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Effects of VDT leading-display design on visual performance of users in handling static and dynamic display information dual-tasks

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Abstract

This study investigated the effects of speed (250 and 300 wpm), text/background color combination (white-on-black, black-on-white, blue-on-yellow, blue-on-white, red-on-white, and green-on-white), jump length (0.35, 0.7, and 1.05 cm), and display position (above- and below-static information) of leading-display information on the subject's visual performance at two different visual display terminal (VDT) screens (CRT and TFT-LCD). Subjects were asked to handle two tasks at the same time, i.e., a search task for static information and a reading task for leading-display information. The results of this study showed that the subject's visual performance on the static-information searching task was not significantly different under different levels of all leading-display factors. The factors of jump length and text/background-color combination of the leading display had significant effects on the subject's comprehension on the leading-display reading task. When the jump length was at 0.35 and 0.7 cm, the subjects' comprehension was better than that at 1.05 cm. Regarding the color combinations of the leading-display text/background, the effects of the factor on the subjects' comprehension can be classified into two categories. The first priority effect was that of the background color on the leading display. Under the condition of white background color of the static information, the experimental results showed that the leading displays with white background color resulted in higher subjects' comprehension. The second was the effect of the color difference. Experimental results showed that leading display with greater color differences of the text/background color combinations resulted in higher subjects' comprehension.

Relevance to industry

Leading display is a widely used dynamic information display medium in the design of websites. The results of this study demonstrate the user's comprehension of the different designs of leading displays. Suggestions from this study may assist website designers in devising a more adequate leading display for promoting greater comprehension on the part of users.

Keywords: VDT; Leading display; Visual performance; Comprehension

1. Introduction

Leading display, which is widely used in the design of websites, is one of the dynamic-informa-

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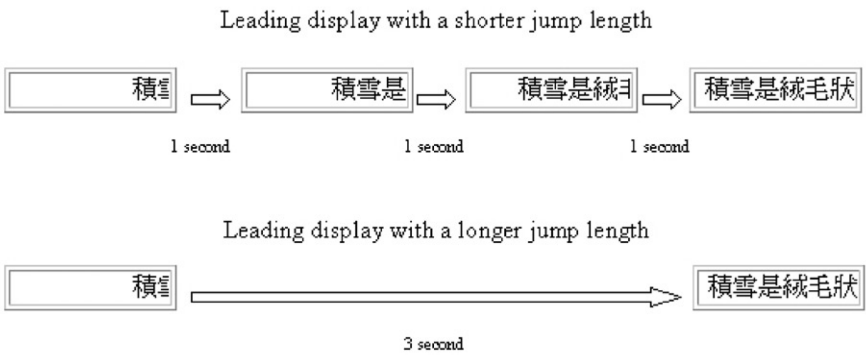

Fig. 1. Example of two leading displays with the same speed but different jump length settings.

tion display media. In the leading display, string of texts moves from right to left sequentially along a single line within a small window (see, e.g., Granaas et al., 1984; Chen and Tsoi, 1988; Chen et al., 1988; Wang and Chen, 2003; Wang et al., 2002) Because leading display is designed to show dynamic information within a small window, the effects of leading display factors on user's comprehension deserve to be discussed further. Additionally, leading display is not usually designed to appear alone; rather, it is usually designed to appear with static information on websites. When users access a website to search for needed information and find a leading display on the homepage, they share their visual and mental resources to continue the searching task for the static message and to read the content of the leading-display information simultaneously. The design of the leading display may affect not only user's comprehension of the leading message but also their visual performance on static information.

