	25	100	11	100	20	100	11	100	15	100	13	100	10	100	7	100	20	100	21	100

Table 5 represents line spacing (handwriting feature) among seven ethnic groups. Majority of writers among Brahmin, Panjabi, Jat, Ahir and Bengali used to leave 0.20-0.30 c.m. spacing between two lines. Maximum percentage was found among Jat females with 54.5% followed by Ahir males with 46.7%. 71.4% females in Bengali ethnic group used to

leave 0.30-0.40 c.m. spacing which is maximum followed by Panjabi females with 43.8%. Line spacing among males of Baniya, Jat, Bengali and tamilian ethnic group was low i.e. 0.10-0.20 c.m. Maximum of this range was found among Baniya i.e. 40% whereas among females highest was found among Ahir ethnic group with 46.2% followed by Tamilian females i.e. 38.1%.

Table 6: Word Spacing (Handwriting Feature) among Ethnic Groups

Word Spacing in c.m. (Handwriting)	Ethnic Groups																											
	Brahmin				Panjabi				Jat				Baniya				Ahir				Bengali				Tamilian			
	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%	M	%	F	%
0.17-0.37	6	16	13	65	2	6.9	4	13	3	12	2	18	5	25	1	11	4	27	4	31	1	10	-	-	3	15	2	9.5
0.37-0.57	11	29	4	20	16	55	18	56	12	48	5	46	10	50	4	44	6	40	4	31	4	40	4	57	8	40	12	57
0.57-0.77	14	37	3	15	9	31	7	22	6	24	3	27	4	20	3	33	4	27	4	31	3	30	2	29	8	40	5	24
0.77-0.97	6	16	-	-	2	6.9	3	9.4	2	8	1	9.1	-	-	1	11	1	6.7	-	-	2	20	1	14	-	-	1	4.8
0.97-1.17	1	2.6	-	-	-	-	-	-	1	4	-	-	-	-	-	-	-	-	1	7.7	-	-	-	-	-	-	1	4.8
1.17-1.37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.37-1.57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.57-1.77	-	-	-	-	-	-	-	-	-	-	-	-	1	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.77-1.97	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	-	-
1.97-2.17	-	-	-	-	-	-	-	-	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	38	100	20	100	29	100	32	100	25	100	11	100	20	100	9	100	15	100	13	100	10	100	7	100	20	100	21	100

Table 6 presents the word spacing among seven ethnic groups. Out of seven, six ethnic groups i.e. Panjabi, Jat, Baniya, Ahir, Bengali and Tamilian used to leave 0.37-0.57 c.m. spacing between words. Tamilian and Bengali females spacing was found to be higher that is 0.57-0.77 c.m. whereas among females word spacing was lower i.e. 0.17-0.37 c.m. with 65.0%.

Micro - Features

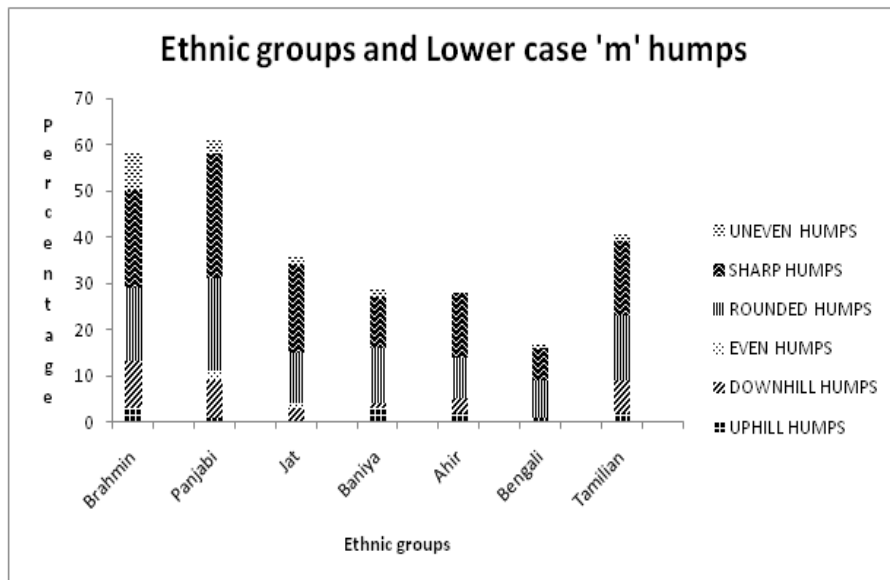


Figure 1: Patterns of Lower Case ‘m’ Humps among Ethnic Groups

Figure 1 represents interaction between ethnic groups and lower case ‘m’ humps. Sharp humps was most prevalent among Panjabis. Out of the total Baniyas (10.7%), 4.4% Writers tend to form round humps in alphabet ‘m’. Sharp humps was also found among Brahmin, Jat, Tamilian and Ahir ethnic groups with 7.8%, 7.0%, 5.9% and 5.2% respectively.

