Statistical Examination of Common Characteristics for Disguised Handwriting amongst Malaysian

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ABSTRACT: This research presented a microscopic and statistical examination of handwriting characteristics. Two handwriting specimens were involved which are normal and disguised handwriting specimen forms. The normal handwriting of 60 respondents were examined and classified into class characteristic (script types, letter size, slant, angularity alignment and word spacing) and individual characteristic of letters "a", "e", "g", "y", "d", "f", "h", "o", "E" and "D" and grapheme "th". The other set of 50 handwritings were requested for comparison between disguised and normal handwritings. A statistical technique known as Pearson Chi-squared (χ^2) test was performed to determine the relationship between race, gender, age, first education system, education level and occupation with the normal habits of handwriting. The results showed that the handwriting can be uniquely classified (χ^2<0.05). Only alignment and word spacing were not affected. During disguising their own handwriting, respondents tend to change the letter size, slant, initial capital letter and the speed of the writing, while the word spacing became inconsistent.

Keywords: Questioned document, disguised handwriting, normal handwriting, class characteristics, individual characteristics

Introduction

Every individual's style of handwriting is unique and has its own personalized touch. Handwriting is a movement habit that is very strong and individual. It is a mixture of what we have been taught and our personality [1]. Handwritings fall into two general groups; class and individual characteristics. Class characteristics are actually common characteristics such as basic type of handwriting, slope of writing, line position and word spacing. The writing may result from such influences as the writing system studied, family associations and education [2].

Individual characteristics are extremely rare in handwriting. Such characteristics actually would be found in only one person's writing and would be practically the only factor necessary to identify the writer. Some people like an Italic writing while others prefer a rounder writing with more upright hand. Some keep to the copperplate-based cursive of their late school days while still others have developed a quick, practical, personal hand styles to suit their own needs [1].

Handwriting is very difficult to disguise and forge, making handwriting analysis an effective tool for incriminating a suspect. Handwriting examination relies upon a combination of principles used successfully for the past century, and techniques and technology that are at the leading edge of twenty first century. Common criminal charges involved in a document examination case include forgery, counterfeiting, identity theft, fraud or uttering a forged document. Many examinations in the document analysis involve a comparison of the questioned document or components of the document, to a set of known standards. The handwriting section of forensic science involves comparing and authentication of written documents such as ransom notes, diaries, forged contracts, checks, forged wills, fake identity cards and passports and any other form of writing or printed material.

Questioned documents are often important because documents are used in different contexts and purposes. 'Document' is defined in a very broad sense as being any material bearing marks, signs or symbols intended to convey a message or meaning to someone [3]. This encompasses traditional paper documents but also includes things like handwriting on the mirror, graffiti on a wall, marks on doors, windows or boards, stamp impressions on meat products, or covert markings hidden in a written letter and other things.

Proving disguised handwriting on a document is a problem faced by many document examiners. By

disguising handwriting, an individual may hope to disclaim it at a later date, so as to exonerate himself from any consequences that may be linked to the document. For example, he may disguise his handwriting to write ransom note or anonymous document and then claiming that the document is not written by him.

As there is a lack of statistical data or any database concerning the specific handwriting characteristics and the occurrence frequency of combinations of particular handwriting characteristics, the identification of handwriting and the examination of questioned document becomes a more difficult task. The forensic document examiners (FDEs) tend to assign the probative values to specific handwriting characteristics and their combinations while the judgments are often based almost entirely on their experience and power recall [4].

Since handwritings identification is a scientific pursuit, statistical data concerning handwritings characteristics seem to offer some promise for providing a basis for the opinions of FDEs. This research was therefore designed to establish the types and differences of class and individual characteristics of Malaysian handwritings, to distinguish between normal and disguised handwritings and as the result, a useful set of standardized data of handwritings characteristics is formed.

