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Genuine handwriting variations in 10 years: a pilot study

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Abstract

Background: The present study aims to examine the extent of variation in genuine handwriting characteristics across 10 years. One hundred samples (one admitted handwriting and three exemplars) were collected from 25 subjects (male and female, age ranging from 30 to 55) using purposive sampling technique. The admitted handwriting sample included documents like notebooks, wills, diaries, and record books that had been written 10years earlier, and 3 exemplars with the same information, written now in a similar kind of material. Both individual and class characteristics were analyzed in admitted as well as three exemplars which includes size of letters, slant, i-dot, t-bar (diacritics), humped letters (m, n, h), and formation of rounded letters (o, a, d, b, g, p, q).

Results: Cohen's kappa showed that there is a significant agreement between admitted and exemplars in the characteristics except for size.

Conclusion: The results imply that once an adult has acquired a particular handwriting pattern, the master pattern of each letter, as well as both class and individual characteristics, remain unchanged. The size of the letters may change across age.

Keywords: Forensic science, Forensic Document Examination, Variations in handwriting characteristics, Genuine handwriting

Background

The examination of disputed handwriting is a forensic necessity rather than a forensic task. Authorship of documents has overwhelming importance in the civil as well as criminal lawsuits. There are situations when anonymous or unsigned writings in a document become potentially important with relative or incriminating information (Huber and Headrick, 1999). Researchers since the late nineteenth century searched for the provision to find out the authorship of such documents (Bird, Found, Ballantyne, and Rogers, 2010). Studies conducted during the past 30 years show that the scientific inquiries in this field have become more intense (Risinger, Denbeaux, and Saks, 1989; Saran, Kumar, Gupta, and Ahmad, 2013; Mnookin, 2001). A common focus of these articles was to identify the individual differences in the script. Less attention was given to the similarities in the handwriting of the same individual. Verifying the similarities of the handwriting has an equal scope in forensic inquiries as in identifying the differences.

Handwriting is a complex type of motor behavior (Van Galen, 1980). While writing, the practiced writer coordinates the eye with the hand that holds the pen or pencil and retrieves the information from the motor memory. Even though the execution of the writing is not with an instrument in hand, but held by the foot or in the mouth, there are similar patterns. Hence, the representation of this motor behavior in our memory appears to be non-muscle specific (Teulings, 1996). While writing, apparent deviations may be present at word boundaries. In many cases, the movement of the pen is continuous, uninterrupted (Teulings, 1996) and structured with a sequence of smooth coordination. The specific pattern of these movements comprises the habitual features of writing that are exclusive to each individual (Gupta and Ravi, 2018).

According to Huber and Headrick (1999), the grip used while writing inhibits or facilitates the writing

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strokes. There are seven types of grips, five power grips, and two precision grips. Power grips are to hold a tool like a screwdriver, and precision grips are to grasp a pen or pencil. During the course of development in writing, the writer will acquire control over the grip with defined finger movements. There will be a gradual decrement in the size of writing with a reduced number of superfluous movements (Van Galen and Weber, 1998). The development of writing has quantitative changes also. The speed in writing can be used as a measure of proficiency. As age increases, speed also will increase (Huber and Headrick, 1999). The rate of increase in speed is higher between the ages of 7 and 14 years. Speed is also influenced by the quantity of writing (Peverly, 2006)

Culture and education influence writing. While learning motor coordination, the individual is introduced to cultural standards like neatness and regularity, and cultural biases such as left-to-right transport and counter-clockwise rotations (Huber and Headrick, 1999). The grasp, posture, and the hand used to write are some of the other constraints that may differ as per the standards of a different culture, resulting in varied effects in writing. Interruptions to these cultural preferences will have strong reasons as in the case of left-hand writers. Conformity to these preferences increases with age (Huber and Headrick, 1999).

Writing habits (or characteristics) are generally distinguished as class characteristics and individual characteristics. Class characteristics are the products of a prescribed writing system. Initially, there was a lot of importance to the class characteristics in educational programs. This importance deteriorated with the growth of electronic communicative processes, and hence in modern-day writers, class characteristics are less discernible and identifiable. Writing, currently, is a composition of individual characteristics. The difference of one from another in writing has been acceptable now (Huber and Headrick, 1999)

A major segment of the observation on handwriting discusses the subject of individual differences (Huber and Headrick, 1999). According to (Osborn 1910), individual differences can be sorted out based on the repeated and general characteristics of the handwriting. Summing up the reports by Osborn (1910), based on the difference between writings, we can conclude that they are by different writers. Huber and Headrick (1999) here raises a question regarding the possibility that variations of the same author resulting from extenuating circumstances.