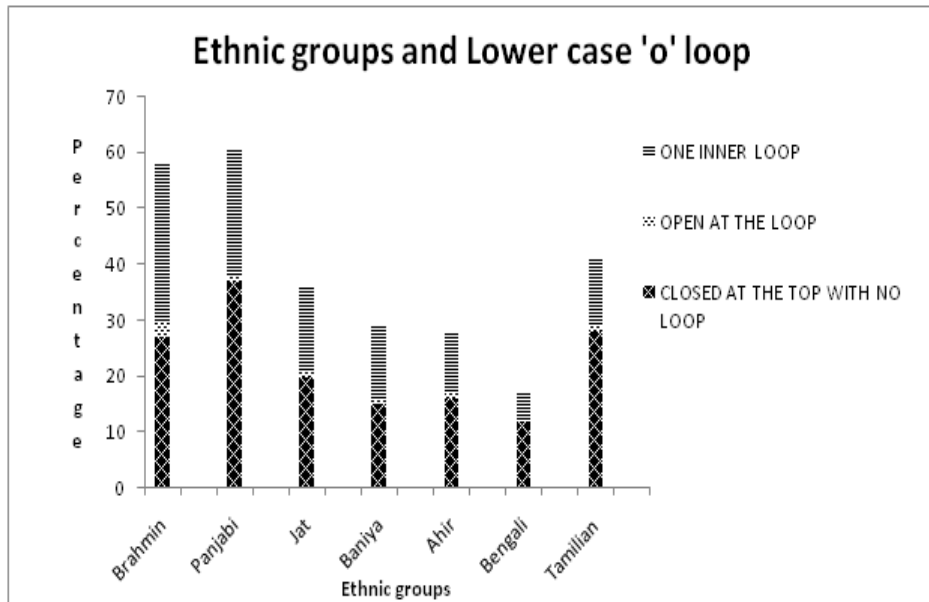


Figure 2: Patterns of Lower Case 'o' among Ethnic Groups

Figure 2 depicts the patterns of lower case 'o' loop among ethnic groups. 10.4% Brahmins tend to form inner loop in the lower case 'o' which is maximum in this category. Out of the total writers 57.4% subjects close the alphabet 'o' at the top with no loop. In this category Panjabis were maximum with 13.7% followed by Tamilian, Jat and Ahir ethnic groups.

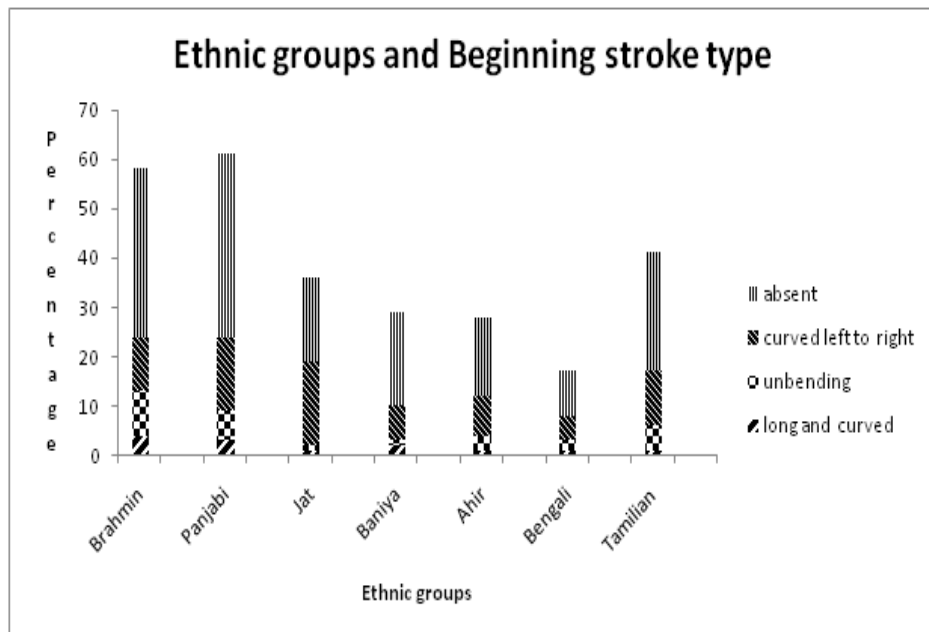


Figure 3: Patterns of Beginning Stroke among Ethnic Groups

Figure 3 represents the patterns of Beginning Stroke among ethnic groups. Out of the total Jats i.e. 13.3%, 6.3% Jats tend to form beginning stroke that is curved from left to right. Total 57.8% writers did not form beginning stroke. Panjabis and Brahmins were highest in this category with 13.7% and 12.6% respectively.