Experimental

Materials and Instrumentation

Two types of handwriting specimen; normal handwriting specimen and disguised handwriting specimen were obtained by requesting participants to copy a control passage provided in each handwriting specimen form for three times. There was different control passage for each specimen. Each control passage was typed onto a piece of unruled A4 white paper (Premium Multi-purpose paper, ePaper, 70 gsm, 210 mm x 297 mm). A pen of the same type, brand and color (Ballpoint pen, Papermate-Kilometrico 100, Blue, Medium) was provided for each participant. A stereomicroscope (Motic SM2168, China) equipped with camera and software (Motic Image plus Version 2.0) with the capability for image measurements and data processing was employed. A magnifying glass (2 times magnifications, 90 mm diameter, Balloon®, China) was used for handwriting examination. A digital camera (Nikon, D60, AF-S DX NIKKOR 18-55 mm f/3.5-5.6G VR, 10.2 megapixels, Thailand) was used to obtain an enlarge of the handwritings.

Participants

Participants were selected randomly amongst Malaysians of age range between 20 and 60 years old. Sixty respondents were selected for analysis of normal handwriting consisting of 20 participants of each racial groups; Malay, Chinese and Indian. Another set of 50 individuals amongst Malaysian were selected randomly for the comparison study between normal and disguised handwritings.

Sampling

The participants were seated together batch by batch in a comfortable condition to complete the handwriting specimens. The participants were requested to copy the control passages in the unlined space of the same make of paper using the pen provided. They were required to copy the passage for three times for each handwriting specimen forms. They were also required to copy the passage in front of a witness whenever possible to ensure that the writings were their normal handwriting. They were given about 30 minutes to complete each form and submitted for further analysis.

Microscopic Analysis

A stereomicroscope was used for comparison of handwriting characteristics. Handwriting specimens were imaged by camera attached to microscope and the images were analyzed and compared using software capability of the stereomicroscope. Certain measurements such as the height and width of an alphabet were measured using the software installed in the stereomicroscope.

Statistical Analysis

The numerical data obtained were treated statistically using SPSS® 10.0 (SPSS Inc.). Pearson Chi-squared (χ^2) test was applied to each handwriting characteristics in order to see the relationship between the details of respondents' background with the handwriting characteristics. Equation 1 was used to calculate the χ^2 value, where O_i is observed value; E_i is expected value and k is the number of sample size. Expected values were calculated by multiplying the sum of observed values for all possibly outcomes of characteristic by the sum of the observation in the respondents' handwritings. This value was then divided by the sample size, k.

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

Results and Discussion

Details of Respondents Background

Table 1 summarized the background in format of sixty respondents. This study involved 28 males and 32 females, which only 8 of them were above 40 years old. The age range of the other respondents was between 20 and 40 years. Most of them were educated at national government schools (36 persons).

Table 1: Respondents background

Background Life		M	C	I	Total
Gender	Male	11	9	8	28
	Female	9	11	12	32
Age	<30	10	13	15	38
	<40	5	6	3	14
	40 < x < 60	5	1	2	8
Education Level	SPM	7	7	7	21
	Diploma	4	3	4	11
	Degree	9	10	9	28
Initial Education System	National Education	18	9	9	36
	Chinese Education	0	11	0	11
	Indian Education	0	0	11	11
	Others	2	0	0	2
Handedness	Right	18	20	17	55
	Left	2	0	3	5
Occupation	Student	7	7	9	23
	Academic	7	7	2	16
	Non-academic	6	6	9	21

*M=Malay, C=Chinese, I=Indian

Common Characteristics of Normal Handwriting

In order to reveal the normal writing habits of Malaysians, respondents were required to copy a control passage for three times, thereby revealing the types of class characteristics and individual characteristics on the handwriting specimens (samples). Class characteristics were grouped into six basic categories; script types, letter size, slant, angularity, alignment and word spacing. All data gathered were presented in percentage (%) as tabulated in **Table 2**.

