Preference Impact of Diverse Modes of Occlusion on Single Composition Structure Chinese Characters and Arabic Numerals

Ching Chih Liao

Department of Commercial Design, Ming Chuan University, Taipei, Taiwan.

Abstract.

Based on the hypothesis that for occluded text to be liked requires that it is easy to recognize, different modes of occlusion were applied in this study to nine each of single composition structure Chinese characters and Arabic numerals, for a total of 18. Four occlusion objects were applied (a gray rectangle occluded a character, a rectangle formed from tiny characters occluded another character, tiny characters occluded strokes, and occluding a character without a visible covering object), comprising 72 samples. Coming from design and non-design education backgrounds, 170 experiment participants were recruited with the goal of investigating how they would rank the modes of occlusion they liked best and the reasons why. The resulting data was analyzed with the nonparametric methods. Experimental results revealed a significant difference among the four modes of occlusion for numbers and Chinese characters. The primary reason given for liking the tiny characters occlusion better was that most participants considered that the mode of tiny characters occluding the strokes could be recognized easily because the character form was intact. The main reason the rectangle formed from tiny characters was not preferred was that participants were distracted by the tiny characters and found it harder to recognize the occluded character. Regarding differing education background of the participants, besides the non-design education participants liking the tiny characters occlusion significantly more than design education participants did, there were no other differences.

Keywords: Single composition structure, Chinese characters, Arabic numerals, Mode of occlusion, Preference

1. Introduction

When designing a poster, card, package surface, or book cover, designers often process text (or characters) to attract attention, to facilitate memory, or to provoke emotion. One commonly used method is to occlude parts of texts (or characters) and to deliberately create texts or characters that appear incomplete. Luijkx, Thillou, and Gosselin (2006) defined incomplete text (or characters) as unknown and invisible text (or characters). In other words, the notion of "incomplete text (or characters)" refers to "cut characters" or "occluded text (or characters)."

For design, methods for occluding text or characters can be classified into two categories (no visible covering object and visible covering object) and eight modes. The three modes for the first category (no visible covering object) are as follows: (1) along the edge of an editing area, one side or two sides of the character moves out the editing border (bleed) to remove some strokes; (2) some strokes of the character are occluded but no covering object is seen; (3) part of the text is turned to the other side and cannot be seen from the front. The five modes for the second category (visible covering object) are as follows: (1) Strokes are occluded by an object; for example, some strokes of a character are occluded by lines or color patches; (2) a character is cut from the middle and separated by an object; (3) a block of tiny characters to occlude another character; (4) a tiny and thin character is used to occlude strokes; (5) for a term composed of two characters, the two characters share some strokes and thus some strokes are missing.

Although designers often apply the aforementioned methods to Chinese or English media design, the designed texts or characters are incomplete. How users feel, whether the texts or characters can be easily recognized, or what factors affect users' preferences for these types of texts or characters have not been explored empirically. Preferences are embodiments of a person's views and judgments on objects. Numerous factors can affect preferences. Understanding why people dislike certain designs helps designers improve their designs.

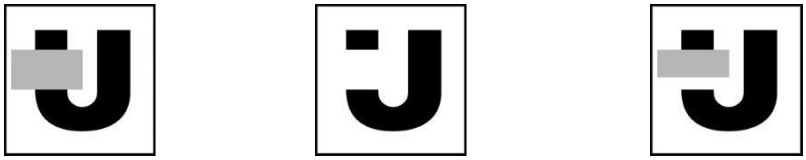
1.1 Research on Text or Character Occlusion and Gestalt Theory

Before exploring textual occlusion or character occlusion, understanding related theories is necessary. Among visual grouping principles proposed by gestaltists, continuation and closure are considered to be related perceptual responses (Solso, 1996). Continuation means that when people perceive an object, they tend to move their eyes according to the continuation of the object. Even if a line is interrupted by another object, people's eyes tend to move according to the direction of the line (Lidwell, Holden, Butle, 2003). If the gap between two elements is small, the extended element will be considered relevant. Conversely, if the gap between two elements is large, the two elements will not appear to be connected and will be considered to be irrelevant. However, if the object has a convexity (Fig.1), that convexity plays an assisting role in completing visual perception (Liu, Jacobs, & Basri, 1999). Closure means that people's eyes automatically fill the gap in an object to perceive a complete object (Solso, 1994; Lidwell et al., 2003). This results from visual continuation. Therefore, continuation and closure complement each other.

