

Comparative Study of Habitual with Left and Right Handwritings of The Same Person

การศึกษาเปรียบเทียบความเคยชินในการเขียนด้วยมือซ้ายและมือขวาของบุคคลคนเดียวกัน

Ms. Anongnath Soison (อนงค์นาถ สร้อยสน)* Assoc. Prof. Dr. Montip Tiensuwan (ดร. มนต์ทิพย์ เทียนสุวรรณ) **

Assoc. Prof. Dr. Suda Riengrojpitak (ดร. สุดา เรียงโรจน์พิทักษ์) ***

Pol. Lt. Col. Pitsanu Fupleum (พิชญ์ ฟูปลื้ม) ****

ABSTRACT

Handwriting document examination is one of the important knowledge in forensic science. Forensic Handwriting features examination is feature comparison between question and known documents. One method that suspects use to change their handwriting habitual is to disguise by unaccustomed handwriting. By researcher observation, there was stability in some feature.

In this study, researcher collected accustomed and unaccustomed handwritings from the elementary school teachers in Bangkok. The examined features were slant, size of wide letter, size of narrow letter, size of normal letter, space, alignment and height. These features were measured by video microscope. The data was analyzed by two independent t-test and the percentage of each feature similarity was computed. The result was shown that 75% of the subjects have similarity in narrow-size letter.

บทคัดย่อ

เอกสารที่เกิดจากการเขียนด้วยลายมือเป็นเอกสารที่สำคัญในการตรวจพิสูจน์ทางด้านนิติวิทยาศาสตร์เมื่อถูกพบในที่เกิดเหตุหรือเกี่ยวข้องกับคดีความต่างๆ วิธีหนึ่งที่ใช้ตรวจพิสูจน์นั้น เป็นการตรวจลักษณะตัวอักษรเปรียบเทียบกันระหว่างลายมือเขียนจากเอกสารปัญหา กับเอกสารลายมือเขียนตัวอย่างซึ่งได้จากการเขียนโดยผู้ต้องสงสัย วิธีที่นิยมใช้ในการเปลี่ยนแปลงลักษณะของลายมือเขียนเดิมของผู้เขียนคือการเขียนด้วยมือข้างที่ไม่ถนัดของตน แต่ลายมือเขียนที่เกิดจากการเขียนด้วยมือข้างที่ไม่ถนัดก็ยังคงไว้ซึ่งความคงที่ในบางลักษณะของตัวอักษร

ในการศึกษานี้ผู้วิจัยได้ทำการจัดเก็บลายมือเขียนภาษาไทยที่เขียนโดยมือข้างที่ถนัดและไม่ถนัดของกลุ่มประชากรครูประถมศึกษาในกรุงเทพมหานคร มาวัดค่าของลักษณะต่างๆ ของลายมือเขียน ได้แก่ การเอียงลาด, ความสูง, ขนาดของตัวอักษร, ระยะห่างระหว่างตัวอักษรกับเส้นบรรทัดและช่องไฟด้วยกล้องจุลทรรศน์วิดีโอ จากนั้นนำค่าที่ได้มาวิเคราะห์โดยการทดสอบสมมติฐานในกรณีสองกลุ่มตัวอย่างที่เป็นอิสระต่อกันแล้วหาความเป็นไปได้ โดยคำนวณร้อยละของกลุ่มประชากรที่มีค่ากลางไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ จากการศึกษาพบว่า พบความคงที่ของขนาดตัวอักษรแบบแควมากที่สุดคือเป็นร้อยละ 75 ของกลุ่มประชากรทดสอบ

คำสำคัญ : ลายมือเขียน, การเขียนด้วยมือข้างที่ไม่ถนัด, การคัดแปลงลายมือตนเอง

Key Words: Off-Line Handwriting, Unaccustomed Handwriting, Disguise

* Master of Science, Forensic Science, Graduate School, Mahidol University.

** Assoc. Prof., Faculty of Mathematic, Mahidol University.

*** Assoc. Prof., Faculty Immunopathology, Mahidol University.

**** Pol. Lt. Col., Office of Forensic Science Police, Ministry of Defence.

Introduction

Handwriting is a system of communication consisting of small part and a set of rules which decide the way in which these parts can be combined to produce messages that have meaning.

Handwriting is a function of the conscious [2] and subconscious mind that present by individual nerve and muscular movement of the body [3] such as fingers, hand, wrist, arm [1, 2] are simply a device with which to carry out instructions sent to it by the nerve from the brain [1]. When a person writes, he or she is conscious of the subject matter but not usually conscious of the way letters are formed or put together. Not only individual nerve and muscular movement that affected in the process of handwriting, many biological/physiological factors are affected too. Saudek (1978) [1], Saferstein [3] and Jarman et al. [4] proposed factors that influence letter formation were as follows.