According to the characteristics of dynamic information, speed and jump length are two important factors for leading-display design. The speed of leading display is measured by the number of words entering the right-hand side of leading-display window per minute, which provides the effect of the continuous movement of the text string. Under the same speed setting, a leading display with the smaller jump length will move smoother (Wang and Chen, 2003). Fig. 1 shows an example of two leading displays with the same speed but different jump length settings. In the English leading-display paper of Chen and Tsoi (1988), it was found that speed was a significant factor for the subjects' comprehension performance. In addition, the interaction between speed and jump length also had a significant effect on subjects' comprehension of the leading display. When the speed was 200 wpm, the subjects' comprehension was higher when the jump length was at five characters than at one and nine characters. In the study by Juola et al.(1995), the results indicated that the subject's reading accuracy at a leading display were not significantly different when the leading-display speeds were at 260 and 171 wpm. However, the jump length of the leading display was a significant factor for the subject's reading accuracy. The reading accuracy from best to worst was when the jump length was three characters, two characters, and then one character, respectively. Chen et al. (1988) also found jump length was a significant factor for subjects' reading efficiency at a leading display. When the jump length was five and nine characters, the subjects showed higher reading rate than the one-character jump length. Granaas et al. (1984) also found that subjects had poorer reading comprehension when the jump length was at one or two characters, but had no significant difference when the jump lengths were at 4–10 characters. Regarding Chinese leading display, Wang et al. (2002) pointed out that speed and jump length were two significant factors for subject's searching performance at a leading display. Nevertheless, in a leading-display reading study by Wang and Chen (2003), speed had no significant effect on the subjects' reading performance. However, jump length was still a significant factor in the subjects' reading performance. When jump length was 0.35 or 0.7 cm, subjects exhibited the best reading performance.

Text/background color combination is also an important factor in the design of websites. Lippert (1986) proposed a formula to evaluate the color difference between text and background. According to the Commission International del'Eclairage (CIE), with regard to text and background colors, the color difference is calculated as follows:

$$\Delta E(Y, u', v') = \left[(155\Delta Y/Y_M)^2 + (367\Delta u')^2 + (167\Delta v')^2\right]^{0.5},$$

where $u' = 4x/(x + 15y + 3z)$, $v' = 9y/(x + 15y + 3z)$, Y_M the brighter value between target and background, ΔY the brightness difference between target and background, $\Delta u'$ the difference value of u' coordinate between target and background, $\Delta v'$ the difference value of v' coordinate between target and background.

On the basis of the previous formula for color difference, Shieh and Chen (1997) reported that the subject's viewing distance was significantly affected by the text/background color difference. A color combination with a color difference value approximating 140 may be required for adequate VDT screen design. In the leading-display study by Wang et al. (2002), it was also found that color difference had a significant effect on subject's search performance at a leading display. The subject's search error decreased when the text/background color difference increased. In addition, Wang and Chen (2003) found that color difference was also a significant factor in the subject's reading performance at a leading display. When the jump length of leading display was larger, i.e., 1.05 cm, the color combination had a much more significant effect on visual performance. Since leading displays accompany static information, whether text/background color differences of leading display still affect user's visual performance on both static information and leading displays needs to be discussed further.

The other important factor in leading displays affecting user's comprehension is the position. A leading display usually does not appear alone but, rather, accompanies static information. Consequently, the allocated position of a leading display on a website becomes a critical problem. Generally, a leading display is placed at the upper or lower side of a website. According to the general ergonomics guideline, the location of a display should follow four principles: (1) importance, (2) frequency-of-use, (3) functional, and (4) sequence-of-use (Sanders and McCormics, 1993). The issue of whether leading display should be located above or below the static information will be discussed in this study.

Display media also constitute an important factor in user's visual performance. Because the liquid crystal display of thin film transistor (TFT-LCD) has gradually replaced cathode ray tube (CRT) as the major VDT monitor, two types of monitors (TFT-LCD and CRT) were chosen as the display media in this study. In the study by Shieh and Lin (2000), it was found that screen type significantly affected visual identification performance and that TFT-LCD screens seemed to have both performance and preferential advantages over CRT screens. In the leading-display studies of Wang et al. (2002) and Wang and Chen (2003), the subjects' search and reading performances at leading displays were not significantly different at the two different monitors. Since leading display and static information are usually designed to be a dual in function, the effects of the VDT type on comprehension of leading display and search performance of static information display will be investigated in this study.