Figure 1. Data source: Liu, et al., (1999)

Among several researchers who explored occlusion of English words, Fukushima (2001) indicated that it is easier to recognize an English letter occluded with a visible covering object than it is to recognize an English letter occluded without a visible covering object. The reason is that with a visible covering object, the cognitive system can determine what characteristics are relevant or irrelevant to the occluded letter and therefore can remove irrelevant characteristics and recognize the occluded letter. Fukushima used " U"(Fig. 2) as an example and conducted an experiment. The results showed that in (a), "U" can be correctly recognized and in (b) and (c), the letters are easily perceived as "J." The reasons are as follows: the covering object in (b) is an invisible white square; in (c), although a square covering object is seen, a gap exists in the middle and therefore a mistake occurs. Fukushima's views (2001) accord with the views of Liu et al. (1999). Nevertheless, English words differ from Chinese words in their structure. Even for a simple Chinese character with few strokes, the directions of strokes can be diverse. This warrants further exploration.

Figure 2. Object recognition with and without a covering object; data source: Fukushima (2001)



(a) (b) (c)

1.2 Structure of Traditional Chinese Characters and Numerals

A traditional Chinese character is composed of a main radical and other components; a Chinese character must be written with specific strokes. For Chinese characters, a total of 26 types of strokes can be identified. Most characters are mainly composed of horizontal strokes and vertical strokes. Horizontal strokes are the main components of Chinese characters (Peng, 1982). A character composition can be one of nine forms: (1) a character that cannot be taken apart such as character 大; (2) a character that is composed of right and left parts such as 林; (3) a character that is composed of upper and lower parts at the right side of the character and an undivided left part; for example, 騎; (4) a character that is composed of upper and lower parts at the left side of the character and an undivided right part; for example, 剖 ;(5) a character that is composed of upper and lower parts suc as 尖; (6) a character that is composed of right and left parts for the upper part of the character and an undivided lower part; for example, 碧 ;(7) a character that is composed of right and left parts for the lower part of the character and an undivided upper part; for example, 露;(8) a character that is composed of upper, middle, and

lower parts; such as 棻;(9) a character that is composed of left, middle, and right parts such as 遨. (Chen, 1974; Wu & Chiu, 1995; Liao, 2018).

English font designs, including English words and numerals, can be catogoried into six types (Zhu, 2009): old style, sans serif, slab serif, script, modern style, and decorative style. Sans serif has no serif; sans serif is simple, clean, and modern; Helvetica is an example of sans serif. Slab serif is a vintage style that features serifs and right-angle turns; it is suitable for headings; Memphis is an example. Numerals and English words are composed of vertical, horizontal, and/or sloping lines and/or curves. Aside from 4, 5, and 7, other numerals can be written in one stroke. Chinese characters differ from numerals because Chinese characters have multiple strokes with variety of directions.

1.3 Preferences

In psychology, preferences refer to a person's attitude toward people or events (Lichtenstein & Slovic, 2006) or a person's likes and dislikes for an object (Scherer, 2005). Preferences are not stable and can be substantially changed during decision making (Brehm, 1956; Sharot, DeMartino, & Dolan, 2009). Affective factors play a crucial role in forming and maintaining preferences (Zajonc, & Markus, 1982). In addition, geographical location, cultural background, religious beliefs, education, and nurture can affect a person's preferences.

1.4 Cognitive Comparison Between Different Educational Backgrounds

Studies have shown that people with a design background and those without sometimes presented different cognitive understandings. Eisner (1994) mentioned that people who have received fine arts education are open-minded; they have been encouraged to be creative and have been trained to use the right hemisphere of the brain (responsible for visual space) to think (Chiang & Sun, 2014). Therefore, people trained in design are good at image thinking. Lo and Lin (2007) investigated perception of brand recognition-based design patterns. They considered well-trained designers as experts and those who had no design background as novices; they assumed that designers differ from non-designers regarding their perception of brand recognition-based design patterns. Hsu and Wang (2009; 2010) found that considering preferences for graphic simplification, compared with designers, those who had not received design training preferred figural graphics. Liao (2018) discovered that non-designers recognized occluded characters faster than designers did.

The purpose of this study was to explore the preferences of people with different educational backgrounds for character occlusion modes. To prevent designers from being trapped into subjective thinking and to apply the results of this study on preference in future research and design, this study proposed two hypotheses as follows: (1) the basic requirement for preferring characters occluded with or without a visible covering object is that the characters must be recognized; (2) people with a design background and those without prefer different occlusion modes.

