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ABSTRACT

A study investigated how different combinations of background color, text brightness and text color in Chinese CAI (computer assisted instruction) software programs may influence the affection, perception, and cognition of elementary school students in Taiwan. A sample size of 332 was drawn from the sixth-grade students of 2 elementary schools. Students were assigned to 16 groups which represented the total number of combinations between 8 background colors and 2 text brightnesses. For each group, 7 sets of testing materials and questions were presented on the computer screen corresponding to 7 different text colors. Testing materials included questions on the Chinese language (memory retention of words, phrases, and short sentences) and from the natural sciences (memory and comprehension of articles of different length). Results indicated that: (1) purple background color was significantly preferred over red, however background color had no effect on perception and cognition; (2) text brightness had no effect on affection, perception, and cognition; and (3) text color had significant effects on affection and perception, but it had no significant effect on cognition. (Contains 17 references.) (Author/RS)

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# The effect of color design in Chinese CAI softwares

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## Abstract

The purpose of this study was to investigate how different combinations of background color, text brightness and text color in the Chinese CAI softwares may influence the affection, perception and cognition of elementary school students in Taiwan. A sample size of 332 was drawn from the sixth grade students of two elementary schools.

During the experiment, students were assigned to sixteen groups which represented the total number of combinations between eight background colors and two text brightness. For each group, seven sets of testing materials and questions were presented on the computer screen corresponding to seven different text colors.

The subject domains of the testing materials included Chinese Language and Natural Science. The former focused on testing memory retention of words, phrases and short sentences. The latter focused on testing both memory and comprehension of articles of different length.

Statistical analyses were applied to analyze the experimental data. The results showed that purple background color was significantly preferred over red background color. However, background color had no effect both on perception and cognition of elementary school students. As far as text brightness was concerned, there was no effect on affection, perception and cognition. On the other hand, text color had significant effect on affection and perception, but it had no significant effect on cognition.

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## **Introduction**

Blocks of texts are commonly used to explain messages in the CAI softwares. The combination of background color, text brightness and text colors may affect learners' attention differently. For instance, it influences the extent and type of the stimulus that the learners accept, and consequently the learning effect (Hu, 1979).

Many software designers either took a trial-and-error approach in the design of colors, or made decisions according to their own preferences. However, these approaches are somehow inaccurate, inefficient, and time consuming (Lin, 1987). The investigation of the effect of color design can help users to examine or choose a series of colors in a short time, so that the use of computer in art or graphics will be more feasible (Foldvari, 1989). More importantly, the knowledge of color design can be applied in the CAI softwares, and hopefully it will enhance the interest and learning effect.

However, there are very few research works concerning the color design of the Chinese CAI softwares for the learning of elementary school students in Taiwan. Therefore, this study aims to investigate how the combination of background color, text brightness, and text color in the Chinese CAI softwares may influence the affection, perception, and cognition of sixth grade elementary school students in Taiwan. The sample was drawn from two elementary schools, and the sample size was 332.

## **Literature Review**

### **1. The effect of color to affection**

Colors can influence the emotion of human beings. Due to physical, physiological, and habitual reasons, each color has its particular meaning and stimulates different feeling in people. "Color harmony" is defined as a lovely feeling towards different color combinations depends on personal preference. To achieve a better outcome of coloring, it was suggested that the proportions of different colors in a picture or a screen be inversely proportional to their brightness. In other words, the brighter colors should have smaller areas, whereas the darker colors may have larger areas in a picture. Therefore, the background color has been recommended not to be too bright in a picture or a screen (Chou, 1982).

Liu (1988) used colorful cards to investigate the color preference of high school students in Taiwan. The result showed that high school boys' color preferences, ordered from high preference to low preference, were: green, yellow, light green, red, orange, purple, white, green-purple, black, gray and brown. On the other hand, high school girls' color preferences were: white, light-green, green, yellow, purple, yellow-green, green-purple, red, black, orange, gray and brown.

Another researcher in Taiwan conducted a research on the 11th grade students in two professional high schools in Taiwan about their preferred background colors and text colors on the computer screen (Wu, 1995). The result showed that the preference of background colors can be ordered as: blue (25.63 %), light blue (20.38 %), green (14.92 %), purple (13.03 %), black (9.45 %), white (7.35 %), red (5.04 %), brown (4.20 %). At the same time, the preference of text color were: yellow (16.16 %), bright-white (16.16 %), bright-light blue (12.95 %), bright-green (11.40 %), blue (7.64 %), black (6.64 %), purple (4.54 %), light-purple (4.32 %), bright-blue (4.21 %), red (3.21 %), white (2.84 %), bright-red (2.33 %), gray (2.33 %), brown (2.21 %), light blue (1.88 %), green (1.11 %).