- the mechanical means such as pen, ink, writing material etc.
- the writer's degree of graphic maturity and frequency of writing
- the writer's relative speed of writing.
- the system of writing learned.
- the writer's nationality.
- the writer's degree of visual sensitivity and impressionability.
- the writer's power of graphic expression.
- the writer's characterological factors.
- the writer's knowledge of foreign languages, special training.
- the writer's physiological and psychology conditions such as injuries, illness, age, emotion rate, position of writing etc.
- Chronic physical impediments the writer may have.
- Whether the letter form stands alone or at the beginning, middle, end of a word.

As all factors, Handwriting is produced by many individual factors, so, handwriting has long been considered individual [1, 5]. Individual characters of handwriting are used for the identification, which is based upon all of the elements. The elements are combined to create its individuality [2]. Individuality rests on the hypothesis that each individual has consistent handwriting and separated from the handwriting of another individual [5]. Individually characters are used in the handwriting identification that is the point of the handwritten documents analysis. The aim of handwriting document analysis is to determine who was the writer of the suspect document. For these reasons, handwriting

document analysis has great bearing on the criminal justice system [5, 6].

Handwriting recognition is divided into online and offline categories depending on the nature of input data. In this study, we collected **Offline handwriting** deal with a written documents data set which has been obtained the image hand written document with an optical sensitivity device such as a **scanner or digital camera** and become to 2-D image of the writing sample. When the examiners describe quantitative value of handwriting sample, they will measure feature of handwriting [6]. So, they should understand about the type of feature and how to measure each type of feature.

Features of handwriting are divided into two types. In this study, we examined **Document examiners features** that are commonly used by the forensic document examination community. These features are normally extracted from handwriting using tools such as rulers, templates etc. **Document examiners features** can be classified into two categories as the following.

1. Individual characteristics are subconscious [3] characteristics which are highly personal and are unlikely to occur in other instances [2]. They are define as those discriminating elements that serve to differentiate between members within any or all groups and can usually identify a specific individual [3].

Individual characteristic are given as follows [3].

- | | |
|--|--|
| 1. Line quality. | 7. Unusual letter formations. |
| 2. Spacing of word of letter. | 8. Shading. |
| 3. Ratio of relative height, width, and size of letters. | 9. Slant. |
| 4. Pen lifts and separations. | 10. Base line habits. |
| 5. Connecting strokes. | 11. Use of flourishes or embellishments |
| 6. Beginning and ending strokes | 12. Placement of diacritics such as I dots and t cross |

2. Class characteristics are common characteristic [2] that define as elements or quality of writing that situate a person within a group of writers, or that give a written communication a group identity. They may result from such influence as the writing system study; have a little weight in identifying a writer and can usually serve to eliminate a writer but alone can't identify a specific writer [2, 3].

For example, Hispanic writers have a tendency to ornateness in the formation of capital letters.

Disguised handwriting

Disguised handwriting is one in which the person had made a deliberate attempt to remove or to modify all or some of his normal writing habits. A purpose of disguise is to avoid detection. But, when as much as a page of writing is disguised, the writer's normal habits are partially veiled [2, 3, 10].

Disguised writing has highly characteristic features which distinguish it from normal writing. Disguised writing usually contains evidence of conflict – the struggle between natural habits and the effort to suppress them [2].

Unaccustomed handwriting or left-hand writing or wrong-hand writing (writing with the opposite hand from that which is habitually used [2]) is used to disguise. This study was referred to unaccustomed handwriting disguise case in Thailand which Thai characters were used. So the following would be the introduction of Thai alphabets character's structure [11, 12].

The Thai alphabets character's structure

The Thai characters consist of 42 consonants, 18 vowel, 4 controlled voice tones and 3 special symbols (**Figure 1**). The structure of most Thai character consists of small loops (head of character) combined with curves and lines. Most of Thai character consists of small loops, for example, a circular part in the upperleft of the character “u”, and combined with many curves. Consonants are located on the consonant line level of the word. Some consonants occupy more than one level such as [๓] which occupies both the body and lower vowel levels, or [๑] which occupies both the body and upper vowel levels. Three tall vowels, i.e., [๑], [๑] and [๑], occupy both the body and upper vowel levels. Vowels are located on the upper or lower line of the consonant line level, called the “upper vowel line level” and the “lower vowel line level” respectively. Tonal symbols are located on the upper line of the upper vowel line level, called the “tonal line level”.

Objectives

There were some crime cases that relate to handwriting identification. There was a letter as evidence and then the police caught one suspect. The police believed that the suspect wrote it. When the post-scene sample that wrote by the suspect's right hand came to the handwriting examiner, these handwriting features showed characteristic difference. When the examiner search the feature related to hand-side writing, he found that the post-scene sample wrote by the right hand but the evidence wrote by

the left hand. So when the examiner received new post-scene sample wrote by the suspect's left hand, it showed that both of the evidence came from the same person – a suspect. Therefore the objectives of this study were given as follows.

