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FORENSIC ANALYSIS OF EFFECTS OF SWITCHING HANDEDNESS ON THE HANDWRITING CHARACTERISTICS

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ABSTRACT

Handwriting is a neuromuscular task and natural variation in an individual's handwriting may be affected by a variety of factors. Switching handedness or writing executed using an unaccustomed hand may affect the handwriting characteristics of an individual significantly. The present study was undertaken to determine if the writings executed by accustomed and unaccustomed hands can be compared. Handwriting samples executed with both accustomed and unaccustomed hands were collected from 50 individuals. Various handwriting characteristics, such as rhythm, tremor, connecting strokes, initial and terminal strokes, pen lifts, retouching and overwriting, letter form and formation, overall size, spacing between letters and words, diacritic marks (dot on i and j, t-crossing) were analysed in accustomed writings, which were compared inter-se with characteristics of corresponding unaccustomed writings of all participants. The results demonstrated significant changes in handwriting characteristics of unaccustomed writings as compared to their corresponding accustomed writings.

***Keywords**: Handwriting, handedness, unaccustomed writing, accustomed writing, handwriting characteristics*

INTRODUCTION

Handwriting is an acquired neuromuscular act as it is produced by the muscles of the body through direct commands given by the human brain (Huber and Headrick 1999). It is one of the automated habits that require no conscious directions while executing naturally. Variation occurs during writing in case of every individual to a certain extent due to the absence of duplicity of neuromuscular coordination. These natural variations in the handwriting of

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an individual may be affected by a number of factors, such as handedness, writing instrument, environmental conditions, illness, etc (Osborn, 1929; Huber and Headrick 1999; Saini, 2015; Saini *et al.,*2019; Saini *et al.,*2021; Kaur *et al.,*2022; Saini *et al.,*2022).

Handedness is one of the important factors, which provides uniqueness to the handwriting of every individual. Change in handedness or handwriting executed by an unaccustomed hand may cause significant variation in handwriting characteristics like skill of the writing, fluency slant, letter designs, etc. (Huber and Headrick, 1999). These variations may arise in handwriting due to the lack of writing practice with an unaccustomed hand. This may lead to drastic change in appearance of the writing sometimes, making the handwriting to be unrecognizable and thus raising doubt about the authorship of these writings (Harrison, 1966; Huber and Headrick, 1999).

Some previous research works have also been reported on writings executed by unaccustomed hands, which includes effect of handedness on various handwriting characteristics like lack of skill, lack of pen control, large letter size, abrupt or jagged letter design, formation of mirror images, etc. (Harrison, 1966; Stangohr, 1968; Tankle and Heilman, 1983; Totty *et al.,*1983; Dawson, 1985; Vaid and Davis, 1989; Singh and Gupta, 1995; Huber and Headrick, 1999; Chapman and Henneberg, 1999; Tucha *et al.,*2000; Ellen, 2006; Kelly and Lindblom, 2006; Dziedzic, 2011; Laskowski and Henneberg, 2012; Sahu and Kujur, 2017; Lanners, 2018). However, limited research works have been conducted on the systematic analysis of characteristics in writings executed by unaccustomed writing hand as compared to the writings executed by corresponding accustomed hands.

Keeping the above-mentioned facts in view, the present study has been conducted on inter-se comparison of handwriting characteristics executed by accustomed and unaccustomed hand. The research study is aimed to determine if the writings executed by both hands of the same individual can be compared with each other. The results of this research study will definitely assist the Forensic document examiners in solving cases related to disguise, involving the use of unaccustomed writing hand specifically.

MATERIALS AND METHODS

Collection of handwriting samples:

Handwriting samples were collected from a total of 50 individuals by visiting various colleges and universities. The participants were requested to properly read, fill and then sign an informed consent form for participation in the research study according to their will. Background details of each participant were also collected, which included their name, age, gender, educational qualification, handedness, occupation and address (Table-1).

Table-1: Background details of all participants

Information	Category	Count (Out of 50 samples)	Percentage (%)
Age	20-25	42	80%
	26-30	8	20%
Gender	Male	20	25%
	Female	30	75%
Educational	Higher Secondary Education	18	20%
Qualification	Graduation or above	32	80%
Occupation	Student	42	80%
	Self Employed	6	15%
	Job Employed	2	5%
Handedness	Right-Handed	34	60%
	Left-Handed	16	40%

All the participants were provided with a standard text, white A4 size sheets of paper and the same ball point pen. They were requested to write the standard text by using their accustomed and unaccustomed hands both. The participants were first instructed to write the standard text twice by using their accustomed writing hand. They were then instructed to write the same text twice by using their unaccustomed writing hand. The participants were not given any training or instructions regarding writing in cursive or printed form, arrangement, alignment, margins, spacing, spellings, punctuation marks, etc. The participants were asked to write comfortably at their own pace and were not given any time limit for the completion of this task.