2. Methods

2.1 Experimental Design

This study adopted a three-factor mixed design. Two independent variables were character type (Chinese characters and Arabic numerals) and occlusion mode (a gray rectangle occluded a character, a rectangle formed from tiny characters occluded another character, tiny characters to occluded strokes, and occluding a character without a visible covering object (white rectangle)). The dependent variable was the participant's preferences. The nonparametric methods were used for data analysis. Two groups of participants were recruited (people with a design background and those without). Participants were required to rank their preferences for the four occlusion modes and to answer open-ended questions. Each participant was required to view nine Chinese characters and numerals (18 characters in total). Each Chinese character or numeral was occluded by using four occlusion modes. A total of 72 samples were collected.

2.2 Participants

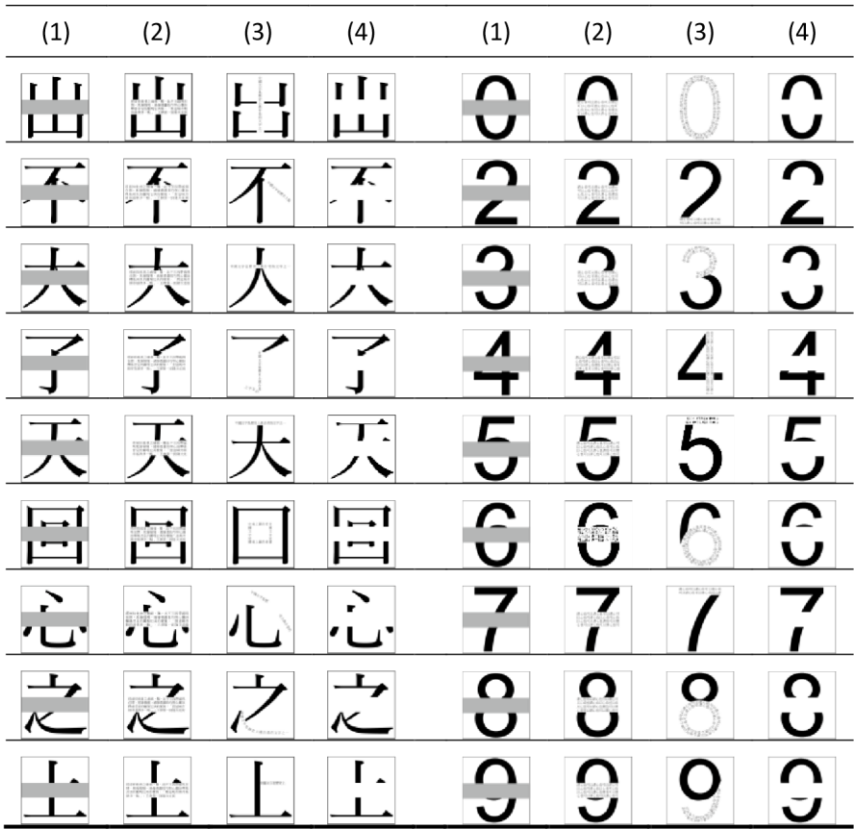
Overall, 170 students from two universities in Taiwan participated (84 students had a design background and 86 students had no design background). The average age of the participants was 23.09 ± 8.37 years. Females and males are half and half.

2.3 Stimuli

According to Wu (1987), from more than 4,000 commonly used Chinese characters, nine characters with single structure were selected as stimuli. The word frequency of these selected characters ranged between 1000 and 9649, including the following Chinese characters: "出," "不," "大," "了," "天," "回," "心," "之," and "上." According to previous studies, Ming is a typeface that can be easily recognized (Shieh, Chen, & Cuang, 1997; Cai, Chi, & You, 2001; Dobres, Chahine, Reimer, & Mehler, 2014). Applying the character occlusion mode in design practice is to attract attention. Typically, the typeface is often enlarged and printed in bold. Therefore, Ming in bold was selected for this study (Tab. 1).