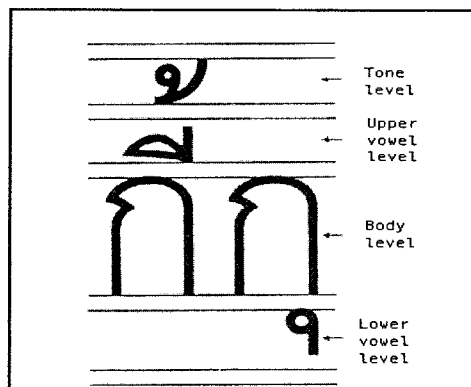


Figure 1 Thai language uses four writing levels

1. Investigate a similarity of each feature that measure from accustomed and unaccustomed handwritings of the same person in subconscious state (not intend to disguise).
2. Estimate the probability using a similarity of each feature of evidence written from accustomed and unaccustomed handwriting of the same person in subconscious state (not intend to disguise).

Limitation of the study

In this study, we will investigate a similarity of feature that measure from accustomed and unaccustomed handwriting by the same person. We limited factors of this study as follows.

1. Group of subjects were the elementary school teachers because of their writing experience. The experienced writer such as teacher concentrates most of his conscious thought on the subject matter rather than the writing process itself. So, writing comes to be made up of innumerable subconscious, habitual pattern, which are as a part of the individual as any of his personal habits or mannerisms. [2].
2. The features analyzed were slant, size of letter, space, alignment and height.

Organization of this study

In this study, subjects received questionnaire and sample collection form. They repeat wrote sentence sample. We measured each handwriting feature and analyzed the similarity by statistical analysis method.

Literature review

In Thailand, there are many experiments that related to handwriting but most of them are online handwriting found at bank, department store etc. For off-line handwriting, there are many techniques to recognize. There were many handwriting experiments in a field of education. However, this study is about wrong-hand writing that used in disguise handwriting. There were not many researches about it. One example was a study of Disguised Handwriting- A statistic Survey of How Handwriting was most frequently Disguised by Edwin and Alford in 1970 [10]. Researcher realized that persons actually attempt to disguise for nefarious purpose might be motivated to greater effort and possible the disguise would be thought-out and practiced than in the case that merely honoring a request to attempt disguise, so, subjects knew that they would disguise his/her writing in the way they want. Interpretation of disguise element in this study consistent with the examining experience of the author. The most often changed elements were most drastically affect the pictorial appearance elements such as slope, size, and slant.

Materials

Each subject received 1 questionnaire, sample's collection form, a blue ball point pen, blue color ink, diameter 0.7 mm. (clic 878, Lancer, Thailand). Both materials were packed in a brown envelope (ba paper open-end envelope no.9×12 ¾, See Thong 555, Thailand)

Equipment

In this study, Digital CCD Microscope MS-804 Scopeman 25 x zoom lens was used.

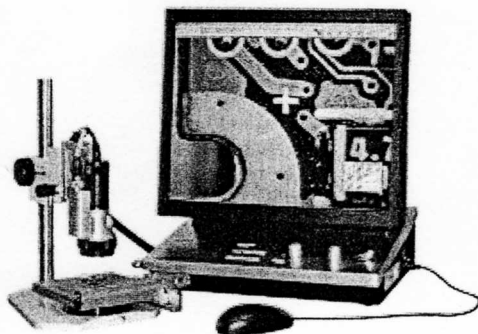


Figure 2 Digital CCD Microscope MS-804 Scopeman [33]

Samples

Researcher randomly distributed questionnaires and sample collection forms to 32 elementary school teachers. Each teacher was asked to provide or copy the source sentence at least 20 handwritten sentence samples; 10 by accustomed hand and the other 10 by unaccustomed hand, the source sentence was completely 4 zones; tonal symbol, upper vowel, consonant, lower vowel, up-to-down, down-to-up, upper loop, lower loop initial point and wide, normal and narrow letter width. A source sentence was “ในวันอาทิตย์แรกของเดือนกรกฎาคมที่จะถึงนี้คุณพิพัฒน์มีนัดประชุมสัมมนาที่ธนาคารแห่งชาติ”.

4. Method

The data analyzed in this study were collected from the questionnaires and the sample's collection forms. So data preparation and examination were given as follows.

4.1. Distributed questionnaires and sample's collection forms. Subjects were allowed to take as much time as they want.

4.2. Collected all sample sentences from each subject and checked for number of sentence and letter for analysis.

4.3. Select 4 sentences from accustomed handwriting sample and at least 6 sentences from unaccustomed handwriting sample.

4.4. Feature analysis

4.4.1 Slant of letter

ใ, สระอา, ฎ, ฬ were selected for slant measurement because they were long letter and easy to measure.

The A line was a horizontal straight line at baseline level and the B line was a vertical straight line which touched by the back line of the letter. Angle X was measured (Figure 3.2).