Four handwriting samples (2 accustomed+2 unaccustomed) were collected from each of 50 participants. Thus, a total of 200 handwriting samples were collected for the present study in order to determine differences in characteristics of accustomed and unaccustomed writings.

Analysis

The present research study includes qualitative analysis of handwriting characteristics, such as rhythm, tremor, initial and terminal strokes, connecting strokes, pen-lifts, retouching and overwriting, letter form and formation, overall size, spacing, and diacritic marks (i-dot, j-dot, t-crossing). These handwriting characteristics were analyzed in accustomed and unaccustomed writings of all participants, followed by the inter-se comparison of each of these characteristics.

RESULTS

Rhythm: Rhythmic nature of strokes was observed in a total of 48 accustomed writings, as indicated by the presence of skilful writing strokes (Figure-1a). However, a total of 42 unaccustomed writings showed non-rhythmic strokes as indicated by the presence of irregular and drawn type of strokes, which pointed towards slow formation of characters with an unaccustomed hand (Figure-1b).

The remaining 8 unaccustomed writings showed moderately rhythmic strokes and no unaccustomed writing showed rhythmic strokes.

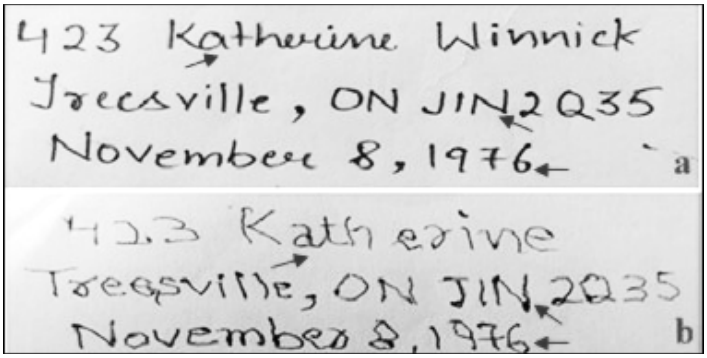

Figure-1: (a) Accustomed writing of a participant showing rhythmic nature of strokes; (b) Unaccustomed writing of the same participant showing non-rhythmic nature of strokes.

Tremor: Complete lack of tremulous strokes was observed in a total of 48 writings (Figure-2a). However, a total of 42 unaccustomed writings showed the presence of a large number of tremulous strokes (Figure-2b). This was demonstrated by the wavy formation of strokes at a high number of places in these writings.

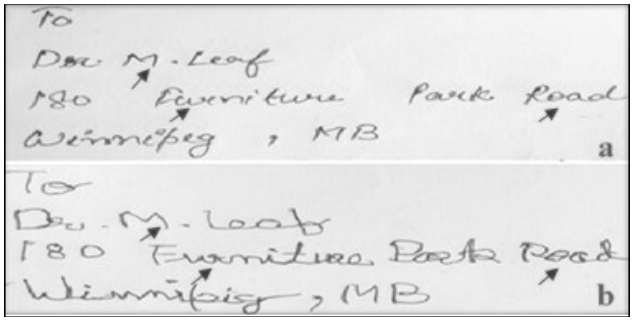

Figure-2 (a) Accustomed writing of a participant showing no tremor; (b) Unaccustomed writing of the same participant showing high tremor.

Connecting strokes: Accustomed writings of a total of 48 participants revealed smooth and curved formation of connecting strokes between the letters (Figure-3a). However, corresponding unaccustomed writings of 41 participants revealed the formation of angular and wavy (tremulous) nature along with abrupt pen lifts at the connecting strokes between the letters (Figure-3b).

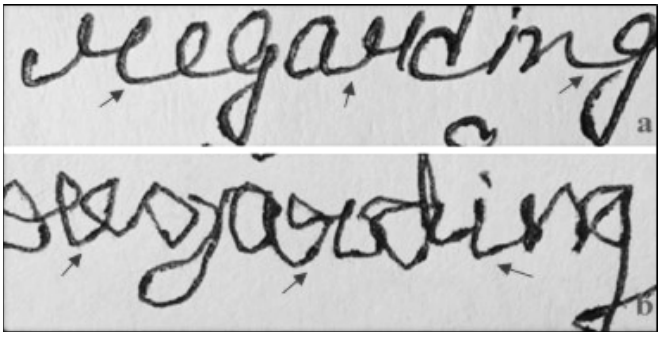

Figure-3: (a) Accustomed writing of a participant showing smooth and curved nature of connecting strokes; 3(b) Unaccustomed writing of the same participant showing tremulous connecting strokes.