2. Method

2.1. Subjects

The subjects consisted of 36 university undergraduates, who were offered 200 New Taiwan dollars for their participation after the experiment. All subjects were right handed, between 18 and 22 years old, and ascertained to have 0.8 corrected visual acuity or better and normal color vision.

2.2. Apparatus

A Topcon Screenscope SS-3 and Standard Pseudo Isochromatic charts were used to test the subjects' visual acuity and color vision. The CIE color values for CRT and LCD were measured by using a Minolta CRT Color Analyzer CA-100 and a Minolta CHROMA METER CS-100. A K7 PC with a Sampo KM-520CL 15-in color CRT or a Sampo PD-70FA 14-in (TFT) color LCD monitor was used to display the experimental task at a screen resolution of 1024×768 pixels.

2.3. VDT workstation condition

The monitor was placed on a table 73 cm in height; the distance from the tabletop to the screen center was 23 cm; the inclination of the monitor was 105°. These parameters were fixed throughout the experiment. The VDT workspace was illuminated by fluorescent lamps with an ambient illumination of about 300 lx. No glare or reflection appeared on the screen. A chin-rest restrained the subject's head 30 cm above the table; the distance from the subject's eyes to the screen was 60 cm.

2.4. Experiment design

This study investigated the effects of five factors, namely, VDT types, speed, jump length, text/background color combination, and leading-display position on the subject's search performance of static information and comprehension of leading display. A CRT and a TFT-LCD were the two VDT screens used in this study. The speed of the leading display was set at 250 and 300 wpm, and the jump length was set at 0.35, 0.7, and 1.05 cm. Six colors were chosen for the text and background, i.e., white, black, green, red, blue, and yellow, the color luminance and CIE coordinates for which are shown in Table 1. Six text/background color combinations were combined by six colors, namely, white-on-black, black-on-white, blue-on-white, red-on-white, green-on-white, and blue-on-yellow. The color difference of each combination is shown in Table 2. The leading-display positions were classified into two types: above- and below-static information.

Regarding the five factors used in this research, text/background color combination and display position were within-subjects factors; whereas, VDT type, speed and jump length were between-subjects factors. Consequently, there were 12 ($2 \times 2 \times 3$) different experiment treatments, with three subjects randomly assigned to each treatment.

2.5. Procedure

For each trial, a warning tone was initiated to call the subjects' attention to the " × "at the center of screen. After 2 s, the static information and leading display were shown on the screen simultaneously. In order to prevent the content-interference effect between static information and leading display, the subjects were assigned to handle different visual tasks for the two types of display information.

The visual task for static information was a search task. The subjects were asked to search for a target Chinese character from an article composed of 120 Chinese characters. The article was

Table 1
CIE coordinates of six colors used in this study

Color coordinates	Color					
	Black	Blue	Red	Green	White	Yellow
x	0.292	0.150	0.605	0.295	0.276	0.348
y	0.337	0.113	0.331	0.155	0.295	0.408
L (cd/m^2)	2	18	30	31	94	130

Table 2
Color differences in six text/background color combinations

	Text/background color combination					
	Green-on-white	Blue-on-white	Red-on-white	Blue-on-yellow	White-on-black	Black-on-white
$\Delta Y/Y_m$	0.670	0.809	0.681	0.862	0.979	0.979
$\Delta u'$	0.054	0.036	0.236	0.045	0.003	0.003
$\Delta v'$	0.108	0.192	0.074	0.295	0.027	0.027
Color difference	107.3	130.1	137.1	141.4	151.8	151.8

Complexity	Frequency	
	High	Low
High	說	碑
Low	因	佣

Fig. 2. Example of the four types of Chinese characters used in this study.

not meaningful and was randomly composed of four types of Chinese characters (30 characters of each type). The four types are (1) high frequency and high complexity, (2) high frequency and low complexity, (3) low frequency and high complexity, (4) low frequency and low complexity. An example of these four types is shown in Fig. 2. The frequency of the characters was based on research by Wu and Liu (1987). High-frequency Chinese characters had frequency counts above 120 per one million characters in Chinese literature, and low-frequency characters had counts less than 50. The complexity of the characters was defined as the number of strokes comprising a character, as defined in a study by Shieh et al. (1997). High-complexity Chinese characters were defined as comprising more than 13 strokes, whereas low-complexity characters had fewer than eight strokes. The size of the 120 characters forming the article was 12 point, with 20 characters per line. The text/background color combination for the static information was black-on-white. When the target character was found in the article, the subjects used the mouse to move the cursor to the character and left-click. Simultaneously, the target character in the article disappeared.