In the present study, we examine the extent of variation in genuine handwriting after 10 years by comparing an admitted and three exemplars. Natural variations are the imprecision with which the habits of the writer are executed on repeated occasions. It is the most important attribute of a writer's habit, which varies with writing skill and the formation of each letter. No two complex writings of the same material by the same person are identical at the microscopic level. Moreover, the natural variation in writing may diverge with the writer's condition (physical as well as mental) and nature of the document (Huber and Headrick, 1999). It is said that with practice, the acquisition of skill, and the application of control, these variations could be addressed to a certain extent, but not completely. A skilled writer may exhibit the consistency that makes the imprecision difficult to perceive especially for the unaided eye, but a more precise method (use of stereomicroscope) will reveal it (Huber and Headrick, 1999).

According to Hilton (1995), natural variation in handwriting is one of the main hurdles that beset the reliability and objectivity of handwriting researches. Osborn (1910) suggested that nearly at the age of 21, the handwriting characteristics of an individual becomes fixed and does not change perceptively. According to Saunders, Davis, and Buscaglia (2011), Forensic Document Examiners may commit mistakes during the examination of handwriting and signatures. Sometimes, they might consider natural variations as disguised/forged, and they frame their opinion upon this error. Usually, there are two types of errors committed by the Forensic Document Examiners—false match error (two writing samples from different individuals may be declared to "match") and false no-match error (two writing samples from the same individual may be declared "no match"). One characteristic that contributes to such errors is the almost exclusive reliance of an automated procedure on a set of features that can be quantified, and it ignores subjective characteristics that can be exploited by any Forensic Document Examiners for identification and verification.

Hypothesis

The handwriting of a person will not vary across time.

Method

Sample

In a total of 100 handwriting samples, 1 admitted handwriting sample which was written 10 years back and 3 exemplars were collected from 25 subjects age ranging from 30 to 55 (male and female) using purposive sampling technique. The participants wrote in the exemplars, the same information in the admitted, using almost the same kind of writing materials (pen and pencil) (Fig. 1).

The admitted samples were collected from documents like notebooks, wills, diaries, and record books. All the subjects were accustomed writers possessing a stable job