Table 2: Total number of respondents corresponds to normal handwriting characteristics

Handwriting Characteristics		Respondents	Percentage(%)
Script Types	Cursive	17	28.3
	Printed	16	26.7
	Mixed	27	45.0
Letter Size	Larger	4	6.7
	Medium	14	23.3
	Smaller	22	36.7
	Mixed	20	33.3
Slant	Upright	12	20.0
	Forward	20	33.3
	Backward	6	10.0
	Mixed	22	36.7
Angularity	Rounded	25	41.7
	Angular	17	28.3
	Mixed	18	30.0
Alignment	Horizontal	11	18.3
	Ascending	23	38.3
	Descending	7	11.7
	Mixed	19	31.7
Word Spacing	Consistent	24	40.0
	Inconsistent	36	60.0

Fig. 1 shows three characteristics of handwriting which show a different trend of writing habits amongst Malaysian. The study found that only 7% of the writers used large sized writing, 10% wrote with a backward slant and 12% of handwriting showed a descending alignment. The numbers make them as minority group and less pronounced, but yet very important characteristics as there were highly individualistic.

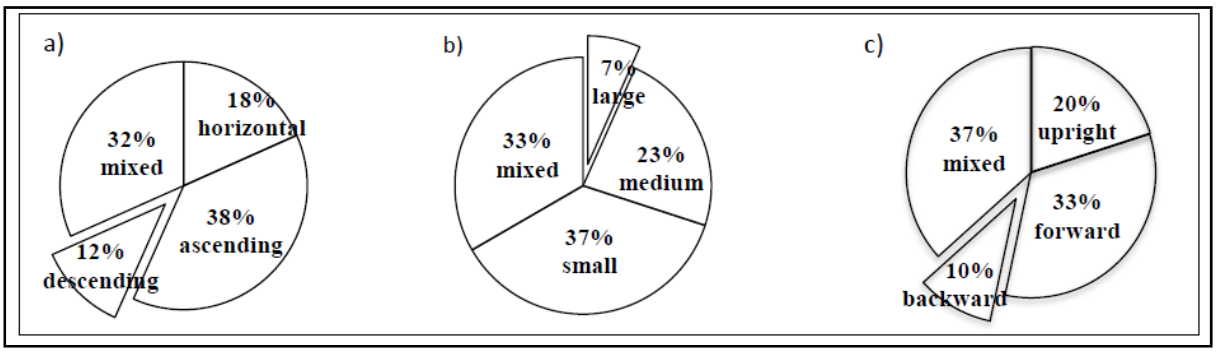

Fig. 1: Percentage of respondents with handwritings according to class characteristics of a) alignment, b) letter size and c) slant.

Common Letter Reoccur in Text

Individual characteristics of handwriting were studied based on the uniqueness of letters in the passage. Several letters were selected and categorized based on three groups which were lowercase letter, uppercase letter and grapheme. The letters studied were selected based on the frequency of occurrence in the text.

Formation of Lowercase Letter

Fig. 2 shows the percentage of respondents with handwritings according to the type of letter formation. Only 13.3% of the respondents were found to prefer writing continuous "a" and "e". This value is parallel with the numbers of writers who prefer cursive writing. However, the respondents were more interested with circular and angular shape of letter "a" and "e". The average of letter "a" written in circular and angular was similar, 43.3%. There was no significant difference between circular 'eye' (45.0%) and angular 'eye' (41.7%) of letter "e". This could be the consequence of the present education system in Malaysia where the used of cursive writing is not necessary. Furthermore, as foreign scripts such as Chinese and Urdu has been taught in Chinese and Indian schools, respecting the writing of English and Malay words could be affected.

Fig. 3 shows the percentage of respondents' handwriting according to the type of letter formation. The first category of letter "d" which is complete "d" upstroke retraced downward has highest percentage of respondents (65%) compared to other categories of letter "d". Percentage of respondents writing all of the four features of letter "f" might not differ significantly as the f-bar were generated unconsciously and will vary even within a person. Besides that, 41.7% of respondents displayed the formation of complete "h" downstroke retraced upward.

Letters "g" and "y" were selected to represent lower zone (descendent) letters. Each letter could be formed in at least five ways of formations and can be made with a single stroke or two. Most writers preferred incomplete "g" circle with cursive tail (31.7%) and complete "y" upstroke retraced downward with total percentage of 43.3% as shown in **Fig. 4**.