During the processing of the experiment, a leading display was shown simultaneously above or below the static information. The frame length of the leading display was 18 cm; the size of the display characters was 12 point. The screen display is shown in Fig. 3. The content article of the leading display was selected randomly from an encyclopedia; each paragraph was composed of 80 Chinese characters. The subjects were asked to read the paragraph content of the leading display in a limited time when they handled the search task for the static information. In each trial, the subjects needed to finish the search and reading task in 50 s. During this period, the leading display repeated again and again. As the time expired, the number of target characters, which had been discovered, was collected. Additionally, three multiple-choice comprehension questions on the leading-display content were displayed on the screen, as shown in Fig. 4. The subjects were to respond by clicking the mouse to choose answer 1, 2, 3, or 4.

The subjects were asked not to attempt any task on-screen for an hour before the experiment, in order to prevent visual fatigue. Before the beginning of each subject's experiment, two practice passages were run. Then 48 trials were conducted in the processing of the experiment for each subject. Consequently, in each 12 leading-display factor combinations (six text/background color combinations × two leading-display positions), four trials of four types (two complexity × two frequency) of target characters for static information were conducted in a random display sequence.

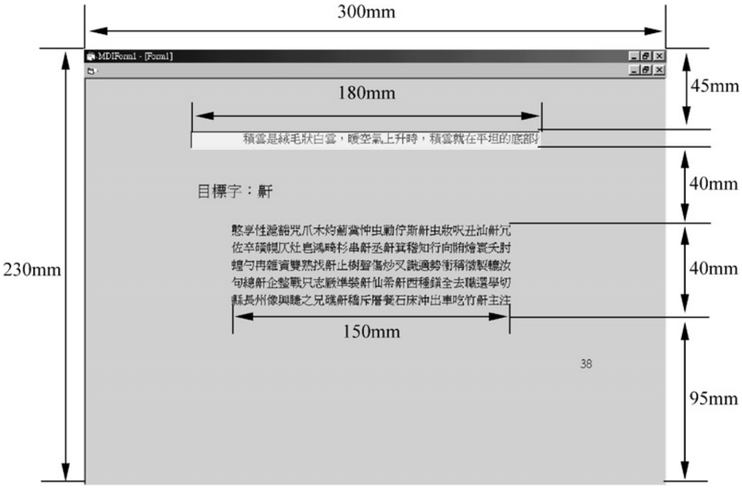

Fig. 3. Example of screen display used in this study.