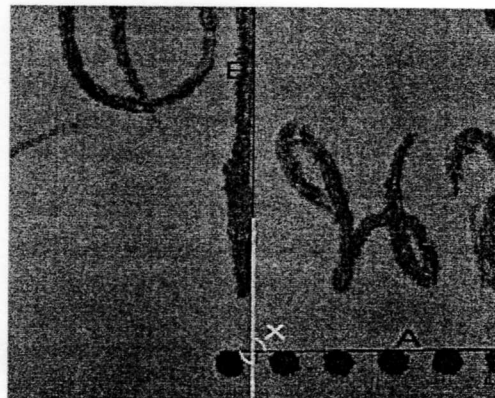


Figure 3.2 The lines and the angle used for slant measurement

4.4.2 Alignment of letter

“ในวันอาทิตย์แรกของเดือนกรกฎาคมที่จะถึงนี้คุณพิพัฒน์มีนัดประชุมสัมมนาที่ธนาคารแห่งชาติ”

The underlined letters were selected for alignment measurement because they were substitute of each phase in the sample sentence.

The A and B were horizontal straight parallel line that respectively touched by the base line and bottom of letter. The distance between A and B line was measured (Figure 3.3).

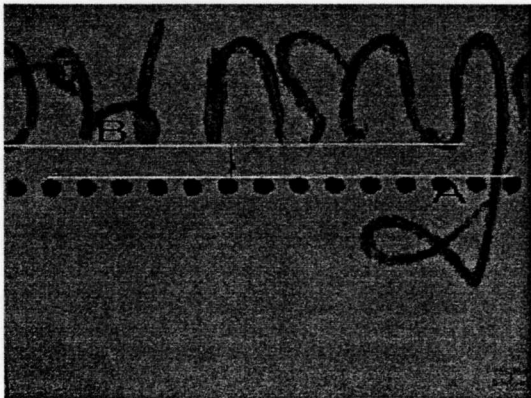


Figure 3.3 The lines used for alignment measurement

4.4.3 Height of letter

น, สระอา, ร, ม were selected for height of letter measurement.

The A and B are straight parallel lines that respectively touched by the front and the back point of letter, then, C and D are straight parallel lines that respectively touched by the top and bottom point of the letter, both lines must be at the right angle to A and B. The distance between C and D lines was measured (Figure 3.4).

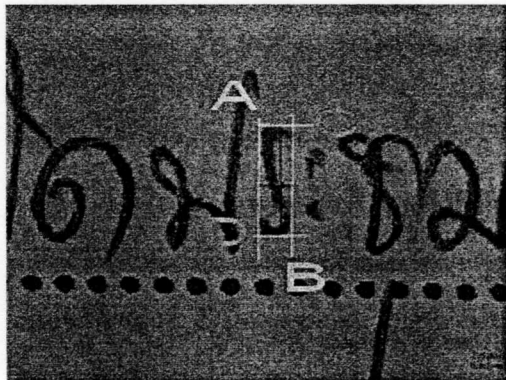


Figure 3.4 The lines used for height measurement

4.4.4 Space between two letters

“ในวันอาทิตย์แรกของเดือนกรกฎาคมที่จะถึงนี้
คุณพิพัฒน์มีนัดประชุมสัมมนาที่ธนาคารแห่งชาติ”

The underlined letters were selected for space between two letters

measurement because they were substitute of each phase in sample sentence.

The A and B were straight parallel lines that respectively touched by the back point of the first letter and the front of the second letter. The distance between A and B line was measured (Figure 3.5).

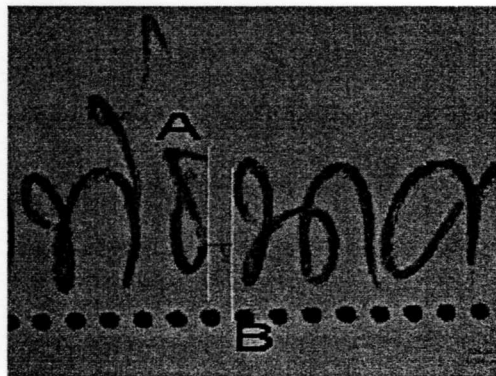


Figure 3.5 The lines used for space measurement

4.4.5 Size of letter

The size of the letter was divided into 3 groups by the width, that is

- Width letter – น พ
- Normal letter – น ม อ ก ฅ ฌ
- Narrow letter – ร สระอา

The A and B were straight parallel lines that respectively touched by the top and the bottom point of the letter then the C and D were straight parallel lines that respectively touched by the front and the back point of the letter, both lines must be at the right angle to A and B. The distance between C and D line was measured (Figure 3.6).

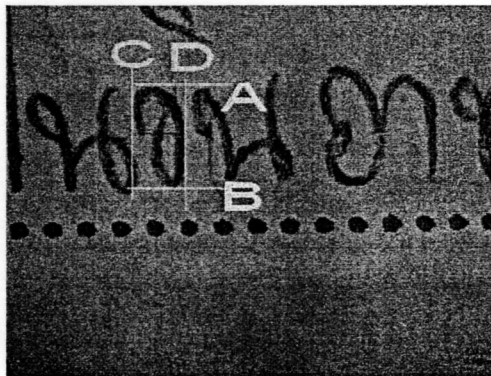


Figure 3.6 The lines used for size of letter measurement

Statistical analysis

The data measured from each feature were analyzed by independent t-test or Mann-Witney test at p-value equal to 0.01.

