

**COMPARATIVE STUDY OF HABITUAL WITH LEFT AND  
RIGHT HANDWRITINGS OF THE SAME PERSON**

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Entitled

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COMPARATIVE STUDY OF HABITUAL WITH LEFT AND RIGHT  
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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.

KEY WORDS : OFF-LINE HANDWRITING / UNACCUSTOMED  
HANDWRITING/ DISGUISE

59 pp.

การศึกษาเปรียบเทียบความเคยชินในการเขียนด้วยมือซ้ายและมือขวาของบุคคลคนเดียวกัน  
(COMPARATIVE STUDY OF HABITUAL WITH LEFT AND RIGHT  
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บทคัดย่อ

เอกสารที่เกิดจากการเขียนด้วยลายมือเป็นเอกสารที่สำคัญในการตรวจพิสูจน์ทางด้านนิติวิทยาศาสตร์เมื่อถูกพบในที่เกิดเหตุหรือเกี่ยวข้องกับคดีความต่างๆ วิธีหนึ่งที่ใช้ตรวจพิสูจน์นั้น เป็นการตรวจลักษณะตัวอักษรเปรียบเทียบกันระหว่างลายมือเขียนจากเอกสารปัญหา กับเอกสารลายมือเขียนตัวอย่างซึ่งได้จากการเขียนโดยผู้ต้องสงสัย วิธีที่นิยมใช้ในการเปลี่ยนแปลงลักษณะของลายมือเขียนเดิมของผู้เขียนคือการเขียนด้วยมือข้างที่ไม่ถนัดของตน แต่ลายมือเขียนที่เกิดจากการเขียนด้วยมือข้างที่ไม่ถนัดก็ยังคงไว้ซึ่งความคงที่ในบางลักษณะของตัวอักษร

ในการศึกษานี้ผู้วิจัยได้ทำการจัดเก็บลายมือเขียนภาษาไทยที่เขียนโดยมือข้างที่ถนัดและไม่ถนัดของกลุ่มประชากรครูประถมศึกษามหาวิทยาลัยราชภัฏวชิรเวศน์ในกรุงเทพมหานคร มาวัดค่าของลักษณะต่างๆของลายมือเขียน ได้แก่การเอียงลาด, ความสูง, ขนาดของตัวอักษร, ระยะห่างระหว่างตัวอักษรกับเส้นบรรทัดและช่องไฟด้วยกล้องจุลทรรศน์วิดีโอ จากนั้นนำค่าที่ได้มาวิเคราะห์โดยการทดสอบสมมติฐานในกรณีสองกลุ่มตัวอย่างที่เป็นอิสระต่อกันแล้วหาความเป็นไปได้ โดยคำนวณร้อยละของกลุ่มประชากรที่มีค่ากลางไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ จากการศึกษาพบว่า พบความคงที่ของขนาดตัวอักษรแบบแฉกมากที่สุดคือเป็นร้อยละ 75 ของกลุ่มประชากรทดสอบ

59 หน้า.

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## **LIST OF ABBREVIATIONS**

### **Abbreviations**

### **Term**

mm.

Millimeter

SD

standard deviation

## **CHAPTER I**

### **INTRODUCTION**

#### **1.1 Statement of the problem**

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. It taught to and learned by, a person using either a copybook letter form, or observing and adopting letter or symbol [1].

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].

### **Categories of handwriting recognition**

In the process of handwriting document (any material which contains marks, symbols or signs either visible, partially visible or invisible that may presently or ultimately convey a meaning or message to someone [2]) analysis, the examiners should know about categories of handwriting recognition because they would know nature of data and obtainable device of each data categories.

Handwriting recognition is divided into online and offline categories [7, 8, 9] depending on the nature of input data as follows.

**1. Online handwriting** deal with a data stream which is coming from a transducer while the user write. It will sample from pen movements in real time and record the positions and activities (e.g. pen-up and down) in a timely order. The advantage of online handwriting is capturing the temporal or dynamic information of the handwriting. This information consists of the number of strokes, the order of the

strokes, the direction of the writing for each stroke, and the speed of the writing within each stroke [8]. The recording device is often called the **tablet digitizer**.

**2. 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 [7, 9].

## **Features of handwriting**

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 as follows [4].

### **1. Document examiners features**

The handwriting attributes that are commonly used by the forensic document examination community. These features are normally extracted from handwriting using tools such as rulers, templates etc.

Broadly handwriting can be classified into two categories as the following.

**1.1 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 characteristics are given as follows [3].

- |  |  |
|--|--|
| 1. Line quality.   | 7. Unusual letter formations.                          |
| 2. Spacing of word or 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 |

**1.2 Class characteristics** are common characteristics [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.

## 2. Computation Features

Features that can be determined by algorithmically, e.g., by software operating on a scanned image of the handwriting.

### Disguised writing

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].

The characteristic of disguised writing that usually found are given as follows [3].

1. Inconsistent slant
2. Inconsistent letter formation
3. Change of capital letters
4. Abnormal appearance
5. Use of block lettering
6. Dramatic change in size of writing
7. Writing with unaccustomed hand
8. Less skill in writing
9. Lack of free-flowing movement
10. Lack of rhythm
11. Unnatural starts and stops
12. Irregular spacing
13. Excessive ornamentation

From the above characteristics, 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].

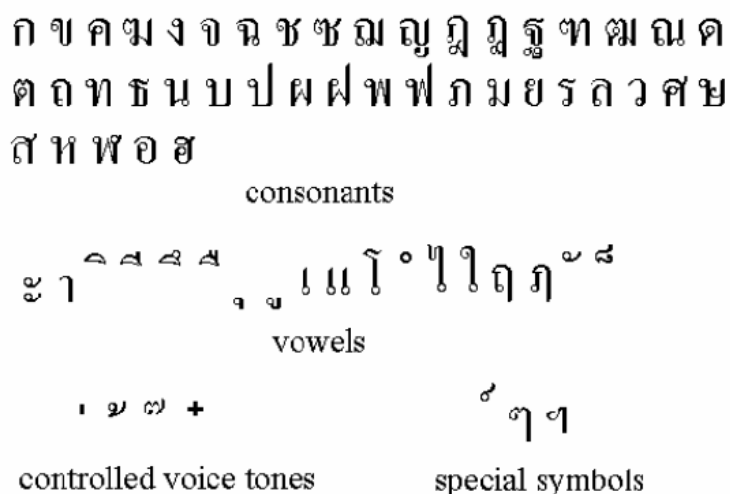
### **The Thai alphabets character's structure**

The Thai characters consist of 42 consonants, 18 vowel, 4 controlled voice tones and 3 special symbols (**Figure 1.1**). The structure of most Thai character consists of small loops (head of character) combined with curves and lines.

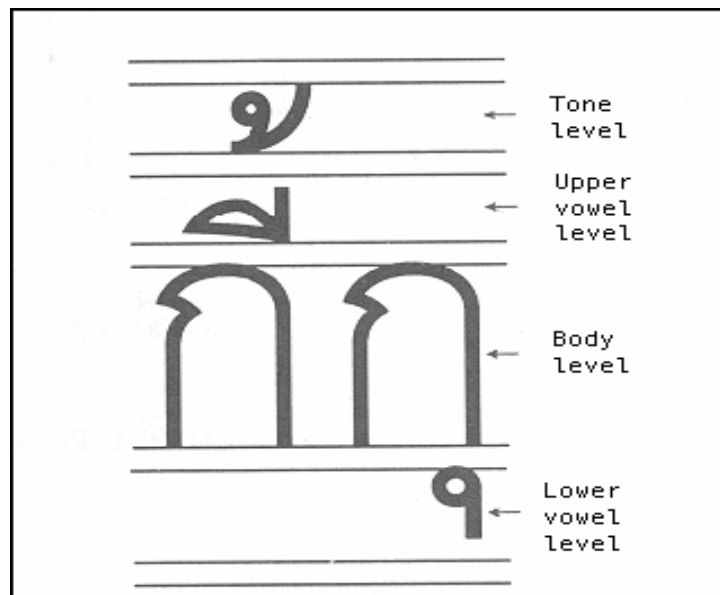
Most of Thai character consists of small loops, for example, a circular part in the upperleft of the character “๓”, and combined with many curves. Thai character always start with a head (if it has) and follows by the other component. Considering with

stroke counting, Thai characters have maximum two strokes in one character. For example, the consonant “ป” is one stroke character, and the consonant “ส” is two strokes character. Although, most Thai characters consist of only one stroke, except “ศ” “ส” and “+”. Thai language sentence is composed of consonants, vowels and tonal symbols on different levels. The vertical level can divide into four parts; tone level, upper vowel level, body level and lower vowel level (**Figure 1.2**).