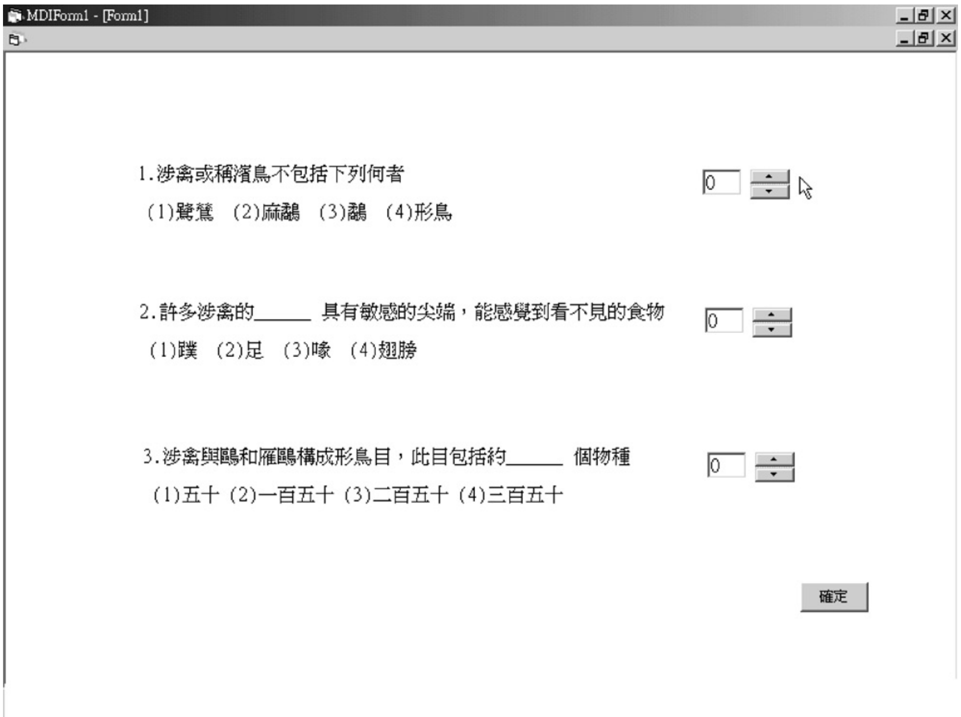

Fig. 4. Display of multiple-choice questions for leading display in this study.

2.6. Data collection and analysis

Two dependent measures collected in this study were percentage of correct searches for static information and comprehension of leading display. The collection procedure was as follows:

1. The percentage of correct searches for static information was calculated by averaging the

percentage of correct searches in four trials under a combination of leading-display factors. Regarding the calculation of the percentage of correct searches in each trial, the formula was as follows:

2.

$$\text{Percentage of correct searches} = \frac{(\text{number of target characters subject discovered})}{(\text{actual number of target characters})}.$$

Comprehension of the leading display was calculated by dividing the number of correct responses to the questions by the total number of questions in each trial.

All statistical analyses were performed by using Statistical Analysis System (SAS) software. An analysis of variance (ANOVA) was conducted on the dependent measures. The factors that were significant were further analyzed using the Tukey's Honestly Significantly Difference (HSD) test to determine the difference among the factor levels.

3. Results

3.1. Visual performance on static search task

The subject's average percentage of correct searches for each independent variable level is shown in Table 3. The results of ANOVA showed that subject's percentage of correct searches for static information was not significantly different under different levels of all leading-display factors, including all interaction effects among factors.

3.2. Comprehension for leading-display reading task

The subjects' leading-display comprehension for each independent variable is shown in Table 4.

3.2.1. Effect of VDT type on comprehension of leading display

The ANOVA results showed that VDT type had no significant effect on the subject's comprehension in reading leading displays. While the experimental VDT screens were TFT-LCD and CRT, the comprehension scores were 0.722 and 0.729, respectively.

3.2.2. Effect of speed on comprehension of leading display

The ANOVA results also showed that the subject's comprehension in reading leading display was not significantly different under different leading-display speeds. While the display speeds were at 250 and 300 wpm, the comprehensions was 0.7271 and 0.7240, respectively.

3.2.3. Effect of jump length on comprehension of leading display

The results of ANOVA showed that the subjects' comprehension in reading leading displays was significantly different under different jump lengths in the leading displays ($F(2, 24) =$

Table 3
Mean percentage of correct searches for static information at each level of leading-display independent variables

Variable	*n*	Percentage of correct searches
VDT type		
CRT	216	0.9119
TFT–LCD	216	0.9083
Speed		
250 wpm	216	0.9187
300 wpm	216	0.9015
Jump length		
0.70 cm	144	0.9277
1.05 cm	144	0.9061
0.35 cm	144	0.8965
Color combination		
White-on-black	72	0.9177
Blue-on-white	72	0.9174
Green-on-white	72	0.9120
Black-on-white	72	0.9049
Blue-on-yellow	72	0.9049
Red-on-white	72	0.9038
Display position		
Above-static-information	216	0.9101
Below-static-information	216	0.9101

Notes: No variable has a significant effect on the mean percentage of correct searches for static information at $\alpha = 0.05$.