Initial and terminal strokes: Tapered nature of initial and terminal strokes was observed in a total of 48 accustomed writings, as indicated by freely executed and sharply formed strokes (Figure-4a). However, unaccustomed writings of 42 participants showed blunt formation of initial and terminal strokes along with tremulous or hesitating strokes at these places (Figure-4b).

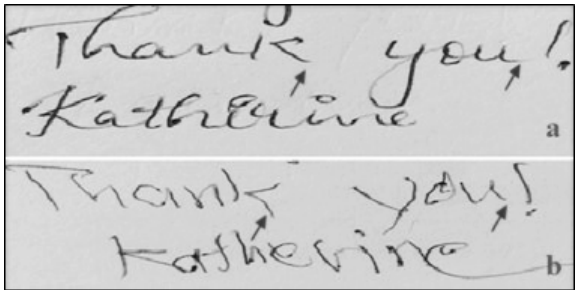

Figure-4: (a) **Accustomed writing of a participant showing tapered nature of initial and terminal strokes;** (b) **Unaccustomed writing of the same participant showing change in the quality of initial and terminal strokes.**

Penlifts: A total of 31 participants showed pen lifts at a medium number of places in accustomed writings, followed by few pen lifts in 17 writings executed by accustomed writing hand. Accustomed writings of only 2 participants showed a high number of pen lifts. However, unaccustomed writings of 26 corresponding participants showed pen lifts at medium number of places, followed by 16 unaccustomed writings showing few pen lifts, and 8 writings executed by unaccustomed hands showed pen lifts at a large number of places.

Retouching and overwriting: Accustomed writings of only 12 participants showed retouching and overwriting. The remaining 38 accustomed writings showed the absence of retouching and overwriting. However, unaccustomed writings of 32 participants showed the presence of boldly executed retouched and overwritten strokes and 18 unaccustomed writings showed the absence of retouching and overwriting.

Letter form and formation: Significant change was observed in the form

and direction of strokes in unaccustomed writings of 45 participants as compared to their corresponding accustomed writings (Figure-5a, 6a). The letters and numerals also revealed significant deterioration in the quality of strokes of unaccustomed writings (Figure-5b) as compared to their corresponding accustomed writings. In addition, the majority of these unaccustomed writings revealed the formation of mirror images, which might have been formed due to the lack of practice and muscular control along with the unfamiliarity of the unaccustomed writing hand about the whole writing process (Figure-6b). This was demonstrated by the formation of mirror images of small letters, such as 'd', 'e', 'f', 'n', 'o', 's', 't', and 'y' and numerals like '0', '2', and '8' in these writings.

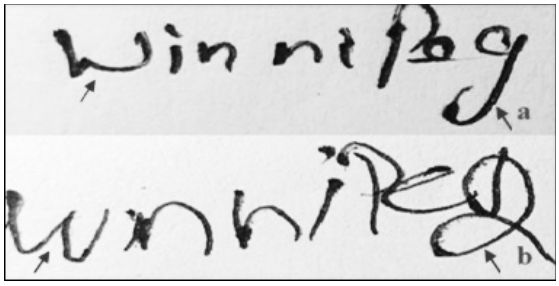

Figure-5: (a) Accustomed writing of a participant showing no deterioration of letter formation; (b) Unaccustomed writing of the same participant showing changed and deteriorated formation of letter 'g'.

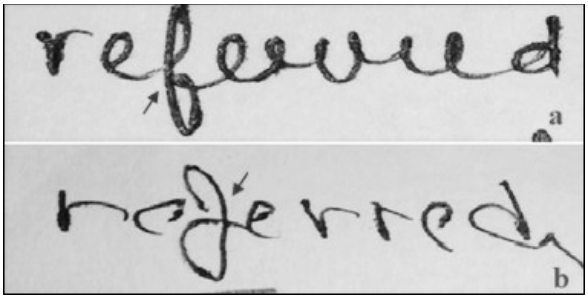

Figure-6 (a) Accustomed writing of a participant showing no letters in their mirror images; (b) Unaccustomed writing of the same participant showing a mirror image of letter 'f'.