5.1. Data (distance) from each feature was divided into 2 groups: accustomed and unaccustomed handwrittens. Descriptive statistics of each data group were calculated by using SPSS 13.0 for windows.

5.2. Each feature was tested for normality distribution of each data population. If both were normal, t-test was used, but, if one or both were not normal, Mann-Witney test was used.

5.3. The subjects in each feature that significant different at p-value equal to 0.01 were analyzed by percentage method to calculate a probability that find 1 or more handwriting features in 1 handwriting sample which written by unaccustomed hand compare to accustomed hand.

Results and Discussion

Similarity of accustomed and unaccustomed handwriting was analyzed by data description (mean and median) and t-test.

Data description

In this study, thirty two elementary school teachers were randomized from school in Bangkok, Thailand. Each case contained 2 groups of data i.e. accustomed handwritten and unaccustomed handwritten. Seven handwriting features were examined.

T- test

The purpose of this method is to evaluate the null hypothesis ($\mu_a = \mu_u$ or $\mu_a - \mu_u = 0$) at a significant level $\alpha = 0.01$. If the difference between the sample mean and the specified population mean is so large, its associated probability under H_0 is equal to or less than 0.01, was rejected H_0 .

The testing hypotheses were written as.

$$H_0: \mu_a = \mu_u$$

$$H_1: \mu_a \neq \mu_u$$

Where

μ_a = data population mean of each feature that measure from accustomed handwritten.

μ_u = data population mean of each feature that measure from unaccustomed handwritten.

Similarity of accustomed and unaccustomed handwriting in each feature was presented in table 1.

Table1 Similarity of accustomed and unaccustomed handwriting in each feature

Features	Similarity of accustomed and unaccustomed handwriting	
	mean and median (Numbers of subject)	t-test and Mann-Witney (%)
Size [narrow]	20-15	75.00
Size [wide]	10-5	65.62
Space	15-10	62.50
Size [normal]	15-10	59.37
Slant	15-10	50.00
Alignment	10-5	41.93
Height	10-5	28.12

Percentage method

In this study, percentage method was used to calculate the percentage to find 1 or more features that were not significant different between accustomed handwriting and unaccustomed handwriting. However, both type of handwriting were written by the same person.

Steps of handwriting feature examination depended on the percentage that mean of data population from accustomed handwritten and unaccustomed handwritten by the same person were not significant different. Values of percentage arrange by a great number to a few number were given as follows.

1. Size [narrow]
2. Size [wide]
3. Space
4. Size [normal]
5. Slant
6. Alignment
7. Height

Example of percentage calculates was present in table 2.

Table 2 The figures of subjects with not significantly different means between two groups of population in three features examine

Significant different	Size [narrow]	Size [wide]	Space	Total
No	24	21	20	<u>65</u>
Yes	8	11	12	31
Total	32	32	32	<u>96</u>

There was 67.71% that the examiner found size [narrow], size [wide] and space of accustomed handwritten and unaccustomed handwritten by the same person were not significant different.

So, probability that the examiner found 1-7 features together in accustomed handwritten and unaccustomed handwritten by the same person were presented in table 3.

Table 3 Probability found 1-7 features together in accustomed handwritten and unaccustomed handwritten by the same person

Feature found together	Probability (%)
size [narrow]	75.00
size [narrow], size [wide]	70.31
size [narrow], size [wide], space	67.71
size [narrow], size [wide], space, size [normal]	65.62
size [narrow], size [wide], space, size [normal], slant	62.50
size [narrow], size [wide], space, size [normal], slant, alignment	59.16
size [narrow], size [wide], space, size [normal], slant, alignment, height	54.71

Application

The results of this study were applied to the accustomed and the unaccustomed handwriting examination in case of the writer was a teacher. Handwriting samples were collected. Question document was written by the unaccustomed hand and known documents were written by the accustomed hand of 3 suspects.

Examination of each feature was given as follows.

1. Data description
2. Test for normality distribution
3. If data was normality distribution, t-test was used.

If data was normality distribution, Mann-Witney test was used.

The tests were performed at $p\text{-value} = 0.01$.

The results were presented in **Table 4** There were different numbers of features that mean of data population from question and known handwrittens were not significant different. The handwriting of suspect 1 had similarity of size [narrow], size [wide], space, size [normal] and alignment. The handwriting of suspect 2 had similarity of size [narrow], size [normal] and slant. The handwriting of suspect 3 had similarity of size [narrow], size [normal], slant and alignment.