The Thai word is constructed by combining consonant characters, vowel characters and tonal symbols. Consonants are located on the consonant line level of the word. Some consonants occupy more than one level such as [ฦ] which occupies both the body and lower vowel levels, or [ป] which occupies both the body and upper vowel levels. Three tall vowels, i.e., [โ], [ใ] and [เ], 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”.



**Figure 1.1** Thai character set consist of 42 consonants, 18 vowels, 4 controlled voice and 3 special symbols [11].



**Figure 1.2** Thai language uses four writing levels [7].

Like Latin-based languages, Thai is alphabetic, written from the left to the right, from the top to the bottom, and in block style. In other words, Thai script is non-cursive, no capital letters, no spaces between words and there are no connections between letters. However, a break may be introduced between groups of words at the writer's discretion, the ending of an idea or expression, or the separation of character and numeral [7].

## 1.2 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.

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).

### **1.3 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.

### **1.4 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.

The background and literature survey summarized the study about analytical method, tool and statistical method are used in off-line handwriting study were presented in chapter 2. In chapter 3 showed the material and method of this study. Results and discussion were shown in chapter 4 and chapter 5 were indicated the conclusion and recommendation.

## **CHAPTER II**

### **LITERATURE REVIEWS**

#### **2.1 World wide handwriting examination method**

The experiments about handwriting in the world wide correlate with both of on-line and off-line handwriting. In the case of off-line handwriting, there are many studies. In 1998, Parisse [13] studied the lexicons recognition based on n-gram extraction and identification. In 1998, Tang et al's study another off-line recognition system [8] by referring to Chinese character hand written multifeature and multilevel classification by two new technologies; overlap clustering and Gaussian distribution selector. Both studies used samples that collected by their own. In 2002, Kavallieratou et al [14] used different source of samples, i.e. NIST (National Institute of standard and technology) database, IAM-DB and GRUHD (A Greek Database of unconstrained handwriting). All of three databases were used for an unconstrained handwriting recognition system and the system of this study was OCR (Optical Character Recognition).

In feature extraction process, there were two experiments that using algorithms for extracting features; line separation, slant, character shape etc, from scanned images of handwriting and using machine learning approaches to quantitatively establish individuality. These two studies were studied by Sargur, Cha and Sangjik in 2001 [6] and Arora was participated in 2002 [15]. Cluster analysis is use to compared different profiles for individuality by KH Jarman, RC Hanlen, PAU Manzolino (1998) [4].

There are many statistical models that used to analyze. Hidden Markov Model (HMM) is a statistical model that used in many studies of off-line handwriting. For example, in 2002, offline cursive handwriting (word-level) recognition problems were solved by Hidden Markov Model (HMM) in Arica, Yarman-Vural study [16]. In same year, Justino et al. [17] used HMM to be a software-base for interpersonal and

intrapersonal variable study. In 2003, Vinciarelli et al [18], used HMM in the similar way, system-base, for the off-line recognition of cursive handwritten lines of text and continuedness.

However other statistical techniques are used for off-line handwriting recognition, such as Kolmogorov-Smirnov Test that can be applied to obtain a probability of similarity between two distributions and be applicable to unbinned distributions that are functions of a single independent variable [19]. Others are Bayes classifier and the k-nearest neighbor (k-nn) classifier by Pervouchine et al [20].

## **2.2 Handwriting examination method in Thailand**

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. As world wide experiment, Neural Network (NN) technique was used in 1998, by Phokharatkul and Kimpan [21], to classify off-line handwriting which detected space feature. In 2002, U-seng and Tanprasert [22] used NN to recognize each individual writer. Two years later, Methasate and Sae-tang [23] used NN to recognize off-line handwriting from the detection of vertical stroke.

For fuzzy system and neural network-type method, Tanprasert et al used them to distinguish among similar characters and used outpost vector technique to enhanced generalization [24]. Further, in 2003, Pomchaikajomsak and Thammano [25] used the concept of fuzzy membership function and fuzzy ARTMAP neural network to recognize off-line Thai characteristic.

Hidden Markov Model (HMM) used all over the world was proposed by Theeramunkong et al [26] and also approached with interpolated n-gram model (n-gram) to solve the problem-miss of local feature due to fast writing. Nopsuwanchai and Povey's reported in 2003 [27] that they used discriminative training, Maximum Mutual Information (MMI) training and block-based Principal Component Analysis

(PCA) techniques to improve performance in a HMM based isolated handwritten character recognition system. Not only vowel, consonant or tonal symbol but also lexicons, which much value in financial cases, are recognized by Chatwiriya, Klinkhachom and Lass [28].

Ant-minor algorithm (data mining based on Ant colony optimization) was used to construct the classification rules in order to classify Thai characters by Phokharatkul et al. [29]. In 2002, Mitrpanont and Kiwprasopsak [30] developed feature extraction algorithms for the recognition of off-line Thai handwritten characters.

There were many handwriting experiments in a field of education such as Jaggapat [31]. This study was about the relation between personal experience and qualities of fourth graders' handwriting. In this study, qualities of handwriting were analyzed by percentage method. The relation between personal experience and handwriting qualities were analyzed by Chi-square test. In a study of Grade 6 student handwriting qualities by Sudaporn [32], percentage method was used to analyze qualities of handwriting.

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.

## CHAPTER III

### MATERIALS AND METHODS

#### 3.1 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)

#### 3.2 Equipment

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



**Figure 3.1** Digital CCD Microscope MS-804 Scopeman [33]

#### 3.3 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”.

### 3.4 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.

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

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

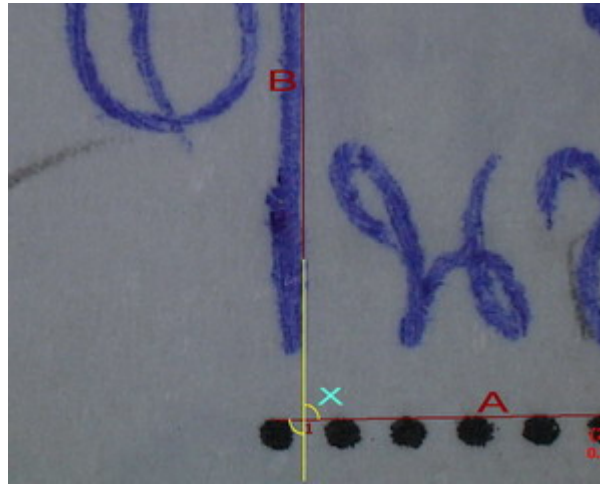
**3.4.3.** Select 4 sentences from accustomed handwriting sample and at least 6 sentences from unaccustomed handwriting sample.

**3.4.4.** Feature analysis

#### 3.4.4.1 Slant of letter

ใ, สระอา, ฎ, ป 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**).



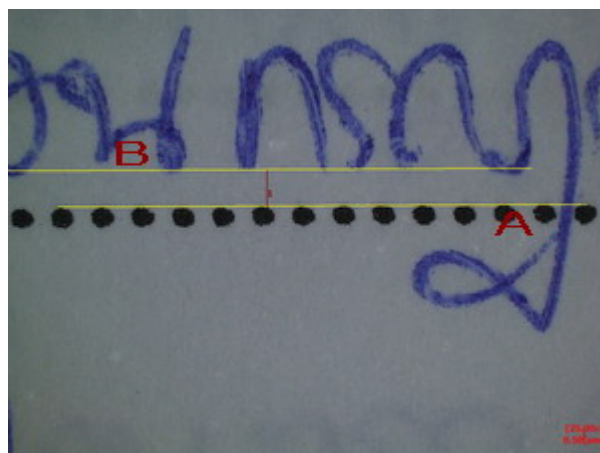
**Figure 3.2** The lines and the angle used for slant measurement

#### 3.4.4.2 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**).

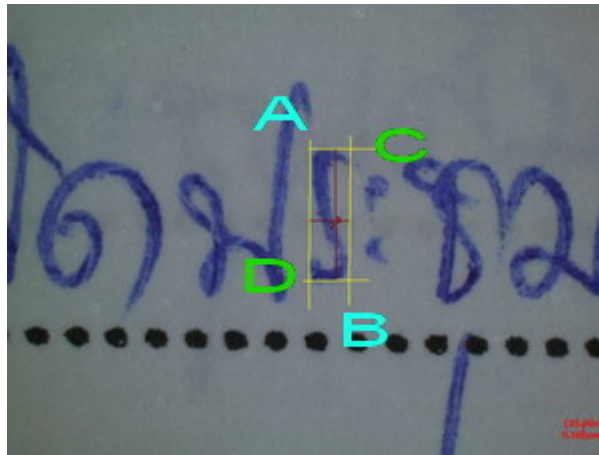


**Figure 3.3** The lines used for alignment measurement

### 3.4.4.3 Height of letter

พ, 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**).



