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## Determination of the state of origin of the writer from the class characteristics in English handwriting

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In this research work, we discuss class characteristics in English handwriting of people from Tamil Nadu, Uttar Pradesh and West Bengal. The subjects had primarily studied in their local language, with English as their second language. The regional handwriting samples from 750 subjects were collected randomly in the age group between 18 and 60 years and their class characteristics such as writing movement, formation of letters, letter designs, pen-lifts, letter size, artistic ability, letter spacing and embellishments were exam-

ined. Several characteristic features peculiar to the individual linguistic groups were identified and the impact of the regional language script writing system was observed on the English handwriting of almost all the subjects.

**Keywords:** Class characteristics, forensic science, handwriting, linguistic groups.

THE multi-linguistic society in India provides ample opportunities for examining English handwriting of different linguistic group as the education system emphasizes on bilingualism. Thus, each child learns English and also his/her local language. The subjects selected for the study are from the states: Tamil Nadu (TN), West Bengal (WB) and Uttar Pradesh (UP)<sup>1</sup>. It is common that Tamilian children learn Tamil, children from UP learn Hindi and Bengali children learn Bengali in their schools and also at home. Exposure to a writing system<sup>2</sup> using characters different from the Latin script may give rise to the observed distinctive characteristics of different linguistic groups while writing English. In this communication, we study the class characteristics of the subject's English handwriting and explore possible influence of local language on English handwriting.

The Tamil writing system<sup>3–5</sup> is the most common Indian language used and learnt by the Tamilians in TN. It has 12 vowels, 1 rhythm and 18 consonants (Figure 1).

### Numerals

0	௧	௨	௩	௪	௫	௬
பூச்சியம்	ஒன்று	இரண்டு	மூன்று	நான்கு	ஐந்து	ஆறு
pūcciyam	onru	iranṭu	mūṇṇu	naaṅku	ainṭu	āru
0	1	2	3	4	5	6
௭	௮	௯	௧௦	௧௧	௧௨	௧௩
ஏழு	எட்டு	ஒன்பது	பத்து	நூறு	எந்	
ēṭu	ettu	onṇatu	pattu	nūru	en	
7	8	9	10	100	1000	

### The 12 vowels

அ	ஆ	இ	ஈ	உ	ஊ
எ	ஏ	ஐ	ஓ	ஔ	ஔள

### The aytham

ஃஃ

### The 18 consonants

க்	ச்	ட்	த்	ப்	ற்
ங்	ஞ்	ண்	ந்	ம்	ன்
ய்	ர்	ல்	வ்	ழ்	ள்

Figure 1. Tamil numerals, vowels and consonants<sup>5</sup>.

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The vowels and consonants combine to form over 200 letters, and each letter in turn combines with another to form words. Tamil is not a cursive script, thus no letters are joined while writing. It is also written from left to right as in the case of English handwriting.

The Bengali alphabets<sup>6,7</sup> are derived from the Brahmi alphabets<sup>8</sup>. They are also closely related to the Devanagari alphabets<sup>9</sup>, from which they started to diverge in the 11th century AD. A few archaic letters were modernized during the 19th century.

The Bengali alphabets (Figure 2) are syllabic alphabets in which consonants have inherent vowels with two different pronunciations, the choice of which is not always easy to determine, and sometimes not pronounced at all. Vowels can be written as independent letters, or using a variety of diacritical marks which are written above, below, before or after the consonant.

Hindi is an Indo-Aryan language<sup>10,11</sup> spoken by about 487 million people. The national language of India and is the most common language used in the northern states (Figure 3). Hindi was first used in writing<sup>11</sup> during the 4th century AD. It was originally written with the Brahmin script, but since the 11th century AD, it has been written in Devanagari.

Several studies have been conducted in the past to understand the class characteristics of handwriting for local language writers. Although most findings were positive in identifying a few features to be representative amongst the particular group of writers, few took a quantitative approach to see if the observed characteristics were of statistical significance<sup>12-14</sup>.

Seven hundred and fifty English writing specimens were collected in person from the specific geographical locations. Among these, 250 samples were collected from

Tamilian, Bengali and Hindi people. The subjects fell in the age group of 18–60 years. Data on their occupational and educational background were also collected. All of them had completed primary and secondary school education with the regional language, viz. Bengali and Tamil, Hindi as local language and English as their second language.