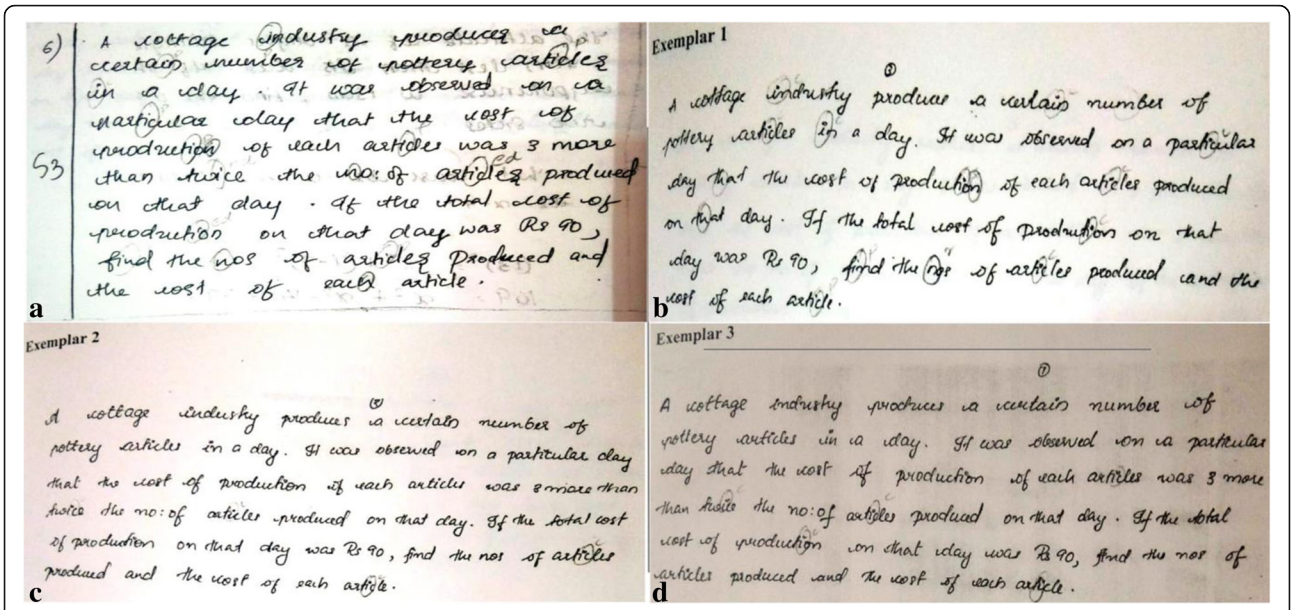

Fig. 1 Admitted and exemplar samples. **a** Admitted writing, drafted ten years before **b, c** and **d**, Exemplar 1, 2, and 3 respectively drafted at present

and had optimal health conditions. The background details of the subjects are given in Table 1.

Procedure

The trials were constructed according to the accepted process of comparing admitted writing with an exemplar sample. The rationale for the structure of the trial material, where repetitions of a single person's admitted handwriting compared to three exemplar handwritings. Individual and class characteristics in the admitted and the three exemplars were analyzed. The analysis included the size of the letters, slant, i-dot, t-bar, humped letters (m, n, h), and formation of rounded letters (o, a, d, b, g, p, q). Characteristics of the admitted and the exemplars were then tabulated and compared.

Table 1 Background details of the subjects showing variables, number of subjects who belongs to a particular category

Variables	Category	*N*	Percentage
Gender	Male	15	60
	Female	10	40
Age group	30–40	6	24
	41–50	12	48
	51–60	7	28
Educational qualification	Below graduation	11	44
	Above graduation	14	56
Occupation	Self-employed	8	32
	Job employed	17	68

Statistical analysis

Cross-tabulation of the size, slant, rounded letters, i-dot, t-bar, and humped letters with admitted and exemplars were done to consolidate the sample characteristics. Cohen's kappa was used to assess the agreement between the admitted and exemplars.

Results

Notable changes between the admitted and exemplar can be seen in certain characteristics (Table 2). In the 25 admitted, considering the size, 6 are categorized as small, 16 as medium, and 3 as large. In each set of 25 exemplars, 4 are categorized as small, 18 as medium, and 3 as large. Among slants of the 25 admitted, 12, 2, and 11 are respectively categorized towards right, towards left, and vertical. Among each set of 25 exemplars, these are 13, 1, and 11, respectively. Among the rounded letters of the 25 admitted, 6 are narrow oval, 10 are rounded, 4 are oval, and 5 are irregular. In each set of 25 exemplars, these are 6, 11, 4, and 4 respectively. Considering i-dot of the 25 admitted, 5 are circular, 14 are pointed, 6 are extended dots, and 0 are irregular. In exemplar 1, these are 11, 9, 5, and 0; exemplar 2, these are 11, 7, 6, and 1; and in exemplar 3, these are 11, 8, 5, and 1, respectively. Considering t-bar, 12 are categorized as center in the admitted, exemplar 1, and exemplar 3, but 11 in exemplar 2. High, low, pre-placed, and post-placed are 5, 2, 4, and 2, respectively in the admitted. These are respectively 5, 2, 2, and 4 in exemplar 1 and exemplar 3, but 5, 3, 2, and 4 in exemplar 2. Among the humped letters in the admitted, 11 are categorized as pointed, 4 as round, 7 as

Table 2 Cross-tabulation of the size, slant, rounded letters, i-dot, t-bar, and humped letters with admitted and exemplars