Table 4
Mean comprehension of leading display at each level of the leading-display independent variables

Variable	n	Comprehension	Tukey grouping[a]
VDT type			
CRT	216	0.7290	
TFT–LCD	216	0.7221	
Speed			
250 wpm	216	0.7271	
300 wpm	216	0.7240	
Jump length*			
0.35 cm	144	0.7505	A
0.70 cm	144	0.7456	A
1.05 cm	144	0.6804	B
Color combination**			
Black-on-white	72	0.7695	A
Blue-on-white	72	0.7689	A
Red-on-white	72	0.7683	A
White-on-black	72	0.7080	B
Green-on-white	72	0.7015	B
Blue-on-yellow	72	0.6369	C
Display position			
Above-static information	216	0.7288	
Below-static information	216	0.7223	

Notes: *Significant at $\alpha = 0.05$ level.
** Significant at $\alpha = 0.01$ level.
[a] Values with same letter are not significantly different.

4.66, $p<0.05$). The subjects' comprehension of jump lengths of 0.35, 0.7, and 1.05 cm were 0.7505, 0.7456, and 0.6804, respectively. The result of the Tukey's HSD test demonstrated that the subject's comprehension of jump-length groups of 0.35 and 0.7 cm was significantly higher than for the 1.05 cm group.

3.2.4. *Effect of text/background color combination on comprehension of leading display*

The ANOVA results showed that the text/background color combination in a leading display had a significant effect on the subject's comprehension in reading leading displays ($F(5, 120) = 13.08$, $p<0.01$). The subject's comprehension for the color combinations of black-on-white, blue-on-white, red-on-white, white-on-black, green-on-white, and blue-on-yellow was 0.7695, 0.7689, 0.7683, 0.7080, 0.7015, and 0.6369, respectively. The result of the Tukey's HSD test demonstrated that the subjects' comprehension for color-combination groups of black-on-white, blue-on-white, and red-on-white was significantly higher than for the group of white-on-black and green-on-white, and higher than for the blue-on-yellow group.

3.2.5. *Effect of display position on comprehension of leading display*

The ANOVA results showed that the position of a leading display had no significant effect on the subjects' comprehension in reading leading displays. While the display positions were above and below the static information, the comprehension scores were 0.7288 and 0.7223, respectively.

3.2.6. *Interaction effect among factors on comprehension for leading display*

All other interactions among leading-display factors had no significant effect on comprehension, including two-factor interactions and three-factor interactions.

4. Discussion

4.1. *Performance on static-information searches*

In previous research, visual performance on leading display has been the major focus of measures for evaluating the adequacy of leading-display design (Granaas et al., 1984; Chen and Tsoi, 1988; Juola et al., 1995; Wang and Chen, 2003; Wang et al., 2002). Leading display usually does not appear alone; however, especially on websites, it is always designed to accompany static information. The effect of leading-display design on visual performance for static information has also been an important issue. On the basis of observation during the experiment, most subjects tended to consider the search task for static information as a primary and the reading task for leading display as secondary. Because both tasks required the use of both visual and mental resources, the subjects should use their limited resources to handle the dual tasks simultaneously by using time-sharing methods. The tasks for static information and leading display were designed to be different in this study; that is, searching for static information and reading a leading display. Subject's mental resources can be simultaneously shared by these two tasks. When most primary resources of the subjects were used on the primary task (searching for static information), the effect of the leading-display factor on the visual performance of the two tasks did not affect the search for static information but, rather, in reading the leading display. Nevertheless, if the tasks for static and leading information were both reading tasks, the effect of leading-display design on visual performance of static and dynamic information needs to be investigated further.

