A PRELIMINARY OF BACKGROUND COLOR EFFECTS FOR ELDERLY AND YOUNG PEOPLE BY USING NEAR-INFRARED SPECTROSCOPY

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ABSTRACT Many studies have suggested that the design of tablet screens can affect the performance of the tablet users. The purpose of this study is to investigate the effects of screen background colors on the brain functions for elderly and young people when they are performing a task on a tablet computer. The authors conducted an experiment to understand the effects of background colors on attention. Twenty university students (15 males, 5 females) and 10 elderly people (7 males, 3 females) participated in the experiment. The subjects were told to count the number of circles on a five different background colors, which are white, blue, yellow, red, and green randomly, in a short period of time. Each background color consisted of ten circle counting task. All the task pages were designed in the same way, in which three different symbols including circles were presented in black and randomly drawn on a single-color background of a tablet screen. The circles counting task was used as an attention exercise. By using near-infrared spectroscopy, we investigated the activities of the brain of each subject when he/she was performing the circle counting task. The average percentages of correct answers for the circle counting tasks that the subjects performed were higher with yellow and blue backgrounds for young people, while for elderly people the percentages of correct answers were higher for blue background than with the white background color. The results indicate that white color may not be the best choice for a background color of a tablet screen for best performance and attention for both young and elderly people.

INTRODUCTION

Currently, the technology has been growing up very fast. The use of a tablet computer with the fast speed of the Internet that has been penetrated into our life becomes an essential part for people. Tablet computer with its portability, efficiency, ease-of-use, and its speediness, has been considered to be an ideal tool whether for elderly or young people (Jayroe & Wolfram, 2012). Tablet computers also have been used to enhance people everyday life and to strengthen the brain cognitive ability (Chan, Haber, Drew & Park, 2014). Many studies have suggested that the design of a tablet computer screen can affect the attention, concentration and performance when people use a tablet computer (Yamazaki & Eto, 2015).

Some studies also have investigated the combination of text and background colors on a computer screen in relation to its effect on task performance (Tharangie, Irfan, Marasinghe & Yamada, 2008), (Jang, Kim & Yi, 2007). Hall and Hanna suggested that greater contrast ratios between background and font colors lead to better readability (Hall & Hanna, 2004). A study of background colors conducted by Mehta and Zhu indicated that task performance can be affected by background colors (Mehta & Zhu, 2009). Yamazaki examined whether the background colors of computer-based and Web-based tests influenced the scores of test takers and suggested that neurological factors associated with color characteristics can affect the test score averages of university students for different background colors (Yamazaki, 2010). A preliminary study also by Yamazaki and Eto on the effects of blue backgrounds on a tablet screen for elderly people suggested that white color may not be the best choice for a background color of a tablet computer screen for elderly people. The objective of this study is investigate whether different background colors can make a difference in terms of performance and brain function of elderly and young people when they perform a task on a tablet computer. Therefore, in this study, we compare the brain activity of young and elderly people to see the difference in the working memory area and concentration ability so that it can give a help to provide a suitable training method to control the rate of mental declining. The suitable background color that could

enhance the cognitive ability of elderly people should be investigated through this study.

EXPERIMENT

The experiment was conducted to investigate the concentration levels and working memory of elderly and young people when they performed task on a tablet computer with five different screen background colors: white, blue, yellow, red, and green. A total of 30 subjects (20 young people, 10 elderly people) participated in this experiment. In order to identify which part of subjects` brain is activated, a circle counting task was used in this experiment. Subjects` concentration levels and relative changes in blood hemoglobin (Hb) concentrations in the brain will be measured by using a near-infrared spectroscopy (NIRS) system during the task.