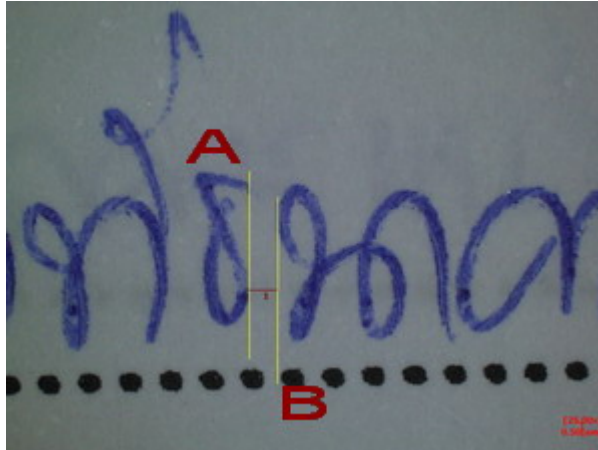
**Figure 3.4** The lines used for height measurement

### 3.4.4.4 Space between two letters

“ในวันอาทิตย์แรกของเดือนกรกฎาคมที่จะถึงนี้คุณพิพัฒน์มีนัดประชุมสัมมนาที่ ธนาคารแห่งชาติ”

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

#### 3.4.4.5 Size of letter

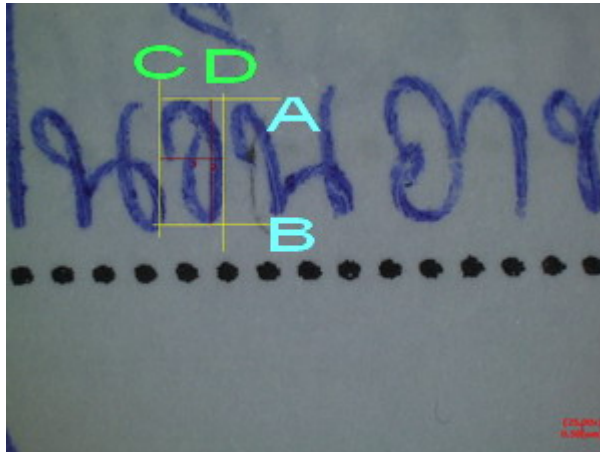
The size of the letter was divided into 3 groups by the width, that is

Width letter – น ฉ

Normal letter – น ม อ ก ข ค

Narrow letter – วรร 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

### 3.5 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.

**3.5.1.** 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.

**3.5.2.** 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.

**3.5.3.** 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.

## **CHAPTER IV**

### **RESULTS AND DISCUSSION**

In this chapter, the results were divided into 4 sections as follows: data description, test of normality, t- test, percentage method and discussion. The last section was the application.

#### **4.1 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. Data description for each group was present in the following section. The results of data description for each feature were shown in **Tables 4.1-4.7**.

**Table 4.1** Description of data from alignment measurement (unit: mm.)

Subjects	Accustomed handwritten			Unaccustomed handwritten		
	n	Mean $\pm$ SD	Median	n	Mean $\pm$ SD	Median
1	28	.568 $\pm$ .279	.500	161	.389 $\pm$ .383	.250
2	28	.282 $\pm$ .144	.250	161	.296 $\pm$ .283	.200
3	28	.364 $\pm$ .228	.300	154	.339 $\pm$ .215	.400
4	28	3.379 $\pm$ .652	3.500	28	1.807 $\pm$ .580	1.800
5	28	.582 $\pm$ .319	.600	70	.464 $\pm$ .272	.500
6	28	3.457 $\pm$ .806	3.400	35	1.768 $\pm$ .750	1.700
7	28	.882 $\pm$ .261	.900	70	.557 $\pm$ .292	.500
8	28	.639 $\pm$ .191	.600	56	.550 $\pm$ .455	.450
9	28	.275 $\pm$ .097	.300	63	.439 $\pm$ .257	.400
10	28	.621 $\pm$ .328	.600	35	.468 $\pm$ .284	.450
11	28	.864 $\pm$ .187	.800	42	.168 $\pm$ .102	.200
12	28	1.407 $\pm$ .558	1.300	42	.571 $\pm$ .280	.600
13	28	.425 $\pm$ .184	.500	42	.496 $\pm$ .126	.500
14	28	.914 $\pm$ .286	.900	28	.518 $\pm$ .549	.400
15	28	1.115 $\pm$ .370	1.150	35	.932 $\pm$ .451	.850
16	28	.807 $\pm$ .236	.800	35	.768 $\pm$ .231	.700
17	28	.507 $\pm$ .146	.500	35	.293 $\pm$ .546	.200
18	28	.850 $\pm$ .252	.900	42	.786 $\pm$ .363	.600
19	28	.679 $\pm$ 1.047	.500	42	.293 $\pm$ .184	.300
20	28	.143 $\pm$ .092	.100	42	.089 $\pm$ .110	.050
21	28	.929 $\pm$ .269	1.000	42	.421 $\pm$ .484	.300
22	28	.271 $\pm$ .146	.300	42	.064 $\pm$ .087	.000
24	28	.475 $\pm$ .132	.400	42	.107 $\pm$ .127	.100
25	28	.696 $\pm$ .282	.700	42	.607 $\pm$ .180	.550
26	28	.164 $\pm$ .202	.100	42	.068 $\pm$ .106	.050
27	28	.421 $\pm$ .123	.400	42	.582 $\pm$ .205	.550
28	28	.743 $\pm$ .283	.800	42	.679 $\pm$ .274	.650
29	28	.225 $\pm$ .201	.200	49	1.129 $\pm$ .413	1.050
30	28	.179 $\pm$ .123	.200	42	.118 $\pm$ .139	.050
31	28	.618 $\pm$ .236	.600	36	.675 $\pm$ .318	.600
32	28	.375 $\pm$ .108	.350	49	1.264 $\pm$ .257	1.200

**Note:** Sample 23 was not measured because of too high variation of alignment.  
: n = figures of letter measurement in each subject

In the descriptive data from **alignment** measurement, there were 5-10 subjects that mean and median from accustomed handwritten were similar to unaccustomed handwritten. In subjects that were not similar, mean and median from unaccustomed handwritten compared to accustomed handwritten were **decreased**.