Table 1. Characters with single structure and those occluded with various occlusion modes

Chinese characters	Arabic numerals



Note: The occlusion modes were: (1) a gray rectangle occluded a character; (2) a rectangle formed from tiny characters occluded another character; (3) tiny characters occluded strokes; (4) occluding a character without a visible covering object

Regarding occluding the Arabic numeral "1," because its appearance is long and narrow, its width is shorter than its height, and its stroke is extremely simple, its occlusion has no effect. Therefore, this study adopted "0" and "2" to "9" instead of "1". Arial Unicode (MS 300 pt) was adopted for sample design; like Helvetica, Arial Unicode (MS 300 pt) is a simple, clean, and modern sans serif font. Each Chinese character and numeral was occluded with four occlusion modes: (1) a gray rectangle occluded the character; (2) a rectangle formed from tiny characters occluded another character; (3) tiny characters occluded strokes; (4) occluding the character without a visible covering object (Tab. 1). A self-developed program was used to display the occluded characters. Versions of the same character occluded by using the four modes were displayed simultaneously. Overall, 18 displays were presented to each participant. Each character was ranked by selecting a number in a drop-down menu. In addition, a space was provided to each participant to write down reasons that he or she preferred or dislike an occlusion mode to the highest degree.

2.4 Apparatus

An IBM computer (17-inch screen with width × height = 34 × 27.2 cm and a resolution of 1024 × 768 pixels) was employed for this study. Each participant was seated in front of the computer; the distance between the participant's eyes and the screen was 45 cm and the visual angle was 15°. The experimental content was displayed by using a self-developed program.

2.5 Procedures

Overall, 170 participants were required to rank their preferences for occluded characters and to answer open-ended questions. To prevent the learning effect that can influence the experiment results, for each pair of two participants, the two character types were presented in reversed order for the second participant. In other words, Participant A first ranked Chinese characters and then numerals; Participant B ranked in reverse order. Participants were asked to rank the characters by preference from 1 to 4 (1=top preference, 2=second prefernce, 3=third preference, 4=fourth preference). Characters to rank (Chinese characters or numerals) were presented randomly. Each participant participated in the experiment independently. Each experiment participation session lasted 20 to 25 minutes. After completing the experiment, each participant received a gift.

3. Results

3.1 Preference ranking

A chi-square test was performed. The results showed that regarding preferences for the occlusion modes applied to Chinese characters, $\chi^2(3) = 138.49$, $p < .001$; regarding preference for the occlusion modes applied to numerals, $\chi^2(3) = 63.4$, $p < .001$. Therefore, for both Chinese characters and numerals, among the four occlusion modes, preferences for at least one mode were significant. A nonparametric Wilcoxon test was conducted for related samples. The results were significant ($p<.001$), indicating that for both Chinese characters and numerals, preferences for the four occlusion modes significantly differed. According to the mean of rank values of preference, for using tiny characters to occlude strokes was lower than those for using a white rectangle, gray rectangle, or a rectangle formed from tiny characters to occlude. It showed that using tiny characters to occlude strokes was top preferenced for both Chinese characters and numerals.

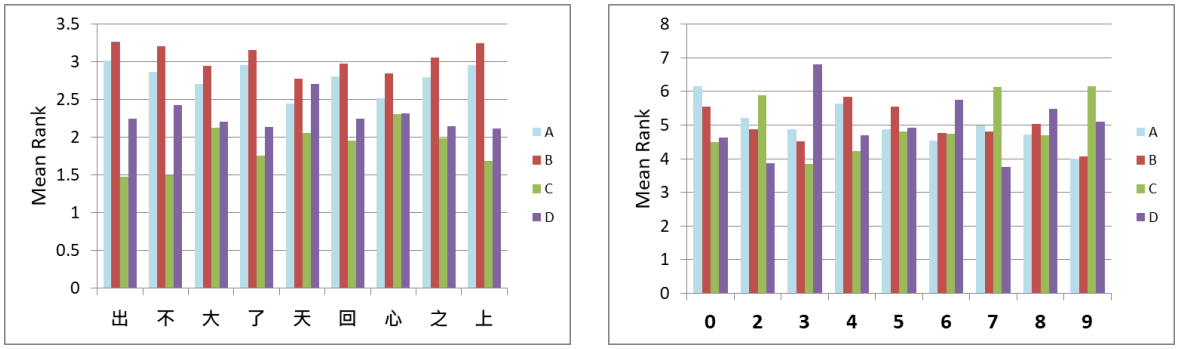
In order to understand that the preference for the four occluded modes to Chinese characters and numerals. A Friedman test involving k correlations was conducted. The results showed that there were a significant difference between each Chinese characters and each numerals.