The number of the subject showing mean of data population were not significant different in size [narrow], size [wide], space, size [normal],

slant, alignment and height was presented in **Table 5**. From **Table 6**, the question and known documents were written by the accustomed and the unaccustomed hands of the suspect 1, suspect 2 and suspect 3 were 61.01%, 52.08% and 56.69% , respectively.

However, Suspect 1 that gave the highest percentage of similarity was the true writer of question evidence. From this part, this study could estimate the probability that question and known evidence were written from accustomed and unaccustomed handwriting of the same person in subconscious state (not intend to disguise).

Table 4 The result of each handwriting feature from 3 handwriting evidence compare to question document

Features	Similarity		
	Suspects		
	1	2	3
Size[narrow]	yes	yes	yes
Size[wide]	yes	no	no
Space	yes	no	no
Size[normal]	yes	yes	yes
Slant	no	yes	yes
Alignment	yes	no	yes
Height	no	no	no

Discussion

In this study, accustomed and unaccustomed handwriting from elementary school teachers were collected. We controlled handwritten factors i.e., paper, pen and source sentence by prepared questionnaires and sample collection form. Source sentence was in sample collection. One questionnaires and sample's collection form that included blue ball point pen were packed in brown envelope and distributed to the subjects.

The occupation of teacher was daily writing. Their handwriting would be of good quality and legibility. So their students could read them easily. For these reasons, teachers' handwriting skill would be good. The good skill writer would concentrate most of his conscious thought on the subject matter rather than the writing process itself and then, teacher handwriting comes to be made up of innumerable subconscious, habitual pattern, which were as a part of the individual as any of his personal habits or mannerisms. So, the feature of teacher's handwriting would be shown their handwriting habitual. Examiner would collect their handwriting to examine habitual of handwriting.

The sentence sample of this study contained all 4 levels of Thai language and 3 types of letter and divided by the letter width. Features studied were size of letter (narrow, normal, wide), space,

1. Percentage of the similarity in each feature and relation factors

Mean and median of each feature was similar to the percentage of the result the mean of data population was not significant different. Percentage that mean of data population from accustomed handwritten and unaccustomed handwritten were not significant different arranged from more to less respectively were size of letter (narrow), size of letter (wide), space, size of letter (normal), slant, alignment and height. First four greatest percentages, i.e. size of letter and space were features that relate with horizontal hand movement. Last three percentage of 3 features, i.e. slant, alignment and height were related with vertical hand movement and position of tools while handwriting period.

Hand movement was related to the skill of the writer, hand muscle, writing tools etc. We already control handwriting tools. We suppose others factors were similar in accustomed and unaccustomed handwriting by the same person. So the different factors between accustomed and unaccustomed handwriting were arm muscle, hand muscle and the accustomed of each hand.

2. Trend of data population from accustomed handwritten and unaccustomed handwritten and its cause

Although each feature had a data population from accustomed handwritten and unaccustomed handwritten that were not significant different, but there was some subject of each feature had significant difference data. Trend of difference in each feature were described as follows.

2.1 Size [narrow]

2.2 Size [wide]

Trend of both data were increased. The reason was while subjects wrote by unaccustomed hand; they had little skill to control their hand to write in an usual way. Unusual way of hand movement produced longer stroke of letter in horizontalness.

2.3 Space

Trend of data was decreased. The reason was that while subjects wrote by the unaccustomed hand; they had little skill to control their hand to write in an usual way. While the subject wrote the front line of the second letter, it was drawn to near back line of

slant, height and alignment. These features were normally found and data analyzed was presented in numerical.

the first letter, so, the space between the first and the second letter was decreased.

2.4 Size [normal]

Trend of data was increased. The reason was that while the subjects wrote by the unaccustomed hand; they had little skill to control their hand to write in an usual way. Unusual way of hand movement produced longer stroke of letter in horizontalness.

2.5 Slant

Trend of data was increased. The reason was angle of hand while they were writing. Most of the subjects in this study were the right-handed writers. In the right-handed writers, the subjects wrote by the accustomed hand (right hand), the slant of the letter was estimated to 90 degree. When the subjects wrote by the unaccustomed hand (left hand), the slant of the letter was increased to nearly 90 degree or more. In left-handed writer, slant was a bit decrease.

2.6 Alignment

Trend of data was decreased. The power of decrease was $\frac{1}{2}$ - $\frac{1}{4}$. The reason was that while the subjects wrote by the unaccustomed hand; they had little skill to control their hands to write in an usual way. There were two possible situations

2.6.1. Unusual way of hand movement produced longer stroke of letter in verticalness.

2.6.2 The writer tried to write letters by using the baseline as a reference line.

2.7 Height

Trend of data was increased. The reason was that while the subjects wrote by the unaccustomed hand; they had little skill to control their hands to write in an usual way. The unusual way of hand movement produced longer stroke of letter in verticalness.