**Table 4.2** Description of data from height measurement (unit: mm.)

Subjects	Accustomed hand			Unaccustomed hand		
	n	Mean $\pm$ SD	Median	n	Mean $\pm$ SD	Median
1	16	2.544 $\pm$ .276	2.550	52	2.800 $\pm$ .371	2.700
2	16	2.689 $\pm$ .269	2.700	52	3.231 $\pm$ .394	3.250
3	16	1.825 $\pm$ .1488	1.850	48	2.456 $\pm$ .449	2.600
4	16	2.375 $\pm$ .536	2.200	16	4.144 $\pm$ .676	4.200
5	16	2.637 $\pm$ .470	2.550	40	4.156 $\pm$ 1.073	3.950
6	16	2.387 $\pm$ .395	2.400	20	4.275 $\pm$ .478	4.350
7	16	3.031 $\pm$ .296	3.100	40	3.237 $\pm$ .422	3.300
8	16	2.469 $\pm$ .236	2.450	32	3.937 $\pm$ .652	4.100
9	16	2.812 $\pm$ .186	2.850	36	3.269 $\pm$ .436	3.200
10	16	2.769 $\pm$ .309	2.750	20	3.194 $\pm$ .525	3.200
11	16	2.894 $\pm$ .315	2.950	24	3.044 $\pm$ .426	2.950
12	16	3.550 $\pm$ .483	3.600	24	2.881 $\pm$ .468	2.750
13	16	2.387 $\pm$ .424	2.300	24	3.319 $\pm$ .475	3.450
14	16	2.306 $\pm$ .295	2.350	16	2.350 $\pm$ .418	2.300
15	16	2.912 $\pm$ .486	2.950	24	3.194 $\pm$ .750	3.200
16	16	2.706 $\pm$ .387	2.800	20	2.656 $\pm$ .408	2.700
17	16	1.662 $\pm$ .182	1.650	20	2.725 $\pm$ .326	2.750
18	16	2.137 $\pm$ .287	2.100	24	2.319 $\pm$ .444	2.300
19	16	2.594 $\pm$ .202	2.600	20	3.906 $\pm$ .664	4.000
20	16	1.881 $\pm$ .259	1.950	24	2.750 $\pm$ .335	2.650
21	16	2.094 $\pm$ .1948	2.050	24	3.044 $\pm$ .419	2.950
22	16	2.719 $\pm$ .306	2.700	20	4.256 $\pm$ .611	4.100
23	16	3.637 $\pm$ .388	3.800	20	4.469 $\pm$ .939	4.250
24	16	2.275 $\pm$ .389	2.300	24	3.319 $\pm$ .390	3.400
25	16	2.244 $\pm$ .427	2.200	24	2.587 $\pm$ .463	2.600
26	16	2.625 $\pm$ .341	2.600	24	4.012 $\pm$ .528	4.100
27	16	2.312 $\pm$ .419	2.200	24	2.069 $\pm$ .320	2.150
28	16	3.294 $\pm$ .460	3.300	24	3.056 $\pm$ .418	3.000
29	16	2.550 $\pm$ .151	2.600	28	3.087 $\pm$ .577	3.050
30	16	2.831 $\pm$ .265	2.950	24	3.225 $\pm$ .371	3.300
31	16	3.494 $\pm$ .286	3.500	24	3.956 $\pm$ .571	3.850
32	16	2.225 $\pm$ .252	2.200	24	2.044 $\pm$ .391	2.000

**Note:** n = figures of letter measurement in each subject

In the descriptive data from **height** measurement, there were 5-10 subjects that mean and median from accustomed handwritten were similar to unaccustomed handwritten. In subjects that were not similar, mean and median from unaccustomed handwritten compared to accustomed handwritten were **increased**.

**Table 4.3** Data description of data population from size of letter [normal] measurement (unit: mm.)

Subjects	Accustomed hand			Unaccustomed hand		
	n	Mean $\pm$ SD	Median	n	Mean $\pm$ SD	Median
1	24	1.971 $\pm$ .555	1.950	137	2.212 $\pm$ .397	2.200
2	24	2.025 $\pm$ .225	2.000	138	2.075 $\pm$ .511	2.150
3	24	2.571 $\pm$ .344	2.550	132	2.092 $\pm$ .405	2.000
4	24	2.000 $\pm$ .463	2.100	24	3.883 $\pm$ 1.000	3.850
5	24	2.637 $\pm$ .345	2.500	60	3.712 $\pm$ .748	3.550
6	24	1.862 $\pm$ .447	1.900	30	4.254 $\pm$ .946	4.250
7	24	3.254 $\pm$ .399	3.200	60	2.921 $\pm$ .609	2.800
8	24	2.754 $\pm$ .455	2.950	48	3.617 $\pm$ .924	3.500
9	24	2.337 $\pm$ .202	2.350	54	2.029 $\pm$ .424	2.050
10	24	2.429 $\pm$ .427	2.400	30	2.479 $\pm$ .512	2.450
11	24	2.196 $\pm$ .492	2.250	36	2.629 $\pm$ .450	2.500
12	24	2.392 $\pm$ .555	2.200	36	2.287 $\pm$ .440	2.200
13	24	2.256 $\pm$ .525	2.350	36	2.708 $\pm$ .522	2.650
14	24	2.550 $\pm$ .356	2.500	24	2.371 $\pm$ .287	2.300
15	24	1.837 $\pm$ .442	1.750	36	2.162 $\pm$ .477	2.200
16	24	2.312 $\pm$ .347	2.300	30	2.096 $\pm$ .334	2.150
17	24	1.929 $\pm$ .235	2.000	30	2.125 $\pm$ .372	2.100
18	24	2.171 $\pm$ .315	2.100	36	2.087 $\pm$ .463	2.000
19	24	2.133 $\pm$ .450	2.200	36	2.321 $\pm$ .448	2.300
20	24	2.254 $\pm$ .331	2.150	36	2.242 $\pm$ .450	2.200
21	24	1.871 $\pm$ .192	1.900	36	2.400 $\pm$ .419	2.300
22	24	2.946 $\pm$ .373	2.900	36	3.496 $\pm$ .546	3.500
23	24	3.333 $\pm$ .523	3.350	36	3.012 $\pm$ .510	3.000
24	24	2.171 $\pm$ .331	2.200	36	2.608 $\pm$ .348	2.750
25	24	2.308 $\pm$ .483	2.400	36	2.462 $\pm$ 2.284	2.100
26	24	2.129 $\pm$ .315	2.150	36	2.962 $\pm$ .511	3.000
27	24	1.712 $\pm$ .251	1.700	30	1.958 $\pm$ .322	2.000
28	24	1.966 $\pm$ .456	2.300	36	2.129 $\pm$ .457	2.100
29	24	1.700 $\pm$ .299	1.750	42	1.754 $\pm$ .539	1.900
30	24	2.121 $\pm$ .402	2.100	36	2.133 $\pm$ .389	2.050
31	24	2.129 $\pm$ .421	2.100	36	2.312 $\pm$ .410	2.250
32	24	1.808 $\pm$ .243	1.850	36	1.779 $\pm$ .394	1.750

**Note:** n = figures of letter measurement in each subject

In the descriptive data from **size of letter [normal]** measurement, there were 10-15 subjects that mean and median from accustomed handwritten were similar to unaccustomed handwritten. In subjects that were not similar, mean and median from most of unaccustomed handwritten compared to accustomed handwritten were **increased**.

**Table 4.4** Description of data from size of letter [narrow] measurement (unit: mm.)

Subjects	Accustomed hand			Unaccustomed hand		
	n	Mean $\pm$ SD	Median	n	Mean $\pm$ SD	Median
1	12	1.225 $\pm$ .238	1.200	69	1.258 $\pm$ .334	1.300
2	12	1.517 $\pm$ .266	1.650	69	1.550 $\pm$ .294	1.500
3	12	1.633 $\pm$ .489	1.650	66	1.525 $\pm$ .400	1.500
4	12	1.558 $\pm$ .476	1.400	12	2.350 $\pm$ .505	2.450
5	12	2.175 $\pm$ .377	2.150	25	2.525 $\pm$ .638	2.350
6	12	1.658 $\pm$ .562	1.500	15	2.725 $\pm$ .540	2.700
7	12	2.558 $\pm$ .450	2.600	30	2.275 $\pm$ .409	2.250
8	12	1.908 $\pm$ .193	1.950	24	2.400 $\pm$ .517	2.450
9	12	1.641 $\pm$ .274	1.700	25	1.542 $\pm$ .261	1.500
10	12	1.517 $\pm$ .374	1.550	15	1.842 $\pm$ .789	1.600
11	12	1.383 $\pm$ .175	1.350	18	1.683 $\pm$ .248	1.600
12	12	1.750 $\pm$ .493	1.800	18	1.842 $\pm$ .387	1.800
13	12	1.667 $\pm$ .389	1.600	18	1.742 $\pm$ .363	1.700
14	12	1.992 $\pm$ .537	1.800	12	1.450 $\pm$ .582	1.100
15	12	1.325 $\pm$ .362	1.400	18	1.417 $\pm$ .361	1.500
16	12	1.733 $\pm$ .320	1.700	15	1.392 $\pm$ .257	1.450
17	12	1.433 $\pm$ .227	1.400	15	1.408 $\pm$ .243	1.450
18	12	1.442 $\pm$ .261	1.300	18	1.408 $\pm$ .235	1.400
19	12	1.350 $\pm$ .188	1.350	18	1.775 $\pm$ .558	1.650
20	12	1.575 $\pm$ .191	1.600	18	1.683 $\pm$ .252	1.750
21	12	1.433 $\pm$ .360	1.450	18	1.558 $\pm$ .271	1.550
22	12	2.092 $\pm$ .472	2.000	18	2.358 $\pm$ .348	2.300
23	12	2.175 $\pm$ .407	2.100	18	2.042 $\pm$ .278	2.000
24	12	1.800 $\pm$ .372	1.700	18	1.667 $\pm$ .144	1.700
25	12	1.617 $\pm$ .455	1.500	18	1.250 $\pm$ .151	1.200
26	12	1.542 $\pm$ .378	1.550	18	2.167 $\pm$ .367	2.000
27	12	1.158 $\pm$ .138	1.100	15	1.325 $\pm$ .238	1.400
28	12	1.442 $\pm$ .247	1.450	18	1.483 $\pm$ .364	1.450
29	12	1.208 $\pm$ .131	1.200	21	1.283 $\pm$ .388	1.250
30	12	1.392 $\pm$ .162	1.400	18	1.575 $\pm$ .317	1.500
31	12	1.583 $\pm$ .295	1.450	18	1.658 $\pm$ .202	1.650
32	12	1.408 $\pm$ .215	1.400	18	1.142 $\pm$ .162	1.200