Formation of Capital Letter

Based on **Fig. 5**, 61.7% of respondents wrote the letter "E" with continuous stem with bottom bar. Only 3.3% preferred the letter "E" with continuous stem with top and bottom bar. Besides that, 46.7% of respondents like letter "D" with stem downstroke upward and combined with the circle, while only 1.7% interested with letter "D" which stem combined with the circle at the bottom.

Formation of Grapheme "th"

There only three types of "th" as discussed in this study which was continuous "th", t-bar and h-stem combine and t-bar and h-stem not combine. Based on Fig. 6, half of the respondents were interested to write "th" with t-bar not combine with the h-stem while only 1/6 respondents writing continuous "th".

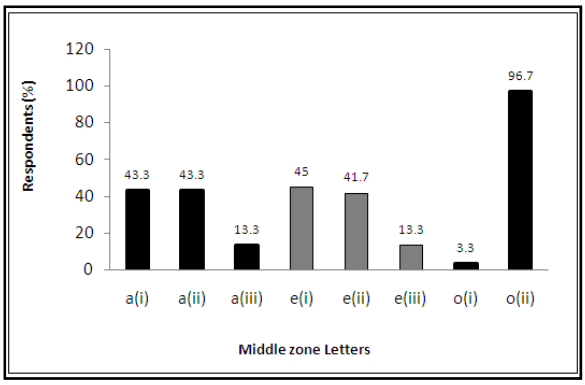

Fig. 2: Percentage of respondents with handwritings according to the middle zone letters: a(i) circular "a", a(ii) angular "a", a(iii) continuous "a", e(i) circular 'eye', e(ii) angular 'eye', e(iii) continuous "e", o(i) clockwise "o" and o(ii) anticlockwise "o".

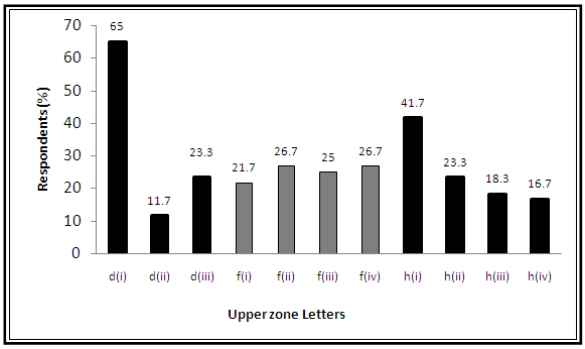

Fig. 3: Percentage of respondents according to the upper zone letters: d(i) complete "d" upstroke retraced downward, d(ii) continuous "d", d(iii) downstroke "d" retraced upward, f(i) continuous "f", f(ii) high f-bar, f(iii) low f-bar, f(iv) middle f-bar, h(i) complete "h" downstroke retraced upward, h(ii) incomplete "h" downstroke retraced upward, h(iii) continuous "h" and h(iv) "h" with short stem

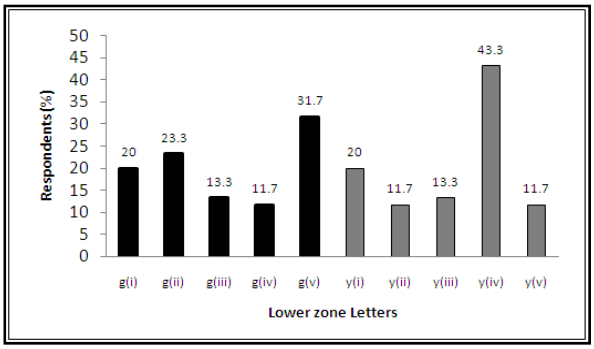

Fig. 4: Percentage of respondents according to the lower zone letters: g(i) circular 'eye', g(ii) incomplete circle/eye, g(iii) continuous "g", g(iv) "g" with extended tail, g(v) incomplete circle with cursive tail, y(i) "y" with straight tail, y(ii) continuous "y", y(iii) incomplete "y" upstroke retraced downward, y(iv) complete "y" upstroke retraced downward and y(v) "y" with extended tail