Changes in Micro Features (Handwriting Features) with Reference to Education Level, Age and Gender

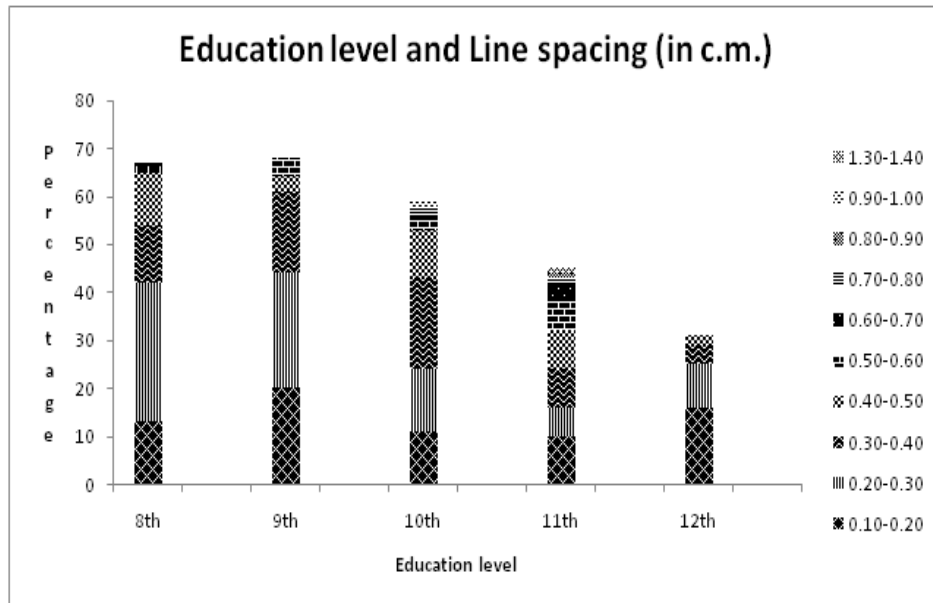


Figure 4: Line Spacing (Handwriting Feature) with Reference to Education Level

Figure 4 displays changes in line spacing (Handwriting feature) with education level. Writers from 11th and 12th classes leave very narrow spaces between lines i.e. 0.10-0.20 c.m. whereas majority of students in 8th and 9th classes leave 0.20-0.30 c.m. between lines.