**Note:** n = figures of letter measurement in each subject

In the descriptive data from **size of letter [narrow]** measurement, there were 15-20 subjects that mean and median data from accustomed handwritten were similar to unaccustomed handwritten. In subjects that were not similar, mean and median from most of unaccustomed handwritten compared to accustomed handwritten were **increased**.

**Table 4.5** Description of data from size of letter [wide] measurement (unit: mm.)

Subjects	Accustomed hand			Unaccustomed hand		
	n	Mean $\pm$ SD	Median	n	Mean $\pm$ SD	Median
1	8	3.171 $\pm$ .221	3.200	46	3.800 $\pm$ .432	3.800
2	8	2.943 $\pm$ .251	3.000	46	3.786 $\pm$ .694	4.000
3	8	3.571 $\pm$ .138	3.500	44	3.714 $\pm$ .460	3.600
4	8	2.900 $\pm$ .673	2.700	8	6.271 $\pm$ 1.151	6.000
5	8	4.014 $\pm$ .449	4.200	20	6.200 $\pm$ 1.355	6.100
6	8	3.000 $\pm$ .351	3.000	10	7.529 $\pm$ .848	7.800
7	8	5.371 $\pm$ .229	5.400	20	5.029 $\pm$ .453	5.100
8	8	4.857 $\pm$ .399	4.900	15	5.629 $\pm$ 1.307	5.800
9	8	3.257 $\pm$ .151	3.200	18	3.171 $\pm$ .377	3.000
10	8	3.243 $\pm$ .369	3.200	10	3.986 $\pm$ .835	4.200
11	8	3.714 $\pm$ .285	3.700	12	4.086 $\pm$ .267	4.100
12	8	3.329 $\pm$ .377	3.300	12	3.971 $\pm$ .335	4.000
13	8	3.543 $\pm$ .369	3.500	12	3.886 $\pm$ .505	4.000
14	8	4.029 $\pm$ .616	4.100	8	3.543 $\pm$ .556	3.400
15	8	3.071 $\pm$ 1.110	2.600	12	3.543 $\pm$ .544	3.600
16	8	3.300 $\pm$ .191	3.300	10	3.614 $\pm$ .452	3.400
17	8	3.057 $\pm$ .299	3.100	10	3.529 $\pm$ .325	3.500
18	8	3.914 $\pm$ .353	3.900	12	3.257 $\pm$ .378	3.300
19	8	4.000 $\pm$ .432	3.900	12	4.100 $\pm$ .337	4.100
20	8	3.343 $\pm$ .181	3.400	12	3.714 $\pm$ .273	3.800
21	8	3.057 $\pm$ .276	2.900	12	4.200 $\pm$ .775	4.100
22	8	4.386 $\pm$ .168	4.400	12	6.343 $\pm$ .476	6.300
23	8	5.500 $\pm$ .321	5.400	12	4.943 $\pm$ .787	4.700
24	8	3.660 $\pm$ .199	3.700	12	4.643 $\pm$ .529	4.600
25	8	3.500 $\pm$ .173	3.500	12	3.229 $\pm$ 1.281	3.700
26	8	3.643 $\pm$ .431	3.700	12	4.814 $\pm$ .647	4.600
27	8	2.857 $\pm$ .431	2.700	10	3.500 $\pm$ .656	3.400
28	8	3.800 $\pm$ .252	3.900	12	3.629 $\pm$ .867	3.900
29	8	2.800 $\pm$ .277	2.700	14	3.642 $\pm$ .725	4.000
30	8	3.457 $\pm$ .299	3.500	12	3.771 $\pm$ .464	3.800
31	8	3.600 $\pm$ .361	3.500	12	3.900 $\pm$ .163	3.900
32	8	2.829 $\pm$ .180	2.800	12	3.043 $\pm$ .282	3.000

**Note:** n = figures of letter measurement in each subject

In the descriptive data from **size of letter [wide]** measurement, there were 5-10 subjects that mean and median from accustomed handwritten were similar to unaccustomed handwritten. In subjects that were not similar, mean and median from most of unaccustomed handwritten compared to accustomed handwritten were **increased**.

**Table 4.6** Description of data from space measurement (unit:mm.)

Subjects	Accustomed hand			Unaccustomed hand		
	n	Mean $\pm$ SD	Median	n	Mean $\pm$ SD	Median
1	24	.467 $\pm$ .195	.500	132	.200 $\pm$ .267	.100
2	24	.612 $\pm$ .225	.600	144	.400 $\pm$ .345	.300
3	24	.237 $\pm$ .164	.250	132	.187 $\pm$ .213	.150
4	24	.896 $\pm$ .365	1.000	24	1.029 $\pm$ .630	1.000
5	24	.683 $\pm$ .263	.600	60	.671 $\pm$ .443	.550
6	24	.700 $\pm$ .353	.800	30	1.083 $\pm$ .493	1.100
7	24	.825 $\pm$ .314	.800	60	.708 $\pm$ .726	.500
8	24	.550 $\pm$ .219	.550	30	.787 $\pm$ .408	.700
9	24	.233 $\pm$ .137	.200	54	.079 $\pm$ .110	.100
10	24	.483 $\pm$ .140	.500	30	.354 $\pm$ .348	.300
11	24	.308 $\pm$ .181	.300	36	.308 $\pm$ .206	.300
12	24	.279 $\pm$ .308	.200	42	1.167 $\pm$ 1.639	.500
13	24	.614 $\pm$ .351	.600	36	.229 $\pm$ .301	.100
14	24	.250 $\pm$ .280	.200	24	.337 $\pm$ .169	.300
15	24	.446 $\pm$ .309	.450	36	.333 $\pm$ .274	.350
16	24	.325 $\pm$ .217	.300	30	.333 $\pm$ .223	.300
17	24	.312 $\pm$ .185	.300	36	.137 $\pm$ .141	.100
18	24	.475 $\pm$ .203	.500	36	.442 $\pm$ .255	.400
19	24	.529 $\pm$ .178	.500	36	.212 $\pm$ .175	.200
20	24	.592 $\pm$ .172	.600	36	.246 $\pm$ .156	.250
21	24	.642 $\pm$ .204	.700	36	.459 $\pm$ .193	.400
22	24	.946 $\pm$ .174	.900	36	.867 $\pm$ .268	.900
23	24	.962 $\pm$ .258	1.000	36	.904 $\pm$ 1.118	.650
24	24	.650 $\pm$ .182	.700	36	.637 $\pm$ .253	.650
25	24	.671 $\pm$ .137	.650	36	.458 $\pm$ .156	.450
26	24	.725 $\pm$ .353	.700	36	.462 $\pm$ .243	.450
27	24	.375 $\pm$ .202	.350	36	.342 $\pm$ .228	.350
28	24	.408 $\pm$ .267	.350	36	.212 $\pm$ .203	.200
29	24	.458 $\pm$ .167	.500	42	.342 $\pm$ .323	.250
30	24	.329 $\pm$ .163	.400	36	.375 $\pm$ .145	.350
31	24	.346 $\pm$ .159	.350	36	.400 $\pm$ .191	.400
32	24	.475 $\pm$ .151	.500	36	.450 $\pm$ .200	.400

**Note:** n = figures of letter measurement in each subject

In the descriptive data from **space** measurement, there were 10-15 subjects that mean and median from accustomed handwritten were similar to unaccustomed handwritten. In subjects that were not similar, mean and median from most of unaccustomed handwritten compared to accustomed handwritten were **decreased**.