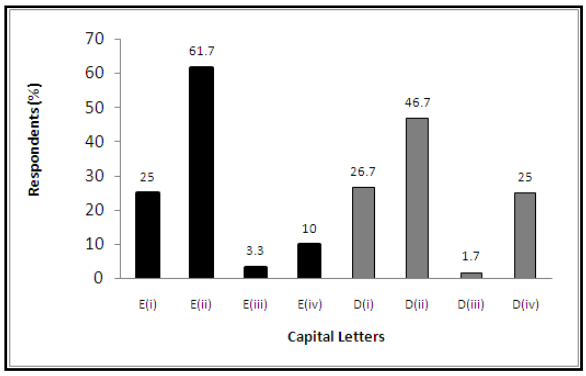

Fig. 5: Percentage of respondents according to the capital letters: E(i) stem and all bar not connected, E(ii) continuous stem with bottom bar, E(iii) continuous stem with top and bottom bar, E(iv) cursive "E", D(i) stem and the circle not combine, D(ii) stem downstroke upward and combine with the circle, D(iii) stem combine with the circle at the bottom and D(iv) coiled "D" at the bottom

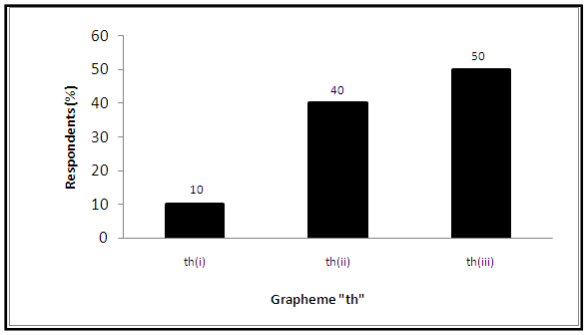

Fig. 6: Percentage of respondents according to the grapheme "th": th(i) continuous "th", th(ii) t-bar and h-stem combine and th(iii) t-bar and h-stem not combine.

Relationship between all Variables

Each characteristic studied in this research was statistically analyzed by using a Pearson Chi-squared (χ^2) test. Two tests were performed for both class and individual characteristics which were Homogeneity Test and Independent Test.

Homogeneity Test

Homogeneity test was carried out specifically for data by which one of them was fixed from the start. Handwriting specimens collected were based on the race group in which the numbers were fixed to 20 respondents for each race. Thus, the data were analysed using the homogeneity test. The hypotheses developed for this test were as follows:

H_o: The proportions of respondents for each characteristic (script types, letter size, slant, angularity, alignment and word spacing) are similar with racial group.

H_1: The proportions of respondents for each characteristic (script types, letter size, slant, angularity, alignment and word spacing) are different from racial group.

Table 3 shows the Chi-squared value (χ^2) for each characteristic of handwritings based on the factor of race. The null hypothesis was rejected if the χ^2 value was less than 0.050 ($\chi^2 < 0.050$).

Table 3: Chi-squared value for each characteristic of handwritings based on the factor of race

Characteristic of Handwriting	Chi-squared (χ^2)	Inference
Script Types	0.539	No significant difference between racial groups
Letter Size	0.447	No significant difference between racial groups
Slant	0.679	No significant difference between racial groups
Angularity	**0.003**	**Proportion of respondents were different with racial groups**
Alignment	0.638	No significant difference between racial groups
Word spacing	0.435	No significant difference between racial groups

Based on the chi-squared value, only angularity was affected by the factor of race. It is obvious that Indians respondent showed rounded handwriting. Handwritings of Chinese people tended to be more angular while the Malay writing displayed mixed form of letters.

Independent Test

Independent test was carried out specifically for data collections which were dependent between each other. Two hypotheses were made as follows:

H_o: The proportions of respondent for each characteristic of handwriting and the factor that can affect handwriting are independent.

H_1: The proportions of respondent for each characteristic of handwriting and the factor that can affect handwriting are dependent.

Table 4 shows the χ^2 value for each characteristic of handwritings based on the factor of gender, age, education level, education system and occupation. The null hypothesis was rejected if the χ^2 value were less than 0.050.