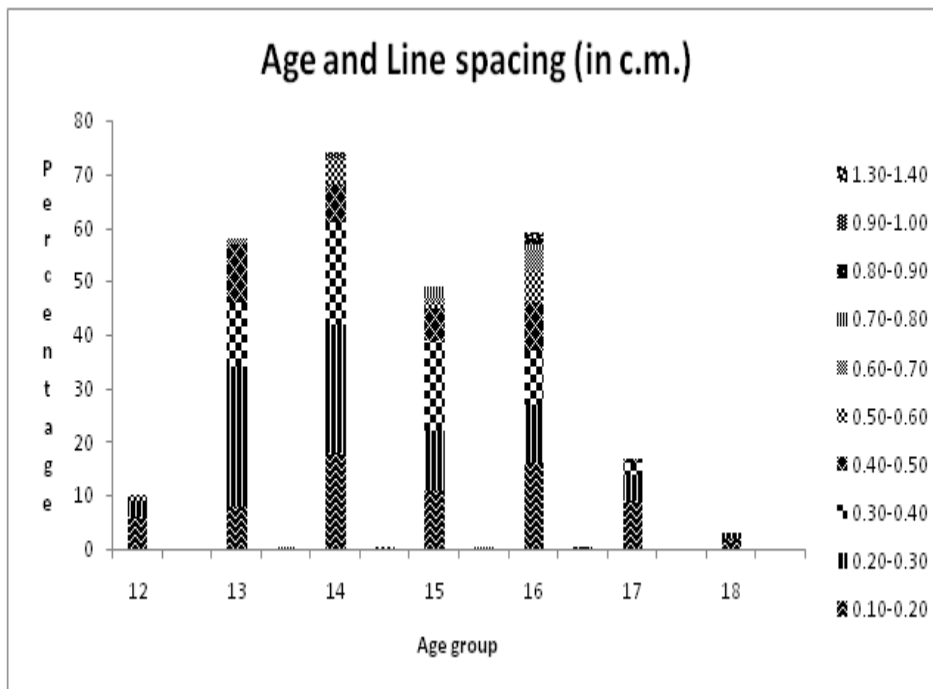


Figure 5: Line Spacing (Handwriting Feature) with Reference to Age

Figure 5 depicts changes in line spacing (Handwriting feature) with age. Spacing between lines decreases with increasing age. Among 16, 17 and 18 age group line spacing is extremely low that is 0.10-0.20 c.m. while in 13 and 14 age group line spacing is 0.20-0.30 c.m. In 15 age group, spacing between lines slightly increases that is 0.30-0.40 c.m.

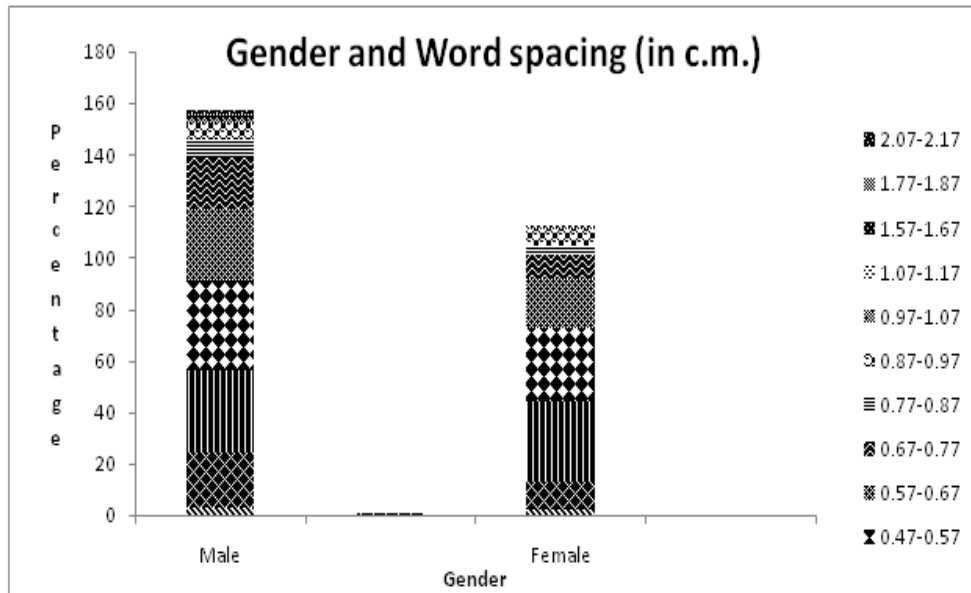


Figure 6: Word Spacing (Handwriting Feature) with Reference to Gender

Figure 6 represents changes in word spacing with Gender. Out of the total male writers majority of males leave larger spaces between words that is 0.47-0.57 c.m. while most of the females leave 0.37-0.47 c.m. spaces between words.

SUMMARY AND CONCLUSIONS

The present study was conducted to see the variations in handwriting patterns or features among different ethnic groups. These variations are easily observable in macro handwriting features like Slant, Word size, Line spacing, Word spacing and Letter spacing. Discriminations were also seen in case of micro handwriting features like lower case ‘m’ hump formation, lower case ‘o’ loop formation and type of beginning stroke. The main characteristic features of Brahmin ethnic group were moderately right slant and inner loop formation in lower case ‘o’. In Panjabi group vertical slant, lower case ‘o’ closed at the top with no loop formation and larger line spacing than other ethnic groups was main features of handwriting. Among Jat ethnic group peculiar handwriting pattern was seen in case of beginning stroke i.e. curved left to right. Rounded humps in lower case ‘m’ was main feature in Baniya ethnic groups. Lowest line spacing was found in Tamilian ethnic group.

Variations were also seen in handwriting features with education level, age and gender. Line spacing decreases with increasing education level and age. Word spacing is larger in most of the males than females. There are many important extensions of the study that could be done with more handwriting samples. Some of these are to study and compare the handwritings of more ethnic groups from other areas of Indian population so that identification of different ethnic groups can be done with the help of handwriting features.

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