**Table 4.7** Data description of data population from slant measurement (unit: degree)

Subjects	Accustomed hand			Unaccustomed hand		
	n	Mean $\pm$ SD	Median	n	Mean $\pm$ SD	Median
1	16	93.037 $\pm$ 3.800	92.550	92	97.531 $\pm$ 6.140	96.200
2	16	93.087 $\pm$ 2.492	93.550	92	94.181 $\pm$ 7.531	93.900
3	16	91.269 $\pm$ 3.179	91.200	88	92.456 $\pm$ 11.692	92.450
4	16	65.000 $\pm$ 4.655	63.550	24	91.600 $\pm$ 11.481	89.750
5	16	87.212 $\pm$ 3.919	88.300	40	91.450 $\pm$ 4.760	93.250
6	16	61.375 $\pm$ 16.281	64.900	20	91.550 $\pm$ 10.518	97.750
7	16	83.275 $\pm$ 4.615	83.500	40	93.144 $\pm$ 7.075	94.900
8	16	97.156 $\pm$ 2.765	97.100	32	92.974 $\pm$ 5.697	94.800
9	16	92.206 $\pm$ 2.295	91.350	40	91.562 $\pm$ 4.829	92.350
10	16	92.937 $\pm$ 4.312	93.000	20	83.125 $\pm$ 8.609	83.000
11	16	90.000 $\pm$ 4.179	90.000	24	92.625 $\pm$ 3.324	92.500
12	16	73.062 $\pm$ 8.706	71.000	24	77.625 $\pm$ 8.671	76.500
13	16	82.687 $\pm$ 7.012	84.500	24	90.000 $\pm$ 7.933	87.000
14	16	86.000 $\pm$ 3.055	85.000	16	86.500 $\pm$ 3.033	86.500
15	16	85.375 $\pm$ 4.193	85.000	24	88.187 $\pm$ 3.674	88.000
16	16	89.750 $\pm$ 2.145	89.000	16	90.625 $\pm$ 5.110	91.500
17	16	97.062 $\pm$ 4.864	95.000	20	90.812 $\pm$ 2.136	90.000
18	16	90.687 $\pm$ 2.869	90.000	24	76.437 $\pm$ 5.378	76.000
19	16	92.687 $\pm$ 2.469	93.000	24	91.187 $\pm$ 4.693	92.000
20	16	85.812 $\pm$ 2.428	86.500	24	93.625 $\pm$ 2.029	93.500
21	16	72.437 $\pm$ 2.220	72.000	24	88.312 $\pm$ 4.143	89.000
22	16	89.937 $\pm$ 2.542	89.500	24	89.750 $\pm$ 2.490	90.000
23	16	93.687 $\pm$ 3.135	93.000	24	90.500 $\pm$ 3.966	90.000
24	16	83.625 $\pm$ 5.702	83.500	24	91.000 $\pm$ 2.476	91.000
25	16	86.437 $\pm$ 4.690	87.500	24	98.187 $\pm$ 6.210	98.000
26	16	90.562 $\pm$ 2.780	90.000	20	90.812 $\pm$ 1.905	91.000
27	16	68.312 $\pm$ 4.643	67.000	24	90.750 $\pm$ 5.961	91.000
28	16	85.687 $\pm$ 2.701	86.000	24	89.750 $\pm$ 3.493	89.500
29	16	91.375 $\pm$ 1.708	91.000	28	92.562 $\pm$ 3.614	92.000
30	16	91.375 $\pm$ 3.667	91.000	24	94.187 $\pm$ 4.943	93.000
31	16	87.312 $\pm$ 2.089	88.000	24	92.125 $\pm$ 5.987	91.000
32	16	92.062 $\pm$ 2.112	92.000	24	91.562 $\pm$ 3.119	92.500

**Note:** n = figures of letter measurement in each subject

In the descriptive data from **slant** measurement, there were 10-15 subjects that mean and median from accustomed handwritten were similar to unaccustomed handwritten. In subjects that were not similar, mean and median from most of unaccustomed handwritten compared to accustomed handwritten were **increased**.

## 4.2 Test of normality

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

## 4.3 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

$\mu_a$  = data population mean of each feature that measure from accustomed handwritten.

$\mu_u$  = data population mean of each feature that measure from unaccustomed handwritten.

The results of mean difference for each feature were shown in **Tables 4.8-4.14**.

**Table 4.8** T-test and Mann-Witney test of data from alignment measurement

Independent t- test					Mann-Whitney test			
Subjects	n	Mean Difference	t	p-value	Subjects	n	z	p-value
3	182	-.112	-1.760	.080	1	189	-2.190	.029
4	56	1.571	9.528	.000	2	189	-.483	.629
5	98	.215	3.169	.002	6	63	-6.018	.000
7	98	.319	4.861	.000	14	56	-4.652	.000
8	84	.068	1.058	.293	15	63	-2.215	.027
9	91	-.130	-3.644	.000	17	63	-5.267	.000
10	63	.173	2.259	.027	18	70	-.188	.851
11	70	.629	16.103	.000	19	70	-4.304	.000
12	70	.747	6.504	.000	20	70	-3.584	.000
13	70	-.039	-.919	.361	21	70	-5.986	.000
16	63	-.064	-.692	.492	22	70	-4.971	.000
28	70	-.0167	-.235	.815	24	70	-6.892	.000
31	64	-.046	-.629	.531	25	70	-.812	.417
					26	70	-3.342	.001
					27	70	-2.940	.003
					29	77	-5.564	.000
					30	70	-1.310	.190
					32	77	-6.848	.000

**Note:** n = figures of letter measurement in each subject

There were 13 of 31 subjects (41.93%) that mean of data population from accustomed and unaccustomed handwrittens were not significant different.

**Table 4.9** T-test and Mann-Whitney test of data from height measurement

Independent t- test					Mann-Whitney test			
Subjects	n	Mean Difference	t	p-value	Subjects	n	z	p-value
1	68	-.360	-3.189	.002	5	46	-5.494	.000
2	68	-.711	-6.121	.000	23	36	-3.464	.001
3	64	-.500	-7.150	.000				
4	32	-1.769	-8.199	.000				
6	36	-1.837	-10.921	.000				
7	56	-.391	-2.778	.008				
8	48	-1.553	-11.390	.000				
9	52	-.321	-3.431	.001				
10	36	-.406	-2.871	.007				
11	40	-.156	-1.328	.192				
12	40	.608	3.766	.001				
13	40	-1.000	-7.097	.000				
14	32	-.044	-.342	.735				
15	40	-.346	-1.753	.088				
16	36	.111	.856	.398				
17	36	-1.007	-10.309	.000				
18	40	-.187	-1.398	.170				
19	36	-1.336	-8.613	.000				
20	40	-.894	-9.272	.000				
21	40	-.990	-10.653	.000				
22	36	1.446	-8.928	.000				
24	40	-1.021	-8.617	.000				
25	40	-.348	-2.523	.016				
26	40	-1.592	-8.373	.000				
27	40	.100	.726	.472				
28	40	.215	1.604	.117				
29	44	.131	-4.883	.000				
30	40	-.352	-3.167	.003				
31	40	-.410	-2.818	.008				
32	40	.233	2.152	.038				

**Note:** n = figures of letter measurement in each subject

There were 9 of 32 subjects (28.12%) that mean of data population from accustomed and unaccustomed handwrittens were not significant different.