4.2. Reading performance for leading display information

Regarding the dynamic characteristics of leading display, speed had no significant effect on the subjects' comprehension in reading the leading displays in this study. However, jump length was a significant factor in the subject's comprehension. This result was similar to that in the English leading display study of Juola et al. (1995), who found that the subjects' accuracy was not significantly different when the speed of the leading display was at 260 and 171 wpm. However, the best accuracy of the subjects was when the jump length was three characters, then two characters; the worst was when the jump length was one character. In this Chinese leading-display study, the subjects' comprehension performance at different speeds and jump lengths was the same as the result obtained by Wang and Chen (2003). When the jump length was at 0.35 or 0.7 cm, the subjects had the best comprehension. Jump lengths of 0.35 and 0.7 cm also can be converted to 0.8 and 1.7 for 12-point Chinese characters. According to the English leading-display results of Granaas et al. (1984), the subjects had poorer reading comprehension when the jump length was at one or two characters, but had no significant difference when the jump lengths were at four to 10 characters. If the phenomenon of an average five characters forming an English word is taken into consideration, four to 10 characters can be converted to 0.8 to two English words. Consequently, the jump lengths of leading displays for English and Chinese have similar findings.

The effects of speed and the interaction between speed and jump length on the subjects' comprehension, which were found in the English leading-display research by Chen and Tsoi (1988), were not found in this study. The major reason may be the difference between English and Chinese words. Because an English word is usually composed of several characters, subjects' comprehension will be reduced by the effect of the partial display of a word caused by a faster speed. Nevertheless, the phenomenon of one character's forming a Chinese word reduces the effect of speed on the subjects' comprehension.

In this study, the color combination of the text/background was also a significant factor for the subjects' comprehension in leading display. In the leading-display studies by Wang et al. (2002) and Wang and Chen (2003), the subject's search and reading performance on leading display was also better when the text/background color differences of leading display became larger. Additionally, when the jump length of the leading display was larger, the text/background color combination had a much more significant effect on reading performance. In this study considering leading display associated with static information display, the subject's comprehension was not affected by only the text/background color differences in the leading display. The effect of color consistency between the leading display and static information also resulted in different comprehension performance. When the text/background color difference is plotted on the x-axis in increasing order, the trend in comprehension associated with color difference is shown in Fig. 5.

The subject's comprehension is found not to increase entirely as text/background color difference increases. On the basis of the results of the Tukey's HSD test, the subject's comprehension was the best when the background color in leading

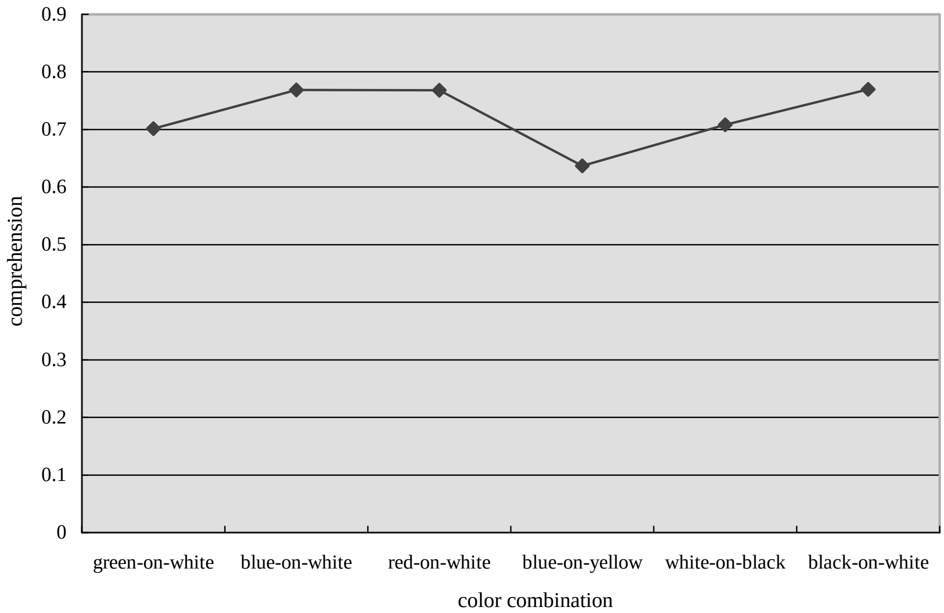

Fig. 5. Subject's comprehension for each text/background color combination in leading displays.