In the USA, Eysenck (1941) used colorful cards to test over 21000 Americans, and the result showed that the preferred colors were: blue, red, green, purple, orange, yellow. Also, Peterson (1993) asked some American high school students to draw their preference colors on square, circle, triangle, rectangle and star figures on the A4 papers. The result showed that the color preference order was: blue (16 %), red (15 %), purple (14 %), green (12 %), yellow (11 %), orange (10 %). However, the least preferred colors were: white (0 %), yellow-green (2 %), gray (3 %), multiple color, green-blue, black (4 %), and brown (6 %).

Valdez (1994) used the color cards of Mussel Color System as testing tools at the State University of California. The pleasure (P), arousal (A) and dominance (D) model were used to test on 200 university students' emotions to the hue, saturation and brightness of colors. He found that the students' PAD are related to saturation and brightness of the color. The effect of the brightness is similar to that of chromatic and achromatic color. Blue, green, and purple color are more pleasant than red, brown and yellow colors. Meanwhile, blue-green and green color were most arousal, while red-yellow was least arousal. As far as the dominance is concerned, yellow-green was more dominant than the red-purple. Both male and female had similar emotional reaction to the saturation and brightness of the colors. However, female was more sensitive than male. Both genders had similar reactions

to the hue of colors.

## **2. The effect of color to perception**

As far as the effect of color to human's perception is concerned, color has been applied to arouse user's attention about the change of status, or to improve the identification of items, or to classify the elements on a computer screen. Moreover, the recognition of the text depends on the luminous contrast rather than the color contrast of the background color and the text color. It is worth noticing that the extent of luminosity and brightness of colors can be ordered as: white, yellow, light blue, green, magenta, red, blue, and black (Van Nes, 1994). When human beings search for information in a large area of text, color can be applied as a better tool than text size and shape (Jones, 1989)

Ydewalle (1986) had done a color perception test on students in Leuven University. The result showed that low color contrast interfered with normal perception of reading, and the subjects needed more time to process information. Hence he recommended that a good contrast of background color and text color were better for the readers to perceive text in the context. Ydewalle's study also showed that students had different color preference, but the combination of background color and text color made no significant difference in students' information processing. Another research work suggested that the ease of perceiving and recognizing words on the computer screen depends on the luminous contrast of the text colors and the background colors more than their color contrast (Bruce & Foster, 1982).

## **3. The effect of color to cognition**

Berry (1991) studied the information storage and retrieval of the learners in varied visual environments. The result showed that the chromatic screen had better effect than the monochromatic screen. In terms of memory recalling, the learners had best performance under the realistic color display, then black-and-white display, while the unrealistic color display had worst result. Also, another research found that there was no so called "the best color combination" for reading comprehension (Peterson, 1984). Among 132 combinations of the background colors and text colors, 35 combinations were considered as acceptable. The best text color was black which had good contrast to most background colors (Peterson, 1984). Foster & Bruce (1982) recommended the dark background colors are used with the light text colors.

They also recommended not to use light background color together with the light text colors in the same picture or screen.

Clausing (1990) used eight screen formats and two paper formats for the learners to read 50 articles. Then he gave the learners sufficient time to fill in blanks based on the knowledge of those articles. The result showed that the display format had no significant influence on the reading speed and comprehension. Spalding (1991) compared three different color combinations on the computer screen: (1) monochromatic screen with white background color and black text color (2) monochromatic screen with underlined or bold word, white background color and black text color, (3) chromatic screen with blue background color and white text color. The result showed that these three screen design made no significant difference on the percent correct scores and the response time.

### **Questions to be answered**

Although there has been some studies on the effect of color design in relation to the affection, perception and cognition of learning at the high schools or university levels, very few studies have been conducted to investigate the effect of color design on the affection, perception, and cognition of elementary school students in Taiwan. Hence, we are motivated to answer the following questions:

1. Does the background color of Chinese CAI softwares make a difference in the affection, perception and cognition of Taiwanese elementary school students?
2. Does the text brightness of Chinese CAI softwares make a difference in Taiwanese elementary school students' affection, perception and cognition?
3. Does the text color of Chinese CAI softwares make a difference in Taiwanese elementary school students' affection, perception and cognition?

### **Method**

The samples were drawn from the sixth grade students of two elementary schools in Taiwan, and the sample size was 332. During the experiment, students were assigned to sixteen groups based on eight background colors (i.e. red, brown, green, light blue, blue, purple, white and black) and two text brightness (high brightness vs. low brightness). For each group, students were presented with seven sets of testing materials and questions on the computer screen on which there were seven different corresponding text colors (i.e. eight colors mentioned above but omit

the one which is the same as the background color). The subject domains included Chinese Language and Natural Science. The test of the Chinese Language was focused on testing about the memory retention of words, phrases and short sentences, while the test of Natural Science subject was focused on testing both the memory and comprehension of different length of articles.

The affection test was operationalized as students' self-reported ratings according to their personal preference of colors. The perception test was operationalized as students' self-reported ratings according to personal perception of the visibility of the color combinations on the computer screen. The self-reported rating was obtained from a questionnaire in the form of a Likert scale. On the other hand, the cognition test was operationalized in three perspectives: 1) students' average reading time, measured in seconds, 2) percent correct score, measured by dividing the number of questioned answered correctly by the total number of questions. 3) average response time, measured in seconds. Both the affection test and perception test were conducted twice, the first time was conducted immediately before the cognition test, and the second time was conducted immediately after the cognition test.