Considering the mean rank of Chinese characters other than "天," using tiny characters to occlude strokes was superior to the modes without a visible covering object, using a gray rectangle or a rectangle composed of characters to occlude (Fig. 3(1)). For various numerals, preferences for the four occlusion modes differed that showed numerals 2, 7, 9 were not preferenced for using tiny characters to occlude strokes due to the difficulty of recognition. For the numerals, 3, 6, 8, and 9, preferences for using a gray rectangle were higher than those for the mode without a visible covering object. For 0, 2, 4, and 7, preferences for the mode were in reversed (Fig. 3(2)).

A Kruskal–Wallis test was performed to compare the preferences of two groups of participants (those with a design background and those without) for occluded Chinese characters and numerals. For Chinese characters, the preferences of the two groups did not significantly differ. For numerals, a significant difference was observed between the two groups regarding their preferences for using tiny characters to occlude strokes ($\chi^2(1) = 5.97$, $p < .05$), indicating that participants without a design background preferred using tiny characters to occlude strokes,

relative to those with a design background. Preferences for other three occlusion modes did not significantly differ between the two groups.

Figure 3. Preference rankings for the four occlusion modes applied to Chinese characters and numerals



(1) (2)

Note: For each bar chart, A, B, C, D in order represents using a gray rectangle to occlude, using a rectangle formed from tiny characters to occlude the character, using tiny characters to occlude strokes, and the mode without a visible covering object, respectively.

3.2 Reasons for preferences

The main reasons for preferences for the four modes are described as follows: (1) a gray rectangle occluded: this mode did not affect character recognition and rendered occluded characters mysterious; (2) a rectangle formed from tiny characters occluded a character: this mode attracted attention; rendered text, description, and occlusion effect interesting; integrated images and text; produced an advertising effect; and embellished characters; (3) tiny characters occluded strokes: this mode provided an intact character form and almost complete character and rendered occluded characters recognizable; (4) the mode without a visible covering object: the occluded character was recognizable because the characteristics of strokes were preserved; and this mode rendered occluded characters special, aesthetic, simple, clean, disappearing, split, and incomplete, thereby producing a sense of beauty.

The main reasons for the least preferences the four modes were as follows. (1) a gray rectangle occluded: this type of colorless patch was misleading because it resembled an unclear image; (2) a rectangle formed from tiny characters occluded the character: this mode produced interferences and made occluded characters difficult to recognize; (3) tiny characters occluded strokes: some characters appeared unstable and weird; (4) the mode without a visible covering object: this mode severely affected character recognition, and recognition mistakes easily occurred.

4. Discussion and Conclusion

The experimental results showed that for both Chinese characters with single structure and numerals except 2, 7, 9, among the four occlusion modes, two groups of participants both preferred using tiny characters to occlude strokes. According to the participants' feedback, the reasons were as follows: the structure was intact. Therefore, both groups emphasized that whether a processed character could be recognized easily was crucial. For numerals, the participants without a design background particularly preferred using tiny characters to occlude strokes because the form were intact. Participants who had received training in design preferred

the mode without a visible covering object because occluded characters appeared special and an aesthetic sense.

According to the results, various modes applied to occlude numerals and Chinese characters substantially affected participants' preferences. This involved the structure of a character. The strokes of a Chinese character are complex. Even for a single structure that cannot be disassembled, the strokes have diverse directions. For example, the extremely simple character "了" involves a horizontal stroke, a lateral hook, and a vertical hook. Therefore, various occlusion modes yielded various levels of difficulty in character recognition. Overall, whether a character could be recognized was the most crucial factor that influences preferences, followed by educational background. In addition, whether an occlusion mode provided an aesthetic sense somehow affected preferences.

Fukushima (2001) indicated that it is easier to recognize a character occluded by a visible covering object than a character occluded by a white patch (i.e., no visible covering object). This study discovered that using the mode without a visible covering object to occlude Chinese characters was preferred by participants over those occluded by a gray rectangle. At least half of the numerals using the mode without a visible covering object to occlude were preferred by participants over those using a gray rectangle to occlude. Fukushima's research used the letter U as a sample, which is very simple. Chinese characters and some numerals are more complicated than that, which leads us to infer that using the non-visible covering object may still provide more identification clues. However, this research and Fukushima's reseaerch investigated on different dependent-value, one was on preference and the other was on recognition. Therefore, this study cannot contend that the results differed from those of Fukushima (2001). The results of this study can serve as a foundation for subsequent research on occlusion modes and character recognition.