3. Steps of examination

The examiner should examine the features by follow the steps (from more to less respectively) the highest percentage showed that high probability was found in the features of the accustomed and unaccustomed handwrittens. Then, second and other features were examined to limit probability. In the lower percentage features, the examiner could not assume that they were not found in both handwrittens and did not examine them. Low percentages meant that there were few subjects had that features.

Low percentage features would help to increase probability that the suspect's handwriting evidence was written by the same person.

Table 5 The figures of subjects with not significantly different means between two groups of population in six features examine

Significant different	Size [narrow]	Size [wide]	Space	Size [normal]	Slant	Alignment	Total
No	24	21	20	19	16	13	97
Yes	8	11	12	13	16	18	62
Total	32	32	32	32	32	31	159

Table 6 Percentage of written question and known document of each suspect

Suspects	1	2	3
Percent	61.01	52.08	56.69

Conclusion

In this study, the data including accustomed and unaccustomed handwritings from 32 elementary school teachers were analyzed. The data feature was examined in the method of description data and independent sample t-test. The conclusions of this study were as follows:

1. The major findings following the **objective 1** of this study: Seven features were analyzed in this study (slant, size of wide letter, size of narrow letter, size of normal letter, space, alignment and height). A similarity of each feature that measure from accustomed and unaccustomed handwritings by the same person in subconscious state (not intend to disguise) elementary school teachers was analyzed by the method of description data and independent sample t-test. The result of similarity (mean of each feature measurement from accustomed handwritten and unaccustomed handwritten were not significant different) was shown as follows. From the similarities, we could arrange values of percentage from high to low as follows:

1. Size of narrow letter (75%)
2. Size of wide letter (65.62%)
3. Space (62.50%)
4. Size of normal letter (59.37%)
5. Slant (50%)
6. Alignment (41.93%)
7. Height (28.12%).

2. The major findings following the **objective 2** of this study : A similarity of each feature was used to estimate probability that evidence was written from accustomed and unaccustomed handwritings by the same person in subconscious state (not intend to disguise) by computing the percentage in the case that 2 or more similarity features were found between the two handwriting evidences. From the application section, question and known handwriting evidences were examined and the result showed that the true writer gave the highest percentage of probability. So this study could estimate the probability that question and known evidences were written from accustomed and unaccustomed handwriting of the same person in subconscious state (not intend to disguise).

Disguise handwriting is one in which the person had made a deliberate attempt to remove or to modify all or some of his normal writing habits. A purpose of disguise is to avoid detection. From Alford study [10], mostly used methods of disguise were methods that change obviously appearance such as change size of letter, slant. But in will or ransom note that contained many letters, if writer disguise by those methods, appearance of letters were unstable because there were both disguised letter and writer habitual letter. So a writer would disguise and show stable style of letters. The disguise method that showed stable style of letters was wrong-hand writing. By this method, writer would produce unsuspecting writing and different from accustomed writing. So writer would deny that the writing was not of his own. This study showed the method to investigate a similarity of each feature that measure from accustomed and unaccustomed handwritings by the same person in subconscious state (not intend to disguise) and use a similarity of each feature to estimate probability of written evidence. However, handwriting is not just "hand" writing. There are many factors that influence in letter formation. The Result obtained from this study was used to

help handwriting examiner estimated probability. Others feature such as speed and line qualities of accustomed and unaccustomed handwritings could be included in the handwritings examination.

Finally, **further interesting studies** are as follows:

1. Investigate a similarity of each feature that measure from accustomed and unaccustomed handwriting by the same person in subconscious state (not intend to disguise) in other group of people.
2. Study other features of handwriting.

Acknowledgements

First of all, I would like to deeply thank my respect teacher and major advisor, Assoc. Prof. Dr. Montip Tiensuwan, Ph.D., for advice on data analysis support especially in statistical analysis, suggestions and precious time to correct my thesis patiently. I would like to deeply thank my co-advisor, Assoc. Prof. Dr. Suda Riengrojpitak, for her compassion, helpful comments and English correction of my thesis. I would like to extend my thanks to my external advisor and chair of the thesis defending committee, Pol. Lt. Col. Pitsanu Fupleum, for advice on data collection, sample examination and his pleasantly warm suggestion was contributing encouragement to me. I would like to thank the Office of Police Forensic science, Royal Thai Police, for supported in part of examination equipment. I would like to thank Panapun phayathai School, Materdei Institute, Rachawinit Pratom School and SateeVorath School for their kind support. I would like to extend my thanks to the Faculty of Graduate Studies, Mahidol University, for supported in part by the Thesis Grant.