Table 4: Chi-squared (χ^2) value for each characteristic of handwritings based on the factor of gender, age, education level, education system and occupation

Characteristics of Handwriting	Chi-squared (χ^2)				
	Gender	Age	Education System	Education Level	Occupation
Script Types	**0.009**	**0.006**	0.120	0.800	0.078
Letter Size	0.412	**0.022**	0.073	0.132	0.096
Slant	0.140	0.319	0.740	**0.034**	0.203
Angularity	**0.001**	0.151	**0.000**	0.134	0.120
Alignment	0.938	0.407	0.256	0.289	0.153
Word spacing	0.526	0.140	0.166	0.733	0.829

Based on the independent test, the χ^2 value for each characteristic of handwritings according to the factor of gender, age, education level, education system and occupation were varied among themselves. As referred to χ^2, script types were affected by gender and age with the χ^2 of 0.009 and 0.006, respectively. The letter size was only dependent on the factor of age and the slant was only dependent on education level. Angularity of handwriting was affected by the gender and education system. However, alignment and word spacing were not affected by all five factors.

Comparison between Disguised and Normal Handwriting

Disguised handwriting specimens were requested from another set of 50 individuals. Both normal and disguised handwritings were collected using same control passage as it is crucial that any comparison between questioned and specimen handwritings is carried out on a 'like for like' basis [5] thus only a meaningful comparison could be made. In all handwriting comparisons, differences in handwriting classes are of profound significance. There will always be similarities between handwritings because there are finite numbers of character forms which can be used. Handwriting could be written by same

authorship if there is a sufficient quantity of both questioned and normal comparison handwritings and they match in all respects without any significant differences being detected.

The results showed that disguised handwritings tend to show great variation in letter size and formation. The size of letters was not consistent as the writing was slowly written. The initial capital letters were also frequently changed. Natural variations of normal handwriting would be more consistent throughout a long period of time. Both disguised and normal handwritings were discussed based on the bar charts as in **Fig. 7**.

As the normal and disguised handwriting were compared certain class characteristics were found to be significantly different. Some interesting trends were observed.