Overall size: Accustomed writings of 46 participants showed overall medium size of whole writing, followed by large size of writing in only 2 accustomed writings and overall small size in the remaining 2 writings. However, unaccustomed writings of 40 participants showed similarity in the overall writing size with respect to their corresponding accustomed writings. Increase in the overall size of words was observed in the corresponding unaccustomed writings of only 10 participants.

Spacing: Accustomed writings of 23 participants showed uniform spacing (Figure-7a), followed by 21 accustomed writings showing wide spacing, and the

remaining 6 writings showing narrow spacing between the selected sets of letters and words. However, 22 unaccustomed writings showed a prominent decrease in the overall spacing (Figure-7b) and 20 unaccustomed writings showed an increase in the overall spacing. No change was observed in overall spacing of the remaining 8 unaccustomed writings with respect to their corresponding accustomed writings.

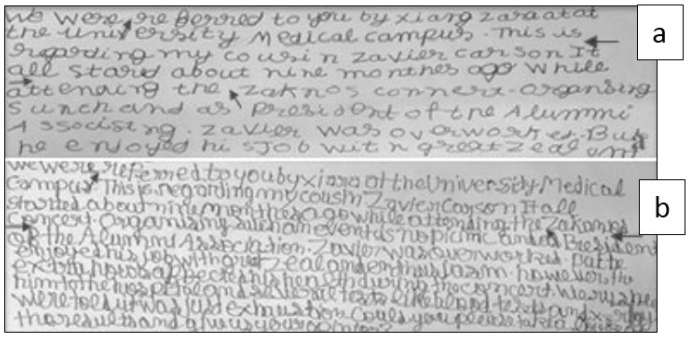

Figure-7 (a) Accustomed writing of a participant showing constant spacing; (b) Unaccustomed writing of the same participant showing narrow spacing, indicating significant decrease in the overall spacing.

Diacritic marks: Accustomed writings of a total of 49 participants showed the presence of 'i'-dot (Figure-8a). However, corresponding unaccustomed writings of 18 participants showed the absence of 'i-dot' (Figure-8b). In addition, accustomed writings of 42 participants showed the presence of 'j'-dot and corresponding unaccustomed writings of 24 participants showed the absence of this diacritic mark. Both accustomed and unaccustomed writings of all the participants showed the presence of t-crossbar. But, the direction of t-crossbar in the majority of unaccustomed writings was observed to be different as compared to their corresponding accustomed writings (Figure-9a, 9b).

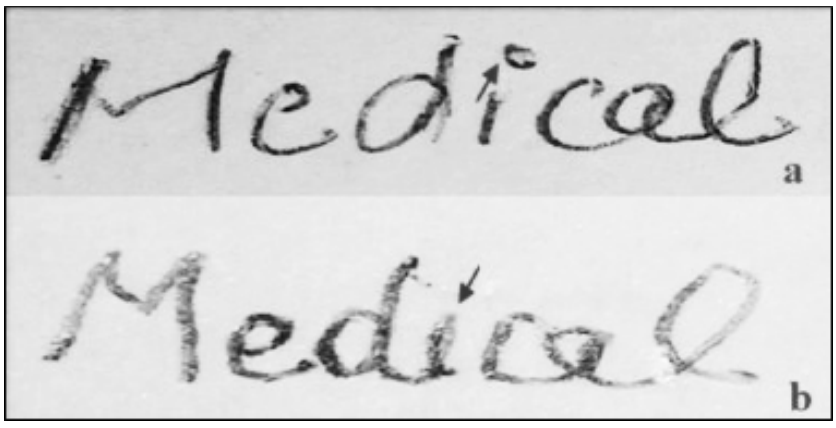

Figure-8: (a) Accustomed writing of a participant showing the presence of 'i-dot'; (b) Unaccustomed writing of the same participant showing the absence of 'i-dot'.

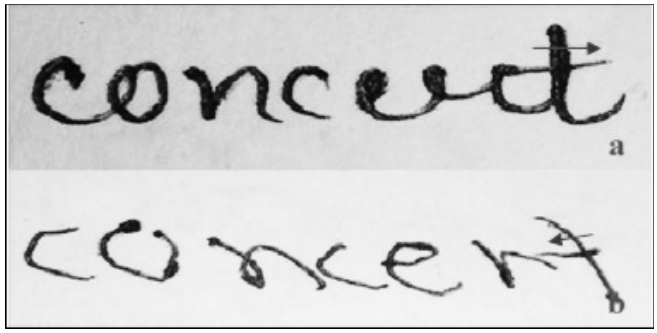

Figure-9: (a) Accustomed writing of a participant showing execution of 't-crossbar' from left to right side; (b) Unaccustomed writing of the same participant showing execution of 't-crossbar' from right to left side.