**Table 4.10** T-test and Mann-Witney test of data from size [normal] measurement

Independent t- test					Mann-Whitney test			
Subjects	n	Mean Difference	t	P-value	Subjects	n	z	P-value
1	161	-.160	-1.470	.144	8	72	-4.362	.000
2	162	-.077	-1.233	.222	25	60	-2.399	.016
3	156	.515	6.012	.000				
4	48	-1.883	-8.369	.000				
5	84	-1.149	-8.645	.000				
6	54	-2.367	-11.772	.000				
7	84	.197	1.430	.156				
9	78	.204	2.853	.006				
10	54	-.017	-.141	.888				
11	60	-.387	-3.236	.002				
12	60	.083	.631	.531				
13	60	-.372	-2.611	.011				
14	48	.179	1.919	.061				
15	60	-.382	-2.746	.008				
16	54	.192	1.835	.072				
17	54	-.217	-2.408	.020				
18	60	.126	1.102	.275				
19	60	-.203	-1.812	.075				
20	60	.026	.263	.794				
21	60	-.532	-6.209	.000				
22	60	-.515	-4.445	.000				
23	60	.328	2.416	.019				
24	60	-.501	-5.297	.000				
26	60	-.921	-8.486	.000				
27	54	-.254	-3.186	.002				
28	60	.053	.443	.659				
29	66	-.014	-.135	.893				
30	60	-.037	-.321	.750				
31	60	-.204	-1.936	.058				
32	60	.047	.525	.602				

**Note:** n = figures of letter measurement in each subject

There were 19 of 32 subjects (59.37%) that mean of data population from accustomed and unaccustomed handwrittens were not significant different.

**Table 4.11** T-test and Mann-Whitney test of data from size [narrow] measurement

Independent t- test					Mann-Whitney test			
Subjects	n	Mean Difference	t	P-value	Subjects	n	z	P-value
1	81	-.110	-.895	.373	14	33	-2.347	.019
2	81	.053	.517	.607				
3	78	.159	1.337	.185				
4	24	-.792	-3.951	.001				
5	37	-.525	-2.335	.025				
6	27	-1.122	-4.883	.000				
7	32	.365	1.998	.053				
8	36	-.517	-2.826	.008				
9	37	.146	1.462	.153				
10	27	-.230	-.982	.335				
11	30	-.317	-3.675	.001				
12	30	-.061	-.403	.690				
13	30	-.056	-.429	.671				
15	30	-.097	-.691	.495				
16	27	.333	3.069	.005				
17	27	.067	.660	.515				
18	30	.053	.554	.584				
19	30	-.422	-3.214	.004				
20	30	-.064	-.800	.430				
21	30	-.200	-1.683	.103				
22	30	-.214	-1.493	.147				
23	30	.086	.654	.519				
24	30	.067	.624	.538				
25	30	.378	2.749	.016				
26	30	-.581	-4.419	.000				
27	27	-.155	-2.125	.044				
28	30	-.064	-.569	.574				
29	33	.018	.171	.865				
30	30	-.103	-1.107	.278				
31	30	-.033	-.374	.711				
32	30	.219	2.961	.006				

**Note:** n = figures of letter measurement in each subject

There were 24 of 32 subjects (75%) that mean of data population from accustomed and unaccustomed handwrittens were not significant different.

**Table 4.12** T-test and Mann-Whitney test of data from size [wide] measurement

Independent t- test					Mann-Whitney test			
Subjects	n	Mean Difference	t	P-value	Subjects	n	z	P-value
1	54	-.491	-2.043	.046	32	20	-1.997	.046
2	54	-.608	-2.505	.015				
3	52	.102	1.141	.260				
4	16	-3.212	-6.896	.000				
5	28	-2.202	-5.507	.000				
6	18	-4.380	-11.220	.000				
7	28	.237	1.001	.326				
8	23	-1.188	-2.740	.012				
9	26	.008	.049	.962				
10	18	-.615	-2.188	.044				
11	20	-.375	-2.654	.016				
12	20	-.737	-2.194	.042				
13	20	-.204	-1.083	.293				
14	16	.675	2.098	.055				
15	20	-.408	-1.145	.267				
16	18	-.400	-2.473	.025				
17	18	-.380	-2.362	.031				
18	34	.608	3.950	.001				
19	34	-.146	-.916	.372				
20	34	-.229	-1.924	.070				
21	34	-1.092	-4.986	.000				
22	34	-1.725	-8.492	.000				
23	34	.837	3.005	.008				
24	34	-.921	-5.194	.000				
25	34	-.083	-.205	.840				
26	34	-1.179	-5.168	.000				
27	18	-.730	-3.047	.008				
28	20	.179	.722	.481				
29	22	-.655	-3.162	.005				
30	20	-.371	-2.235	.038				
31	20	-.083	-.554	.587				

**Note:** n = figures of letter measurement in each subject

There were 21 of 32 subjects (65.62%) that mean of data population from accustomed and unaccustomed handwrittens were not significant different.

**Table 4.13** T-test and Mann-Whitney test of data from space measurement

Independent t- test					Mann-Whitney test			
Subjects	n	Mean Difference	t	P-value	Subjects	n	z	P-value
2	168	.159	2.675	.008	1	156	-3.194	.001
5	84	.008	.101	.920	3	156	-1.525	.127
6	54	-.283	-2.217	.031	4	48	-.755	.450
8	54	-.187	-1.989	.052	7	84	-2.604	.009
11	60	.031	.595	.554	9	78	-3.432	.001
15	60	.049	.459	.648	10	54	-2.220	.026
16	54	-.065	-.961	.341	12	66	-1.832	.067
18	60	.047	.763	.448	13	60	-3.608	.000
19	60	.257	4.534	.000	14	48	-1.502	.133
21	60	.158	2.770	.008	17	60	-3.612	.000
22	60	.168	2.581	.012	20	60	-5.131	.000
24	60	.003	.048	.962	23	60	-2.838	.005
25	60	.240	5.196	.000	26	60	-2.616	.009
27	60	-.017	-.279	.781	28	60	-2.414	.016
32	60	-.014	-.274	.785	29	66	-.918	.359
					30	60	-.908	.364
					31	60	-.940	.347

**Note:** n = figures of letter measurement in each subject

There were 20 of 32 subjects (62.50%) that mean of data population from accustomed and unaccustomed handwrittens were not significant different.

**Table 4.14** T-test and Mann-Witney test of data from slant measurement

Independent t- test					Mann-Whitney test			
Subjects	n	Mean Difference	t	P-value	Subjects	n	z	P-value
1	108	3.407	-1.728	.087	5	56	-2.240	.025
2	108	.205	.201	.841	6	36	-5.095	.000
3	104	-3.536	-2.652	.010	9	56	-1.959	.050
4	40	-28.371	-12.071	.000	13	40	-2.153	.031
7	56	-11.915	-7.053	.000	18	40	-5.070	.000
8	48	4.097	2.777	.008	31	40	-4.034	.000
10	36	8.888	4.099	.000				
11	40	-2.42	-2.107	.042				
12	40	-5.854	-2.255	.030				
14	32	-.500	-.465	.646				
15	40	-3.292	-2.224	.032				
16	32	-.875	-.632	.535				
17	36	6.062	4.442	.000				
19	40	1.562	1.324	.193				
20	40	-7.271	-9.913	.000				
21	40	-15.771	-12.940	.000				
22	40	.562	.717	.478				
23	40	3.354	3.094	.004				
24	40	-7.125	-4.519	.000				
25	40	-10.604	-6.110	.000				
26	36	-.087	-.097	.923				
27	40	-22.021	-14.269	.000				
28	40	-5.604	-4.435	.000				
29	44	.911	.515	.609				
30	40	-2.292	-1.754	.088				
32	40	.937	.775	.443				

**Note:** n = figures of letter measurement in each subject

There were 16 of 32 subjects (50.00%) that mean of data population from accustomed and unaccustomed handwrittens were not significant different.

**Table 4.15** Similarity of accustomed and unaccustomed handwriting in each feature

Features	Similarity of accustomed and unaccustomed handwritings	
	Mean and Median (number of subjects)	t-test and Mann-Witney (%)
Size [narrow]	15-20	75.00
Size [ wide]	5-10	65.62
Space	10-15	62.50
Size [ normal]	10-15	59.37
Slant	10-15	50.00
Alignment	5-10	41.93
Height	5-10	28.12

#### 4.4 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

**4.4.1** Size [narrow] and size [wide] of accustomed handwritten and unaccustomed handwritten by the same person were not significant different. Number of subject that mean of data population were not significant different in each feature are presented in **Table 4.16**.