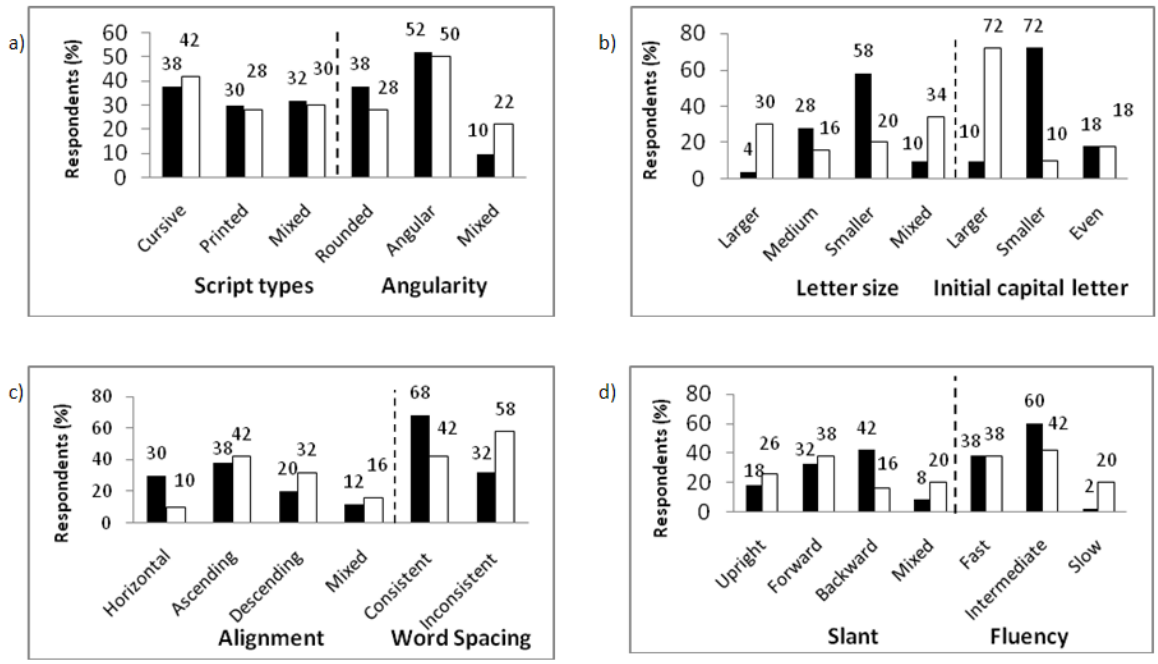

Fig. 7: Percentage of respondents correspond to the characteristics of both normal (■) and disguised (□ handwriting: a) script types and angularity; b) letter size and initial capital letter; c) alignment and word and d) slant and fluency.

Based on **Fig. 7**, there is no similarity between disguised and normal handwritings apart for the script types, where the distribution patterns did not differ so much. Printed letter forms are occasionally employed as a means of disguising writing habits. However, these attempts are usually unsuccessful [6]. It is relatively simple to change one's writing habits in a short passage, however, the writer's normal habits is partially unveiled when much pages of writing is disguised. In this study, 27% of respondents kept the script type maintained between both writings.

The disguised writings were deliberately changed in the other seven classes of handwriting characteristics; letter size, slant, angularity, alignment, word spacing, initial capital letter and fluency. The most obvious feature of the writing of any person is its overall appearance [7]. Therefore, the most likely move in an attempt to disguise is to modify the appearance by changing the size or the slope of the writing.

As showed in **Fig. 7**, the letters were gradually changed to larger size (28%) and 25% of respondent mixed the letter size. When people try to change the habit of normal writing, they might use larger size of letter and the mixture of lowercase joined and unjoined letters. The initial capital letters were also gradually increased from small size in normal writing to the larger size in disguised handwriting.

Less effort is required if only the slope or size is altered. However, the newly chosen slope of the disguised writing may lack of consistency. Some parts will slope more than others, which mean that the consistent angle of slope of the normal habit will not be there [5]. However, some parts may actually revert to the natural slant. From the results, 32% respondents did not change the direction of

the writing slope. 17% respondents preferred writing in a forward slant, while the other 13% preferred mixed slope.

In practice, the result of disguised handwriting is necessarily a compromise between fluency and accuracy. If the writing is speeded up in order to improve fluency, then accuracy will suffer as a result. Conversely, if the writing is slowed down in order to obtain greater accuracy, then some of the fluency will be lost [5]. **Fig. 7** showed that the percentage of respondents who wrote slowly for disguised handwriting increased 17%. As a result, the spacing between words also became more inconsistent.

Conclusion

This study presents variations of writing amongst Malaysian based on class and individual characteristics. Two sets of handwriting specimens were obtained; normal and disguised handwritings. Both handwriting characteristics were examined using statistical technique employed of Pearson chi-square test.

Amongst six categories of class characteristics of normal handwriting, the samples mostly were written in the mixed style. Malaysian writers prefer use small sized and rounded form of handwritings. The results also showed that writers were interested with a mixed slant and ascending alignment. However, mostly of them like to write with inconsistent spacing between words.

The findings showed that angularity of writing was affected by the factor of race and education system. As refer to the relationship between race and education system, Indian writers prefer rounded handwriting while Chinese handwritings tend to be more angular. Script types were affected by gender and age. It has been proved where mostly the group of old generation prefers cursive writing while new generation more interested in printed and mixed styles.

Based on the discriminative power of letter “o”, it indicated that most writers were right-handedness person. Other letters were successfully grouped according to each category. The normal and disguised handwriting could be distinguished as the characteristics of individual handwriting greater differed from each other. Eight categories of class characteristics were used to distinguish handwriting characteristics between normal and disguised handwritings. There is no similarity between disguised and normal handwritings except for the script types. The disguised writings were found to change in seven classes of handwriting characteristics; letter size, slant, angularity, alignment, word spacing, initial capital letter and fluency of writing.

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