Acknowledgment

This study was supported by Ministry of Science and Technology in Taiwan, under the grand numbers of MOST 106-2410-H-130-042, MOST 107-2410-H-130-042

References

[1] Brehm, J.W. (1956). Post-decision changes in desirability of choice alternatives. *Journal of Abnormal and Social Psychology*, 52, 384-389.

[2] Cai, D., Chi, C. F., & You, M. (2001). The legibility threshold of Chinese characters in three type styles. *International Journal of Industrial Ergonomics*, 27, 9-17.

[3] Chen, X. R. (1974). *Graphic design of English and Chinese characters*. Taipei, Taiwan: Dong-Woo Printing. (In Chinese)

[4] Chiang, S. B., & Sun, C. W. (2014). Impacts of learning background and different contextual sentences on shot interpretation in word-to-image transcoding process. *Journal of Design*, 19(3), 41-62.

[5] Dobres, J., Chahine, N., Reimer, B., & Mehler, B. (2014). An exploratory psychophysical investigation of the relative glance legibility of Chinese typefaces. [*MIT AgeLab*]

[6] Eisner, Elliot W. (1994). *Cognition and curriculum reconsidered* (2nd ed), New York: Teachers College Press.

[7] Fukushima, K. (2001). Recognition of partly occluded patterns: a neural network model. Biol. *Cybern*, 84, 251-259.

[8] Hsu, C. C., & Wang, R. W. Y. (2009). The relationship between learning background and the preference to simplified graphics. *Research in Arts Education*, 17, 109-130.

[9] Hsu, C. C., & Wang, R. W. Y. (2010). The relationship between shape features and degrees of graphic simplification. *Journal of Design*, 15 (3), 87 - 105.

[10] Liao, C.-C. (2018). Double-Sided Occluded Chinese Character Recognition Accuracy and Response Time for Design and Nondesign Educational Background. *SAGE Open*, 8(4), 2158244018810065.

[11] Lichtenstein, S., & Slovic, P. (2006). *The construction of preference*. New York: Cambridge University Press.

[12] Lidwell, W., Holden, K., Butle, J., (2003). *Universal principles of design*. Rockport Publishers, Inc.

[13] Liu, Z., Jacobs, D. W., & Basri, R. (1999). The role of convexity in perceptual completion: beyond good continuation, *Vision Research*, 39, 4244–4257.

[14] Lo, K., & Lin, P. C. (2007). An Investigation on the Cognitive Model of High-Brand-Value Identity Design. *Journal of Design*, 12(4), 1-20.

[15] Luijkx, A., Thillou, C., & Gosselin, B. (2006). A prolongation-based approach for recognizing cut characters. In Computer Vision and Graphics (pp. 1125-1130): Springer.

[16] Peng, R. X. (1982). A preliminary report on statistical analysis of the structure of Chinese characters. *Acta Psychologic Sinica*, 385-390.

[17] Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social Science Information*, 44, 695-729.

[18] Sharot, T., De Martino, B., & Dolan, R. J. (2009). How choice reveals and shapes expected hedonic outcome. *Journal of Neuroscience*, 29, 3760-3765.

[19] Shieh, K. K., Chen, M. T., & Cuang, J. C. (1997). Effects of color combination and typography on identification of characters briefly presented on VDT. *International Journal of Human-Computer Interaction*, 9, 169-181.

[20] Solso, R. L. (1994). Cognition and the visual art. *Massachusetts Institute of TechNology (MIT Press)*. p.103.

[21] Solso, R. L. (1996). *Cognition and the Visual Arts*. A Bradford Book.

[22] Wu, J. T. (1987). [*Exploring the phonetic and semantic features of Chinese words: Part 1. Frequency count of Chinese words, characters, and monosyllables*]. (Grant No. NSC-75-0301-H002-24) Taipei, Taiwan: National Science Council. [in Chinese]

[23] Wu, M. S., & Chiu, I. T. (1995). *Graphic design of Chinese character formation*. Taipei, Taiwan: New Image. (In Chinese)

[24] Zajonc, R. B., & Markus, H. (1982). Affective and cognitive factors in preferences. *Journal of Consumer Research*, 9(2), 123-131.

[25] Zhu, Q. M. (2009). *Graphic design (Typography)*. Publishing house: longxi books.