Each participant was given a typed sample of a paragraph which had the letters A to Z, all punctuation marks and numerals from 1 to 10 and was asked to copy the same on a blank sheet of paper in his/her own handwriting. He/she was asked not to copy the handwriting of specimen given or disguise his handwriting. He/she was also requested to maintain constant flow by writing the typed sample at one go.

Participants were requested to copy the sample passage in the space provided below the passage. The handwritten specimens were carefully studied to identify the characteristic features distinctive of the linguistic groups.

The characteristics of the following were examined:

- X<sub>1</sub> Size of the letters (large, medium and small).
- X<sub>2</sub> Artistic ability (artistic and non-artistic).
- X<sub>3</sub> Loop formation on the stem of letters ‘d’ and ‘b’.
- X<sub>4</sub> Loop formation on the lower part of the stem of letter ‘f’.
- X<sub>5</sub> Loop/hook formation in letters ‘S’ and ‘s’.
- X<sub>6</sub> Curved uppermost horizontal stroke of letters ‘T’, ‘J’ and ‘F’.
- X<sub>7</sub> Curved stroke formation of letter ‘E’.

Consonants

ক	ka [kɔ]	খ	kha [kʰɔ]	গ	ga [gɔ]	ঘ	gha [gʱɔ]	ঙ	ṅa [ŋɔ]
চ	ca [tʃɔ]	ছ	cha [tʃʰɔ]	জ	ja [dʒɔ]	ঝ	jha [dʒʱɔ]	ঞ	ña [ɲɔ]
ট	ṭa [ʈɔ]	ঠ	ṭha [ʈʰɔ]	ড	ḍa [ɖɔ]	ঢ	ḍha [ɖʱɔ]	ণ	ṇa [ɳɔ]
ত	ta [tɔ]	থ	tha [tʰɔ]	দ	da [dɔ]	ধ	dha [dʱɔ]	ন	na [nɔ]
প	pa [pɔ]	ফ	pha [pʰɔ]	ব	ba [bɔ]	ভ	bha [bʱɔ]	ম	ma [mɔ]
য	ya [jɔ]	র	ra [rɔ]	ল	la [lɔ]				
শ	śa [ʃɔ/ʂɔ]	ষ	ṣa [ʃɔ]	স	sa [sɔ/ʂɔ]	হ	ha [ɦɔ]		
য়	ya [jɔ]	ড়	ṛa [rɔ]	ঢ়	ṛha [rʱɔ]				

Numerals

০	১	২	৩	৪	৫	৬	৭	৮	৯	১০
শূন্য	এক	দুই	তিন	চার	পাঁচ	ছয়	সাত	আট	নয়	দশ
śūnya	ek	dui	tin	cār	pñāc	chay	sāt	āṭ	nay	daś
0	1	2	3	4	5	6	7	8	9	10

Figure 2. Consonants and numerals in Bengali<sup>12-14</sup>.

Consonants

क	ख	ग	घ	ङ	च	छ	ज	झ	ञ
ka	kha	ga	gha	ṅa	ca	cha	ja	jha	ña
[kɔ]	[kʰɔ]	[gɔ]	[gʱɔ]	[ŋɔ]	[tʃɔ]	[tʃʰɔ]	[dʒɔ]	[dʒʱɔ]	[ɲɔ]
ट	ठ	ड	ढ	ण	त	थ	द	ध	न
ṭa	ṭha	ḍa	ḍha	ṇa	ta	tha	da	dha	na
[ʈɔ]	[ʈʰɔ]	[ɖɔ]	[ɖʱɔ]	[ɳɔ]	[tɔ]	[tʰɔ]	[dɔ]	[dʱɔ]	[nɔ]
प	फ	ब	भ	म	य	र	ल	व	
pa	pha	ba	bha	ma	ya	ra	la	va	
[pɔ]	[pʰɔ]	[bɔ]	[bʱɔ]	[mɔ]	[jɔ]	[rɔ]	[lɔ]	[vɔ]	
श	ष	स	ह						
śa	ṣa	sa	ha						
[ʃɔ]	[ʃɔ]	[sɔ]	[ɦɔ]						