A General Linear Model (GLM) statistical analysis method was applied to answer the first and the second questions in this study. For independent variables which had a significant effect in the dependent variables, a Scheffe's post hoc multiple comparison method was applied afterwards in answering both questions. To answer the third question, the repeated measure design method was chosen because text color was considered as an within-group variable in this study.

## **Result**

In this study, the three independent variables were: background colors, text brightness, and text colors. The three dependent variables were: students' affection (expressed on a 1-5 scale of personal color preference), perception (indicated by a 1-5 scale of personal perceived screen visibility), and cognition (measured by average reading time, percent correct score, and average response time). The univariate analysis of variance (ANOVA) statistical procedure was used to test the effect of between-group variables (background color and text brightness) with respects to each dependent variable. For the consideration of controlling experimentwise error rate due to the large number of pairwise tests, each pairwise difference was tested at

the .005 type I error rate level. Repeated measures design was used to test the within-group variable of text color. The results of statistical analysis were listed as follows:

### **1. The effects of background color**

The differences in personal preference among the examined eight background colors were found to be statistically significant for two affection tests ( $F=3.54$ ,  $p<.0011$  and  $F=3.02$ ,  $p<.0044$  respectively). Scheffe's post hoc multiple comparison procedure was used to follow up on the differences among all possible pairs of means, revealing that a significant difference was found between the red and purple background colors at both affection tests. The students preferred the background color of purple better than red at both times.

As far as the effect of background color on student perception is concerned, there was no significant difference in the perceived screen visibility for both perception tests ( $F=1.19$ ,  $p<.3065$  and  $F=1.56$ ,  $p<.1460$  respectively). Moreover, no significant difference was found for average reading time, percent correct scores, and average response time in the cognition test.

### **2. The effects of text brightness**

With regards to the effects of text brightness, there was no significant difference in both affection tests ( $F=.07$ ,  $p<.7922$  and  $F=.10$ ,  $p<.7479$  respectively). Neither was there significant difference in the perceived screen visibility in both perception tests ( $F=.28$ ,  $p<.5948$  and  $F=.10$ ,  $p<.7538$  respectively). Meanwhile, no significant difference was detected for the average reading time, percent correct scores, and the average response time in the cognition test of this study.

### **3. The effects of text color**

Text color was treated as a within-group variable in this study. The effect of text color to the affection, perception and cognition of the elementary school students was analyzed with both univariate and multivariate analysis of variance procedures. The cognition test consisted of different formats such as single word memory, phrase memory, sentence memory, short essay memory, short essay comprehension, long essay memory, and long essay comprehension. The scores were expressed as percent correct scores. The result showed that text color produced

a significant effect for both affection tests with the univariate ANOVA analysis ( $F=9.08$ ,  $p<.0001$  and  $F=4.45$ ,  $p<.0004$  respectively), as well as the multivariate analysis (Wilks lambda=.871,  $p<.0001$  and Wilks lambda=.932,  $p<.0008$  respectively).

Text color also produced a significant effect on students' perceived screen visibility in both perception tests by the univariate ANOVA analysis ( $F=6.68$ ,  $p<.0001$  and  $F=6.80$ ,  $p<.0001$  respectively), as well as the multivariate analysis (Wilks lambda=.8996,  $p<.0001$  and Wilks lambda=.8959,  $p<.0001$  respectively). The analysis of the cognition test showed that no significant effect was reported with respect to the average reading time and percent correct score using both univariate and multivariate mode of analysis.

## **Conclusion**

The result of this study showed that the sixth grade elementary school students in Taiwan significantly preferred purple more than red as the background color of the computer screen. Other background colors tested in this study had no significant effect on students' affection, perception and cognition. However, the background color contributed to no significant difference in the students' perception and cognition. Meanwhile, text brightness made no significant difference in the students' affection, perception and cognition.

Moreover, text color had a significant effect on the affection as well as the perception of the students. On the other hand, text color had no significant effect on the learners' average reading time, percent correct scores and the average response time in the memorizing words, phrases, sentences, short articles, and long articles for the subject of Chinese Language. Meanwhile, text color also had no significant effect on the percent correct scores and the average response time in answering the comprehensive questions associated with short articles and long articles for the subject of Natural Science.

## **Recommendation**

This study found that the sixth grade students in Taiwan preferred purple much more than red as the background color, but there were no significant

differences among other background colors. Therefore, we suggest that purple background color be used in the Chinese CAI software instead of the red color to interest the students. Also, the text brightness had no effect on the affection, perception and cognition of the students, it is suggested that the CAI designers allow students the freedom of choosing the text brightness.

As far as the text color is concerned, although it had no effect on the cognition of students, but it had significant effect on students' affection and perception. Therefore, we recommend that the CAI software designers allow the students to choose text colors which are preferred and can be seen clearly on the computer screen.

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