**Table 4.16** The figures of subjects with not significantly different means between two groups of population in two features examine

<b>Significant different</b>	<b>Size [narrow]</b>	<b>Size [wide]</b>	<b>Total</b>
No	24	21	<u>45</u>
Yes	8	11	19
Total	32	32	<u>64</u>

There was 70.31% that the examiner found size [narrow] and size [wide] of accustomed handwritten and unaccustomed handwritten by the same person were not significant different.

**4.4.2** Size [narrow], size [wide] and space of accustomed handwritten and unaccustomed handwritten by the same person were not significant different. Numbers of subject that mean of data population were not significant different present in **Table 4.17**.

**Table 4.17** The figures of subjects with not significantly different means between two groups of population in three features examine

<b>Significant different</b>	<b>Size [narrow]</b>	<b>Size [wide]</b>	<b>Space</b>	<b>Total</b>
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.

**4.4.3** Size [narrow], size [wide], space and size [normal] of accustomed handwritten and unaccustomed handwritten by the same person were not significant different. Numbers of subject that mean of data population were not significant different present in **Table 4.18**.

**Table 4.18** The figures of subjects with not significantly different means between two groups of population in four features examine

<b>Significant different</b>	<b>Size [narrow]</b>	<b>Size [wide]</b>	<b>Space</b>	<b>Size [normal]</b>	<b>Total</b>
No	24	21	20	19	<u>84</u>
Yes	8	11	12	13	44
Total	32	32	32	32	<u>128</u>

There was 65.62% that the examiner found size [narrow], size [wide], space and size [normal] of accustomed handwritten and unaccustomed handwritten by the same person were not significant different.

**4.4.4** Size [narrow], size [wide], space, size [normal] and slant of accustomed handwritten and unaccustomed handwritten by the same person were not significant different. Numbers of subject that mean of data population were not significant different present in **Table 4.19**.

**Table 4.19** The figures of subjects with not significantly different means between two groups of population in five features examine

<b>Significant different</b>	<b>Size [narrow]</b>	<b>Size [wide]</b>	<b>Space</b>	<b>Size [normal]</b>	<b>Slant</b>	<b>Total</b>
No	24	21	20	19	16	<u>100</u>
Yes	8	11	12	13	16	60
Total	32	32	32	32	32	<u>160</u>

There was 62.50% that the examiner found size [narrow], size [wide], space, size [normal] and slant of accustomed handwritten and unaccustomed handwritten by the same person were not significant different.

**4.4.5** Size [narrow], size [wide], space, size [normal], slant and alignment of accustomed handwritten and unaccustomed handwritten by the same person were not significant different. Numbers of subject that mean of data population were not significant different present in **Table 4.20**.

**Table 4.20** The figures of subjects with not significantly different means between two groups of population in six features examine

<b>Significant different</b>	<b>Size [narrow]</b>	<b>Size [wide]</b>	<b>Space</b>	<b>Size [normal]</b>	<b>Slant</b>	<b>Alignment</b>	<b>Total</b>
No	24	21	20	19	16	13	<u>113</u>
Yes	8	11	12	13	16	18	78
Total	32	32	32	32	32	31	<u>191</u>

There was 59.16% that the examiner found size [narrow], size [wide], space, size [normal], slant and alignment of accustomed handwritten and unaccustomed handwritten by the same person were not significant different.

**4.4.6** Size [narrow], size [wide], space, size [normal], slant, alignment and height of accustomed handwritten and unaccustomed handwritten by the same person were not significant different. Numbers of subject that mean of data population were not significant different present in **Table 4.21**.

**Table 4.21** The figures of subjects with not significantly different means between two groups of population in seven features examine

<b>Significant different</b>	<b>Size [narrow]</b>	<b>Size [wide]</b>	<b>Space</b>	<b>Size [normal]</b>	<b>Slant</b>	<b>Alignment</b>	<b>Height</b>	<b>Total</b>
No	24	21	20	19	16	13	9	<u>122</u>
Yes	8	11	12	13	16	18	23	101
Total	32	32	32	32	32	31	32	<u>223</u>

There was 54.71% that the examiner found size [narrow], size [wide], space, size [normal], slant, alignment and height of accustomed handwritten and unaccustomed handwritten by the same person were not significant different.

**Table 4.22** Probability found 1-7 features together in accustomed handwritten and unaccustomed handwritten by the same person

<b>Feature found together</b>	<b>Probability (%)</b>
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

## 4.5 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.

**4.6.1** Data description

**4.6.2** Test for normality distribution

**4.6.3** 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 4.23**. 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 4.24**. From **Table 4.24**, 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 4.23** The result of each handwriting feature examination 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

**Table 4.24** 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 4.25** Percentage of written question and known document of each suspect

Suspects	1	2	3
Percent	61.01	52.08	56.69

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

### 4.6.1 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.

#### **4.6.2 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.

##### **1. Size [narrow]**

##### **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.

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

#### **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.

#### **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.

#### **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

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

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

#### **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.

### **4.6.3 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.

## CHAPTER V

### 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.

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## **APPENDIX**

แบบสอบถามนี้เป็นส่วนหนึ่งของวิทยานิพนธ์ของนักศึกษาในโครงการ  
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มหาวิทยาลัยมหิดล

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กรุณาตอบคำถามโดยการกรอกข้อมูล หรือ ทำเครื่องหมาย / หน้าข้อความที่ตรงกับข้อมูลของท่าน

- เพศ  ชาย  หญิง
- อายุ(ปี)  20-25  41-45  
 26-30  46-60  
 31-35  มากกว่า 60  
 36-40
- ประสบการณ์สอน (ปี)
- 1-5  16-20  
 6-10  มากกว่า 20  
 11-15
- ท่านนัดเขียนด้วยมือข้างใด
- มือซ้าย  มือขวา

มีต่อหน้าถัดไป









Example of similar accustomed and unaccustomed handwritings

Accustomed handwriting

๑. ให้ห้พณาที่ตย์แอกทงเถ็ดนหอกฎาตมท้ะถิงห้คอกห้พ้ดมร้มีห้ดประอุมส้มมทห้ชหาทอเน้งชอ  
 ๒. ให้ห้พณาที่ตย์แอกทงเถ็ดนหอกฎาตมท้ะถิงห้คอกห้พ้ดมร้มีห้ดประอุมส้มมทห้ชหาทอเน้งชอ  
 ๓. ให้ห้พณาที่ตย์แอกทงเถ็ดนหอกฎาตมท้ะถิงห้คอกห้พ้ดมร้มีห้ดประอุมส้มมทห้ชหาทอเน้งชอ  
 ๔. ให้ห้พณาที่ตย์แอกทงเถ็ดนหอกฎาตมท้ะถิงห้คอกห้พ้ดมร้มีห้ดประอุมส้มมทห้ชหาทอเน้งชอ  
 ๕. ให้ห้พณาที่ตย์แอกทงเถ็ดนหอกฎาตมท้ะถิงห้คอกห้พ้ดมร้มีห้ดประอุมส้มมทห้ชหาทอเน้งชอ

Unaccustomed handwriting

๑. ให้ห้พณาที่ตย์แอกทงเถ็ดนหอกฎาตมท้ะถิงห้คอกห้พ้ดมร้มีห้ดประอุมส้มมทห้ชหาทอเน้งชอ  
 ๒. ให้ห้พณาที่ตย์แอกทงเถ็ดนหอกฎาตมท้ะถิงห้คอกห้พ้ดมร้มีห้ดประอุมส้มมทห้ชหาทอเน้งชอ  
 ๓. ให้ห้พณาที่ตย์แอกทงเถ็ดนหอกฎาตมท้ะถิงห้คอกห้พ้ดมร้มีห้ดประอุมส้มมทห้ชหาทอเน้งชอ  
 ๔. ให้ห้พณาที่ตย์แอกทงเถ็ดนหอกฎาตมท้ะถิงห้คอกห้พ้ดมร้มีห้ดประอุมส้มมทห้ชหาทอเน้งชอ  
 ๕. ให้ห้พณาที่ตย์แอกทงเถ็ดนหอกฎาตมท้ะถิงห้คอกห้พ้ดมร้มีห้ดประอุมส้มมทห้ชหาทอเน้งชอ



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