display was designed to be the same white color as that of the static information background except the color combination green-on-white. Nevertheless, the subjects had secondary comprehension with the text/background color combination of green-on-white despite its lowest color difference. Additionally, the subject's comprehension with the color combination of white-on-black, which possessed the same highest color difference as black-on-white, was only in the same secondary grouping with green-on-white. Consequently, the subjects' comprehension with the color combination of blue-on-yellow, which possessed a medium color difference and different background color, was the worst. The findings of this study might be due to the two categories of color combination effects. The first priority effect was that of background color. Under the condition of white background color of the static information, the experimental results showed that the leading displays with white background color resulted in higher subject's comprehension. The second was the effect of the color difference. Experimental results showed that leading display with greater color differences of the text/background color combinations resulted in higher subject's comprehension. The two effects of text/background color combinations on the subject's comprehension can also be explained by the VDT display recommendations of Sanders and McCormick (1993), who suggested that VDT designers use as few colors as possible to maximize the color contrast between text and background. White background color is a widely used background-color setting of static information; consequently, the guidelines for the design of the text/background color combination in the leading display under the condition of white background color of the static information are first to select those color combinations in which the background colors of the leading display are also white, then to adopt those color combinations with a higher color difference. Nevertheless, if the background color of static information was set to be other colors, the effect of text/background color combination for leading-display design needs to be investigated further.

On the basis of the four display principles (importance, frequency-of-use, functional, and sequence-of-use) of Sanders and McCormick (1993), static information is usually considered to be the major element and is placed in the center region of the screen. Consequently, the leading display is usually designed to appear above or below the static information. In this study, the subject's comprehension was not significantly different when the leading display was designed above or below the static information. The major reason might be the vertical movement of the subject's eyes when handling the leading display and static information dual-task simultaneously. Regardless of whether the leading display was above or below the static information, the subject's eye movements from static information to leading display, for which time-sharing visual tasks are required, were both vertical. Eye movement during reading is an important factor in comprehension; consequently, there was no significant difference in comprehension performance in the two display-position cases. Nevertheless, a Chinese leading display, which is different from English, can be designed to display vertically (characters advancing form lower to upper). Whether user's comprehension might be affected by a vertical leading-display positions (right or left side of the static information) remains an interesting issue which needs to be investigated in future research.

In this study, the VDT type also had no significant effect on the subject's performance in reading leading displays and searching for static information. The finding for static information was different from the results of Shieh and Lin (2000), who pointed out that a TFT–LCD was better than a CRT for their VDT static-information display. The major reason for the difference might be due to the size and resolution of monitors. In the study by Shieh and Lin, different sizes (17 vs. 12.1 in) and resolutions (1024×768 vs. 99×600) were set in CRT and TFT-LCD monitors. Screen size and resolution are both important factors in visual performance. Consequently, no significant difference in visual performance was found when using TFT-LCD and CRT with the same size and resolution as in this study. The effect of VDT type on the reading performance in leading displays was the same as in the Chinese leading-display studies by Wang et al. (2002) and Wang and Chen (2003). Based on technological progress, the luminance and stability of the TFT-LCD were better than that of a traditional LCD and were not significantly different in comparison with the CRT.

5. Conclusions

In this study, investigating the effects of leading-display design factors on user's search performance for static information and reading performance for leading display, guidelines for website designers in devising a more adequate leading display are as follows:

1. When users access a website to search for needed information and read the information in leading display on the homepage simultaneously, the effect of the leading-display factor on the search performance for static information is not significant.
2. When users handle static information and leading display dual-tasks, the subject's comprehension of leading display was not significantly different at speeds of 250 and 300 wpm; monitors of CRT and TFT-LCD; positions of above- and below-static information.
3. The jump length of the leading display had a significant effect on comprehension for leading display. When the jump length was set at 0.35 and 0.7 cm, the subjects exhibited better comprehension performance.
4. The text/background color combination of the leading display was a significant factor in the comprehension for leading display. Designers should first select those color combinations in which the background color of the leading display is white under the condition of white background color, then to adopt those color combinations with a higher color difference.

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