References

- Morris R. N., *Forensic Handwriting Identification Fundamental concepts and principles*, Academic Press, 2000:6-7.
- Hilton O., *Scientific examination of questioned documents*, CRC Press LLC, 1993.
- Saferstein R., *Forensic Science Handbook Vol.1*, edited by Richard, 2nd edition, Practice hall, 2002.
- Jarman K.H., Hanlen R.C, Manzollilo P.A., *Handwriting examination: Moving from Art to Science*, Pacific Northwest National Lab., Richland, WA (US), 1998.
- Sargur N. S., Cha S.H., Arora H, Sangjik L., *Individuality of Handwriting: A Validation Study*, Sixth International Conference on Document Analysis and Recognition (ICDAR'01), 2001: 0106.
- Sargur N. S., Cha S.H. and Sangjik L., *Establishing Handwriting Individuality Using Pattern Recognition Techniques*, Sixth International Conference on Document Analysis and Recognition (ICDAR'01), 2001: 1195.
- Chatwiriya W., *Off-line Thai Handwriting Recognition In Legal Amount*, Dissertation submitted to College of Engineering and Mineral Resources at West Virginia University, 2002.
- Tang Y.Y. et al, *Offline Recognition of Chinese Handwriting by Multifeature and Multilevel Classification*, IEEE Transactions on pattern analysis and machine intelligence, 1998; 20:556-561.
- Doermann D.S., Rosenfeld A., *Temporal clues in handwriting*, Pattern Recognition. Conference B: Pattern Recognition Methodology and Systems, Proceedings, 11th IAPR International Conference, 1992; 2: 317-320.
- Alford E.F Jr., *Disguised Handwriting- A statistic Survey of How Handwriting is most Frequently Disguised*, Journal of forensic science, 1970; 15(4):476-88.
- Phokharatkul P. Kimpan C., *Handwritten Thai Character Recognition using Fourier Descriptors and Genetic Neural Networks*, Computational Intelligence 2002;18 :270-293.
- Lohakan M., Airphaiboon S., Sangworasil M., *Single-Character Segmentation for Handprinted Thai Word*, Proceedings of the Fifth International Conference on Document Analysis and Recognition, 1999: 661.
- Parisse C., *Global world Shape Processing in off-line Recognition of Handwriting*, IEEE Transactions on PA-ERN Analysis and Machine Intelligence, 1996;18: 460-464.
- Kavallieratou E., Fakotakis N., Kokkinakis G., *An unconstrained handwriting recognition system*, IJDAR, 2002 ;4: 226-242.
- Srihari S, Cha SH., Arora H., Lee S., *Individuality of handwriting*, Journal of forensic science, 2002, 47.
- Arica N., Yarman-Vural F.T., *Optical Character Recognition for Cursive Handwriting*, IEEE Transactions on Pattern Analysis and Machine Intelligence, 2002, 24; 801 – 813.

Example of similar accustomed and unaccustomed handwritings

Example of similar accustomed and unaccustomed handwritings

Accustomed handwriting

ในหน้าสุดท้ายแรกของเอกสารฉบับนี้
ในหน้าสุดท้ายแรกของเอกสารฉบับนี้
ในหน้าสุดท้ายแรกของเอกสารฉบับนี้
ในหน้าสุดท้ายแรกของเอกสารฉบับนี้
ในหน้าสุดท้ายแรกของเอกสารฉบับนี้
ในหน้าสุดท้ายแรกของเอกสารฉบับนี้

Unaccustomed handwriting

ในหน้าสุดท้ายแรกของเอกสารฉบับนี้
ในหน้าสุดท้ายแรกของเอกสารฉบับนี้
ในหน้าสุดท้ายแรกของเอกสารฉบับนี้
ในหน้าสุดท้ายแรกของเอกสารฉบับนี้
ในหน้าสุดท้ายแรกของเอกสารฉบับนี้
ในหน้าสุดท้ายแรกของเอกสารฉบับนี้

Example of different accustomed and unaccustomed handwritings

Anongnath Soison

Appendix / 58

Example of different accustomed and unaccustomed handwritings

Accustomed handwriting

"ในร่มอาฬารย์ แรกของเดือน กรกฎาคม พุทธศักราช ๒๕๖๓
 ปรากฏ สัมมนาเพื่อมาลง แนนท์ ๖๖๖"

"ในร่มอาฬารย์ แรกของเดือน กรกฎาคม พุทธศักราช ๒๕๖๓
 ปรากฏ สัมมนาเพื่อมาลง แนนท์ ๖๖๖"

"ในร่มอาฬารย์ แรกของเดือน กรกฎาคม พุทธศักราช ๒๕๖๓
 ปรากฏ สัมมนาเพื่อมาลง แนนท์ ๖๖๖"

Unaccustomed handwriting

"ใน รุ่ง อาฬารย์ แรก ของ เดือน กรกฎาคม พุทธศักราช
 ๒๕๖๓ ปรากฏ สัมมนา เพื่อ มา ลง แนนท์ ๖๖๖
 สัมมนา ที่ ๖๖๖ แนนท์ ๖๖๖"

"ใน รุ่ง อาฬารย์ แรก ของ เดือน กรกฎาคม พุทธศักราช
 ๒๕๖๓ ปรากฏ สัมมนา เพื่อ มา ลง แนนท์ ๖๖๖
 สัมมนา ที่ ๖๖๖ แนนท์ ๖๖๖"