Variables	Categories	Admitted	Exemplars			Total
			1	2	3	
Size	Small	6	4	4	4	18
	Medium	16	18	18	18	70
	Large	3	3	3	3	12
Slant	Towards right	12	13	13	13	51
	Towards left	2	1	1	1	5
	Vertical	11	11	11	11	44
Rounded letters	Narrow oval	6	6	6	6	24
	Rounded	10	11	11	11	43
	Oval	4	4	4	4	16
	Irregular	5	4	4	4	17
I-dot	Circular	5	11	11	11	38
	Pointed	14	9	7	8	38
	Extended dot	6	5	6	5	22
	Irregular	0	0	1	1	2
T-bar	Centre	12	12	11	12	47
	High	5	5	5	5	20
	Low	2	2	3	2	9
	Pre-placed	4	2	2	2	10
	Post-placed	2	4	4	4	14
Humped letters	Pointed	11	13	13	13	50
	Round	4	4	4	4	16
	Oval	7	7	7	7	28
	Square topped	3	1	1	1	6

oval, and 3 as square topped. In each set of 25 exemplars, these are counted as 13, 4, 7, and 1 respectively.

To assess if the chosen characteristics of the exemplars are consistent with the admitted, Cohen's kappa was used. The result is summarized in Table 3

Cohen's kappa indicated a disagreement while comparing the size of the admitted with exemplars. There is an agreement between admitted and exemplars in slant, rounded letters, i-dot, t-bar, and humped letters. There is an agreement in the slant of the letters in the admitted with that of the exemplars 1, 2, and 3 (kappa = .71, $p < .01$). Rounded letters in admitted agree with exemplars 1, 2, and 3 (kappa = .61, $p < .01$). Agreement in i-dot is low, but significant while comparing admitted handwriting with exemplar 1 (kappa = .40, $p < .01$), 2 (kappa = .31, $p < .05$), and 3 (kappa = .36, $p < .01$). There is an acceptable agreement while comparing the t-bar in admitted with exemplar 1 (kappa = .43, $p < .01$), 2 (kappa = .50, $p < .01$), and 3 (kappa = .43, $p < .01$). There is an agreement while comparing humped letters in the admitted with the exemplars 1, 2, and 3 (kappa = .70, $p < .01$). Findings show that there is no much variation in the characteristics including slant, rounded letters, i-dot, t-bar, and humped letters in a period of 10 years. At the same time, the size of the letters varied considerably.

Discussion

Results showed that certain handwriting characteristics such as slant, rounded letters, i-dot, t-bar, and humped letters of the same individual do not have a significant variation in a period of 10 years. There are chances for change in the size of the letters. Findings partly accept the observation of Gupta and Ravi (2018) concerning the unique identifying features of individual writings. These features, which depends upon the mental and muscular coordination of the writer, have limits to undergo a considerable variation. The similarity in characteristics contributes to individual discriminability. At the same time, dissimilarity due to certain habitual interference across the age is a real challenge for the Forensic Document Examiners.

Literature indicated that handwriting is influenced across ages by various factors including practice (Gupta and Ravi, 2018), grip used to hold the tool, age, culture and education (Huber and Headrick, 1999), movements (Van Galen and Weber, 1998), speed (Peverly, 2006), and so on. Also, there will be deviations around the word boundaries. However, it was not observed that these influences inhibit the similarity significantly. Findings regarding the disagreement in the 'size' characteristic show that there can be a considerable change in the handwriting of a person in a period of 10 years. The argument by Osborn (1910) that individual differences can be sorted out based on the repeated and general characteristics of the handwriting need not be true for all the characteristics. As Hilton (1995) mentioned, natural variation is the main challenge for the reliability and objectivity of handwriting studies.

All the other characteristics observed in the present study stands with the argument by Osborn (1910). There was an agreement in slant, rounded letters, i-dot, t-bar, and humped letters in admitted and exemplars. To avoid false no-match error, document examiners may give importance to these specific characteristics.

Conclusion

The study revealed statistically significant agreement between admitted and exemplars, showing that handwriting of an individual remains stable, in the characteristics such as slant, rounded letters, i-dot, t-bar, and humped letter. There was a disagreement while comparing the size of the admitted and exemplars, indicating that it may change across time. However, it is too early to generalize based on this, as this is a pilot study with a limited sample. A major study which includes admitted handwriting from various periods with several samples

Table 3 Cohen's kappa coefficient showing the agreement in characteristics between the admitted and the three exemplars