Additional consonants (used in loanwords from Persian, Arabic and English)

क़	ख़	ग़	ज़	झ़	फ़	ड़	ढ़
qa	ḫa	ḡa	za	zha	fa	ṛa	ṛha
[qɔ]	[xɔ]	[ɣɔ]	[zɔ]	[ʒɔ]	[fɔ]	[rɔ]	[rʱɔ]

Common conjunct consonants

क्ष	ज्ञ	त्क	द्व	द्य	ह	त्त	द्ध	झ
kṣa	jña	ttka	dva	dya	ḥa	tta	ḍḍha	ḍbha
[kʃɔ]	[dʒɲɔ]	[tʃkɔ]	[dvɔ]	[dyɔ]	[ɦɔ]	[ttɔ]	[dʒdʱɔ]	[dʒbʱɔ]
ब्र	ह्र	ह्य	श्र	त्र	र्प	प्र	र्र	
bra	hra	hya	śra	tra	rpa	pra	rṛa	
[brɔ]	[hrɔ]	[hyɔ]	[ʂrɔ]	[trɔ]	[rpɔ]	[prɔ]	[rṛɔ]	

Numerals

०	१	२	३	४	५	६	७	८	९	१०
शून्य	एक	दो	तीन	चार	पांच	छः	सात	आठ	नौ	दस
śūnya	ek	do	tīn	cār	pāñc	chaḥ	sāt	āṭh	nau	das
0	1	2	3	4	5	6	7	8	9	10

Figure 3. Consonants and numerals in Hindi<sup>19</sup>.



Figure 4 a-e. Examples of different alphabets written by Tamil, Bengali and Hindi writers.

- X<sub>8</sub> Curved stroke formation of letter 'X'.
- X<sub>9</sub> Round top formation of letter 'A'.
- X<sub>10</sub> Round bottom formation of letters 'V' and 't'.
- X<sub>11</sub> Straight stroke formation of letters 'M' and 'N'.

The number of persons who exhibited the characteristic features and those who did not were counted as two different parameters, which is a crucial factor in the identification and evaluation of class characteristics. The results have been tested for their statistical significance using the chi-square test<sup>13</sup>.

The handwriting specimens were studied in detail for characteristic features in letter formation, letter design, pen-lift, artistic ability which is shown to be written in cursive format, letter and word spacing and embellishment, etc. The null hypothesis<sup>14</sup>, if true, would have no statistical significance among the three linguistic groups<sup>15</sup> with respect to the frequency of occurrence of any of the 11 characteristic features stated above.

As there are 11 features under consideration

$$P_i(T) = P_i(B) = P_i(H), \quad \text{for } i = 1, 2,$$

where  $P$  is the probability of observing a characteristic feature in the handwriting of a particular linguistic group, and T, B and H stands for Tamil, Bengali and Hindi population respectively.

The hypothesis would then be

$$P_i(T) \neq P_i(B) \text{ and/or } P_i(T) \neq P_i(H)$$

$$\text{and/or } P_i(H) \neq P_i(B) \quad \text{for } i = 1, 2.$$

For each characteristic feature, a  $3 \times 2$  component table was constructed to compute the  $\chi^2$  value. As shown in Table 1, the significant level 0.05 was chosen, which is the commonly accepted level in scientific research. For degree of freedom = 2, the critical value of  $\chi^2$  at the significance level of 0.05 is 5.99 (rounded up to two-significant figures).