DISCUSSION

Inter-se comparison of accustomed and unaccustomed writings has revealed significant differences in the majority of handwriting characteristics, owing to the change in handedness while writing. Majority of accustomed handwriting samples have been observed to show rhythmic nature of strokes, which may be attributed to the regularity of curvature of strokes, slope, and size with rapidly executed strokes with a freedom of motion. Unaccustomed writings have been found to show significant deterioration in rhythm, which may be attributed to the presence of disconnected, awkward, and poorly directed formation of strokes (Harrison, 1966; Singh and Gupta, 1995; Chapman and Henneberg, 1999; Huber and Headrick, 1999; Tucha *et al.,*2000; Ellen, 2006; Kelly and Lindblom, 2006; Dziedzic, 2011; Laskowski *et al.,*2012; Sahu and Kujur, 2017; Lanners, 2018). These writings have presented the formation of drawn strokes, indicating lack of fluency in the strokes (Tankle and Heilman, 1983). This may be because of the lack of writing practice with an unaccustomed hand, due to the unfamiliarity of this hand with the writing process (Harrison 1966; Huber and Headrick, 1999). Tremor has been observed to be absent in almost all accustomed writings. Whereas, significantly tremulous strokes have been observed at almost all places, including curves, loop formations, and straight strokes in unaccustomed writings. This is also evident by the presence of tremulous, angular, wavy or zig-zag formation of connecting strokes in unaccustomed writings. These writings have also presented hesitations and abrupt changes in the direction of strokes (Huber and Headrick, 1999). This may be due to the lack of neuromuscular regulation to control writing instruments with this hand.

Increase in pen lifts has been observed in most of the unaccustomed writings. Difficulty in continuing the writing process may be attributed to the abrupt pen lifts in unaccustomed writings, clearly giving indication of the lack of movement control over the writing instruments (Huber and Headrick, 1999). Significant retouching and overwriting have also been observed in the majority of unaccustomed writings. These have not been observed to show concealed

retouching of characters for the correct formation of letters (Huber and Headrick, 1999).

A change in letter form and formation has been observed in the majority of unaccustomed writings. Deteriorated and simplified letter forms have also been observed in unaccustomed writings, being executed without any extra effort. Presence of mirror images may be due to the lack of writing control and differences in the dexterity of both hands of an individual (Huber and Headrick, 1999; Kelly and Lindblom, 2006).

Majority of the unaccustomed writings have shown reduction in spacing between letters and words (narrow spacing), causing crowding of words in almost the whole writing. This may be because of the lack of training of holding and moving writing instruments by an unaccustomed hand (Huber and Headrick, 1999). In addition, accustomed writings have revealed the presence of a dot on 'i' and 'j' in the form of a circle and this formation is observed in both clockwise or anti-clockwise directions. However, unaccustomed writings have shown complete change in the direction of this circle present in these dots as compared to those observed in corresponding accustomed writings. Also, t-crossbar has revealed the direction of execution from left to right side in accustomed writings and from both directions (i.e., from left to right or right to left directions). This has been observed to be executed in reversed direction in case of their corresponding unaccustomed writings. Similar observations have been reported by Dawson (1985).

CONCLUSIONS

Forensic document examiners may come across a great number of document cases, which require determination of the genuineness and authorship of handwriting specimen. The present study has been undertaken to determine the effect of handedness on handwriting characteristics. It has been observed that writing by using an unaccustomed hand impacts a number of handwriting characteristics remarkably. Handwriting characteristics like disturbed rhythm, tremor, pen lifts, simplification, significant deterioration of letters, narrowing of space between letters and words, and diacritic marks.

So, it is concluded that accustomed and unaccustomed hands produce totally different handwriting characteristics. This indicates complete difference among both writing hands with respect to neuromuscular coordination, writing practice, and the manner of holding the writing instruments. Thus, it is suggested that the forensic document examiners should collect the standard writings written with both writing hands (accustomed as well as unaccustomed), as the questioned writings written with either of the hands may be encountered in the practical case scenarios. The results of the present study will aid the document examiners in the establishment of genuineness or authorship of a questioned document which is purported to be disguised by using an unaccustomed writing hand.

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