Exemplars	Characteristics	Admitted				Kappa
	Size	Small	Medium		Large	
1	Small	2	2		0	0.178
	Medium	4	12		2	
	Large	0	2		1	
2	Small	2	2		0	0.178
	Medium	4	12		2	
	Large	0	2		1	
3	Small	2	2		0	0.183
	Medium	4	12		2	
	Large	0	2		1	
	Slant	Towards right	Towards left		Vertical	
1	Towards right	11	0		2	0.711**
	Towards left	0	1		0	
	Vertical	1	1		9	
2	Towards right	11	0		2	0.711**
	Towards left	0	1		0	
	Vertical	1	1		9	
3	Towards right	11	0		2	0.711**
	Towards left	0	1		0	
	Vertical	1	1		9	
	Rounded letters	Narrow oval	Rounded	Oval	Irregular	
1	Narrow oval	4	1	1	0	0.605**
	Rounded	2	8	1	0	
	Oval	0	1	2	1	
	Irregular	0	0	0	4	
2	Narrow oval	4	1	1	0	0.605**
	Rounded	2	8	1	0	
	Oval	0	1	2	1	
	Irregular	0	0	0	4	
3	Narrow oval	4	1	1	0	0.605**
	Rounded	2	8	1	0	
	Oval	0	1	2	1	
	Irregular	0	0	0	4	
	I-dot	Circular	Pointed	Extended dot		
1	Circular	5	3	3		0.396**
	Pointed	0	8	1		
	Extended dot	0	3	2		
2	Circular	5	3	3		0.312*
	Pointed	0	6	1		
	Extended dot	0	4	2		
	Irregular	0	1	0		

Table 3 Cohen's kappa coefficient showing the agreement in characteristics between the admitted and the three exemplars *(Continued)*

Exemplars	Characteristics	Admitted					Kappa
3	Circular	5		3		3	0.357**
	Pointed	0		7		1	
	Extended dot	0		3		2	
	Irregular	0		1		0	
	T-bar	Centre	High	Low	Pre-placed	Post-placed	
1	Centre	7	1	2	2	0	0.427**
	High	1	4	0	0	0	
	Low	2	0	0	0	0	
	Pre-placed	0	0	0	2	0	
	Post-placed	2	0	0	0	2	
2	Centre	7	1	1	2	0	0.496**
	High	1	4	0	0	0	
	Low	2	0	1	0	0	
	Pre-placed	0	0	0	2	0	
	Post-placed	2	0	0	0	2	
3	Centre	7	1	2	2	0	0.427**
	High	1	4	0	0	0	
	Low	2	0	0	0	0	
	Pre-placed	0	0	0	2	0	
	Post-placed	2	0	0	0	2	
	Humped letters	Pointed		Round	Oval	Square topped	
1	Pointed	10		0	2	1	0.698**
	Round	0		4	0	0	
	Oval	1		0	5	1	
	Square topped	0		0	0	1	
2	Pointed	10		0	2	1	0.698**
	Round	0		4	0	0	
	Oval	1		0	5	1	
	Square topped	0		0	0	1	
3	Pointed	10		0	2	1	0.698**
	Round	0		4	0	0	
	Oval	1		0	5	1	
	Square topped	0		0	0	1	

*$p < .05$, **$p < .01$

of exemplars is recommended to decide the probabilities related to the variations. The sample may also include other writings by the subject from the period of admitted as well as the present to make an accurate comparison.

Forensic Document Examination reports have been accepted by the court of law for more than 100 years, but over recent years, the reliability and validity of handwriting opinions are often challenged by the lawyers and judges. The use of standard statistical test always helps us to give objectivity to the findings made by Forensic Document Examiners because it can ensure precision in quantities, notations, and generalizations. The application of Bayesian conditional probability, correlational analysis, linear regression analysis, fuzzy mathematical analysis, and so on will help the Forensic Document Examiners to address the queries pertaining to reliability and validity of their reports and opinion (Li, 2016). Research about the changes of

handwriting characteristics with age will always help the document experts to focus more on significant handwriting characteristics (both class and individual) that remain unchanged over a period of time. However, the more significant result can be obtained by increasing the sample size and handwriting characteristics in future studies

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Ethics approval and consent to participate
Prior to data collection, informed consent was taken from the participants. The meaning, relevance, and purpose of the study were explained to them.

Consent for publication
Both the authors have approved the final version of the manuscript and have given their consent for its publication.

Competing interests
The authors declare that they have no competing interests

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