The null hypothesis would be rejected if the  $\chi^2$  value is greater than 5.99. The results of the tested characteristic features were found to have  $\chi^2$  values higher than 5.99, which proves the significance of the results, which were tested twice to confirm the accuracy. A  $2 \times 2$  component table was constructed to compute the  $\chi^2$  value and the

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**Table 1.** Chi-square values of 11 characteristic features

Chara- cteristic feature	Sum of chi- square			Chara- cteristic feature	Sum of chi- square							
	Tamil	Hindi	Bengali		Tamil	Hindi	Bengali					
X <sub>1</sub>	Yes	Observed	208	77	220	229*	No	Observed	108	213	119	
		Expected	168	168	168			Expected	146.7	146.7	146.7	
		Chi-square	9.35	49.6	16			Chi-square	10.2	30	5.22	
	No	Observed	42	173	30		27.28*	Total	250	250	250	
		Expected	81.7	81.7	81.7			X <sub>7</sub>	Yes	Observed	86	44
Chi-square	19.3	102	33	Expected	57.7	57.7		57.7				
Total	250	250	250	Expected	192.3	192.3		192.3				
X <sub>2</sub>	Yes	Observed	121	76	131	27.9*		Chi-square	4.17	0.97	1.118	
		Expected	109.3	109.3	109.3		Total	250	250	250		
		Chi-square	1.24	10	4.29		X <sub>8</sub>	Yes	Observed	116	46	51
	No	Observed	129	174	119		60*		Expected	71.0	71.0	71.0
		Expected	140.7	140.7	140.7				Chi-square	28.5	8.8	5.63
Chi-square	0.97	7.9	3.34	No	No	Observed		134	204	199		
Total	250	250	250	Expected		179.0		179.0	179.0			
X <sub>3</sub>	Yes	Observed	85	33		102		49.9*	Chi-square	11.3	3.49	2.23
Expected		73.3	73.3	73.3	Total	250	250		250			
Chi-square		1.9	22	11	X <sub>9</sub>	Yes	Observed		151	186	166	
No	Observed	165	217	148	11.2*		Expected		167.7	167.7	167.7	
	Expected	176.7	176.7	176.7			Chi-square		1.66	2	0.02	
Chi-square	0.8	9.2	4.7	No		No	Observed	99	64	84		
Total	250	250	250	Expected			82.3	82.3	82.3			
X <sub>4</sub>	Yes	Observed	140	46			99	75.4*	Chi-square	3.37	4.08	0.03
Expected		95.0	95.0	95.0	Total	250	250		250			
Chi-square		21	25	0.2	X <sub>10</sub>	Yes	Observed		54	54	79	
No	Observed	110	204	151	8.9*		Expected		62.3	62.3	62.3	
	Expected	155.0	155.0	155.0			Chi-square		1.11	1.11	4.46	
Chi-square	13	15	0.1	No		No	Observed	196	196	171		
Total	250	250	250	Expected			187.7	187.7	187.7			
X <sub>5</sub>	Yes	Observed	51	56			145	100*	Chi-square	0.37	0.37	1.48
Expected		84.0	84.0	84.0	Total	250	250		250			
Chi-square		13	9.3	44	X <sub>11</sub>	Yes	Observed		169	134	164	
No	Observed	199	194	105	12.2*		Expected		155.7	155.7	155.7	
	Expected	166.0	166.0	166.0			Chi-square		1.14	3.02	0.45	
Chi-square	6.6	4.7	22	No		No	Observed	81	116	86		
Total	250	250	250	Expected			94.3	94.3	94.3			
X <sub>6</sub>	Yes	Observed	142	37			131	110*	Chi-square	1.88	4.98	0.74
Expected		103.3	103.3	103.3	Total	250	250		250			
Chi-square		14.5	42.6	7.41								

\*Indicates values exceeding the critical value of 5.99.

Writing by Tamil writer

*Here for a week at 1496, Zermatt &  
goes to Turin and Rome and will*

Writing by Bengali writer

*The Indian business is good, but Vienna and Berlin  
are quiet. Mr. D. Lloyd has gone to Switzerland and I  
will be there for a week at 1496,*

Writing by Hindi writer

*Lloyd has gone to Switzerland  
I hope for good news. He will  
here for a week at 1496*

**Figure 5.** English handwriting specimen by Tamil, Bengali and Hindi writers.

results are summarized in Table 2. With the significance level set at 0.05 and the degree of freedom = 1, the critical value of  $\chi^2$  would be equal to 3.84 (rounded up to two significant figures). A computed value which is larger than 3.84 is denoted as statistically significant<sup>16-25</sup>.

The following class characteristics were observed from the present study: (i) The curved stroke formation of letter 'x' was found to be a characteristic in the English handwriting of Tamilians in India (Figure 4 a). (ii) The loop formation on the lower part of letter 'S' was found to be a characteristic in the English handwriting of Bengalis in India (Figure 4 b). (iii) The round top formation of letter 'A' was found to be a characteristic in the English handwriting of Hindi writers in India (Figure 4 c). (iv) The straight stroke formation of letters 'M' and 'N' was found to be a characteristic in the English handwriting of Tamilians in India. (v) The loop formation

**Table 2.** Chi-square values of the 11 characteristic features found to be statistical significant

			Tamil	Hindi	Sum of $\chi^2$	Tamil	Bengali	Sum of $\chi^2$	Hindi	Bengali	Sum of $\chi^2$
X <sub>1</sub>	Yes	Obs	208	77	140.0*	208	220	2.3	77	220	169.6*
		Exp	142.5	142.5		214.0	214.0		148.5	148.5	
		$\chi^2$	30.1	30.1		0.2	0.2		34.4	34.4	
	No	Obs	42	173	42	30	173	30			
		Exp	107.5	107.5	36.0	36.0	101.5	101.5			
		$\chi^2$	39.9	39.9	1.0	1.0	50.4	50.4			
Total	250	250	250	250	250	250					
X <sub>2</sub>	Yes	Obs	121	76	17.0*	121	131	0.8	76	131	24.9*
		Exp	98.5	98.5		126.0	126.0		103.5	103.5	
		$\chi^2$	5.1	5.1		0.2	0.2		7.3	7.3	
	No	Obs	129	174	129	119	174	119			
		Exp	151.5	151.5	124.0	124.0	146.5	146.5			
		$\chi^2$	3.3	3.3	0.2	0.2	5.2	5.2			
Total	250	250	250	250	250	250					
X <sub>3</sub>	Yes	Obs	85	33	30.0*	85	102	2.5	33	102	48.3*
		Exp	59.0	59.0		93.5	93.5		67.5	67.5	
		$\chi^2$	11.5	11.5		0.8	0.8		17.6	17.6	
	No	Obs	165	217	165	148	217	148			
		Exp	191.0	191.0	156.5	156.5	182.5	182.5			
		$\chi^2$	3.5	3.5	0.5	0.5	6.5	6.5			
Total	250	250	250	250	250	250					
X <sub>4</sub>	Yes	Obs	140	46	75.6*	140	99	13.5*	46	99	27.3*
		Exp	93.0	93.0		119.5	119.5		72.5	72.5	
		$\chi^2$	23.8	23.8		3.5	3.5		9.7	9.7	
	No	Obs	110	204	110	151	204	151			
		Exp	157.0	157.0	130.5	130.5	177.5	177.5			
		$\chi^2$	14.1	14.1	3.2	3.2	4.0	4.0			
Total	250	250	250	250	250	250					
X <sub>5</sub>	Yes	Obs	51	56	0.3	51	145	74.1*	56	145	65.9*
		Exp	53.5	53.5		98.0	98.0		100.5	100.5	
		$\chi^2$	0.1	0.1		22.5	22.5		19.7	19.7	
	No	Obs	199	194	199	105	194	105			
		Exp	196.5	196.5	152.0	152.0	149.5	149.5			
		$\chi^2$	0.03	0.03	14.5	14.5	13.2	13.2			
Total	250	250	250	250	250	250					
X <sub>6</sub>	Yes	Obs	142	37	95.9*	142	131	1.0	37	131	79.2*
		Exp	89.5	89.5		136.5	136.5		84	84	
		$\chi^2$	30.8	30.8		0.2	0.2		26.3	26.3	
	No	Obs	108	213	108	119	213	119			
		Exp	160.5	160.5	113.5	113.5	166	166			
		$\chi^2$	17.2	17.2	0.3	0.3	13.3	13.3			
Total	250	250	250	250	250	250					
X <sub>7</sub>	Yes	Obs	86	44	18.3*	86	43	19.3*	44	43	0.0
		Exp	65.0	65.0		64.5	64.5		43.5	43.5	
		$\chi^2$	6.8	6.8		7.2	7.2		0.0	0.0	
	No	Obs	164	206	164	207	206	207			
		Exp	185.0	185.0	185.5	185.5	206.5	206.5			
		$\chi^2$	2.4	2.4	2.5	2.5	0.0	0.0			
Total	250	250	250	250	250	250					
X <sub>8</sub>	Yes	Obs	116	46	44.7*	116	51	38.0*	46	51	0.32
		Exp	81.0	81.0		83.5	83.5		48.5	48.5	
		$\chi^2$	15.1	15.1		12.6	12.6		0.13	0.13	
	No	Obs	134	204	134	199	204	199			
		Exp	169.0	169.0	166.5	166.5	201.5	201.5			
		$\chi^2$	7.2	7.2	6.3	6.3	0.03	0.03			
Total	250	250	250	250	250	250					

(Contd)

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Table 2. (Contd)

			Tamil	Hindi	Sum of $\chi^2$	Tamil	Bengali	Sum of $\chi^2$	Hindi	Bengali	Sum of $\chi^2$
X <sub>9</sub>	Yes	Obs	151	186	11.2*	151	166	1.9	186	166	3.84
		Exp	168.5	168.5		158.5	158.5		176	176	
		$\chi^2$	1.8	1.8		0.4	0.4		0.57	0.57	
	No	Obs	99	64	99	84	64	84			
		Exp	81.5	81.5	91.5	91.5	74	74			
		$\chi^2$	3.8	3.8	0.6	0.6	1.35	1.35			
Total		250	250	250	250	250	250				
X <sub>10</sub>	Yes	Obs	54	54	0.0	54	79	6.4*	54	79	6.40*
		Exp	54.0	54.0		66.5	66.5		66.5	66.5	
		$\chi^2$	0.0	0.0		2.3	2.3		2.35	2.35	
	No	Obs	196	196	196	171	196	171			
		Exp	196.0	196.0	183.5	183.5	183.5	183.5			
		$\chi^2$	0.0	0.0	0.9	0.9	0.85	0.85			
Total		250	250	250	250	250	250				
X <sub>11</sub>	Yes	Obs	169	134	10.3*	169	164	0.2	134	164	7.48*
		Exp	151.5	151.5		166.5	166.5		149	149	
		$\chi^2$	2.0	2.0		0.04	0.04		1.51	1.51	
	No	Obs	81	116	81	86	116	86			
		Exp	98.5	98.5	83.5	83.5	101	101			
		$\chi^2$	3.1	3.1	0.1	0.1	2.23	2.23			
Total		250	250	250	250	250	250				

\*Indicates values exceeding the critical value of 3.84.

on the stem of letter 'd' was found to be a characteristic in the English handwriting of Bengalis in India (Figure 4 e).

Also, sizes of letters are observed to be bigger for English handwriting by Hindi writers and the writings were less slanted when compared with those by Bengali and Tamilians.

English writings by Bengalis have the common feature of artistic abilities. The group preferred to use cursive strokes and ornamental features and that could be due to their accustomed hand in writing Bengali letters. The English writings by Bengalis were fluent and rhythmic.

Many people describe English letter 'd' which means Bengali character 'ধ' (tho), another possible impact could be the many 'hiatuses' in their English handwriting. The formation of 'X' with two straight crossing strokes was replaced with two curved strokes. These observed features of Bengali writers using round and cursive and artistic strokes in English handwriting could be due to the influence of their local writings in Bengali language.

Tamilian writers preferred to use long, broad strokes with a slight curvature and the small eyelet formation at the bottom part of letter 'E', shaped like '£' (Figure 4 d). Tamil letters are formed by long strokes running left and right as well as up and down to complete the design. This aspect is reflected in their English writings.

Hindi writers leave a wide space between letters and words, and exhibited a relatively large letter size, and there was lack of connectivity between letters. The placement of punctuation mark also showed relatively

large spacing relative to letters when compared to Tamil and Bengali writers. A lack of fluency was also observed.

The present study provides a statistical examination and determination of class characteristics in English handwriting indicative of the three major linguistic groups of India, in Tamil, Bengali and Hindi. Using these findings, one may be able to determine the class characteristics in English handwriting of different linguistic groups as well as the region or state of origin of the writers.

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