Circle counting task with five background colors

For the experiment, five sets of the circle counting task with each background color and black text were developed. Each test set had ten circle counting task. All the task pages were designed in the same way, in which three different symbols including circles were presented in black and randomly drawn on a single-color background of a tablet screen. The circle counting task was used to test subject`s concentration level. The subjects were told to count the number of circles on each background color in a short period of time. Figure 1 shows the example of the circle counting task pages with white, blue, yellow, red, and green background color and black symbols. Lenovo YOGA 2 tablet computer, which has a screen size 10.1" (1920 by 1200 pixels), was used in the experiment.

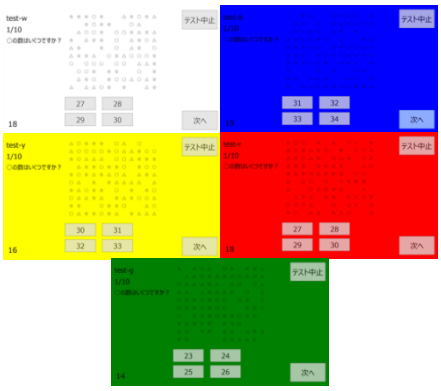

Fig. 1 The example of circle counting task pages for each background color.

Subjects

Twenty Japanese subjects in their twenties (15 males, 5 females) and 10 healthy elderly people ages over 65 years old (7 males, 3 females) participated in this study. None of them was reported to have a color vision deficiency at the time of the experiment. The subjects were given instructions prior to undertaking the tasks. None of them had trouble doing the tasks on the tablet computer during the experiment.

Experimental Method

All the subjects performed the task with black symbols and background in five colors randomly. The duration was set to 30 seconds for one circle counting page. The subjects need to choose the answer by speak out loud the answer and pushing the button on the screen from the four choices of the answers. All the subjects finished the task and give the answer in the time given. The scores of the task obtained were analyzed to see the differences between the test sets of five background colors.

After finishing the task for each color, subjects responded to the designed questionnaire for a feedback about the task. The questionnaire asked about the tiredness, readability and the concentration levels during taking the test using a five-point scale. The relative changes in hemoglobin concentrations were measured and recorded by using the Hitachi NIRS (WOT-100) with 16 channels while subjects performed the task. The probes cover the frontal regions as shown in Figure 2. The relative changes in oxy-, deoxy-, and total hemoglobin concentrations were recorded for each subject.

Fig. 2 A young male subject performing the task

RESULTS

The average percentages of circle counting tasks answered correctly for each background color were calculated and summarized in Table 1.

Table 1. Average percentages of the circle counting task: (a) Young subjects and (b) Elderly subjects.

(a)

Background color	*Average % of correct answers of circle counting task*
White	72
Blue	82
Yellow	84
Red	76
Green	79

(b)

Background color	*Average % of correct answers of circle counting task*
White	67
Blue	72
Yellow	78
Red	69
Green	73

The average percentages for circle counting tasks

performed by both young and elderly subjects were higher for yellow, blue, and green rather than white and red background colors. The authors also conducted a t-test ($p<0.05$) to examine the significance of the differences between for each background colors with white background colors for the correct answers of circle counting task. The examinations results are shown in Table 2.

Table 2. Examination results of t-tests for the circle counting task score: (a) Young subjects and (b) Elderly subjects.

(a)

	White	*Yellow*
Mean	7.15	8.4
Variance	2.976315789	1.936842105
Pearson Correlation	0.368272312	
t Stat	-3.152338575	
P(T<=t)	0.00524504	
	White	*Blue*
Mean	7.15	8.15
Variance	2.976315789	2.028947368
Pearson Correlation	0.482967659	
t Stat	-2.75680975	
P(T<=t)	0.012548265	
	White	*Green*
Mean	7.15	7.9
Variance	2.976315789	2.831578947
Pearson Correlation	0.621851488	
t Stat	-2.262688772	
P(T<=t)	0.035563027	

(b)

	White	*Yellow*
Mean	6.1	7.8
Variance	6.544444444	3.955555556
Pearson Correlation	0.462970389	
t stat	-2.234350567	
P(T<=t)	0.052323778	
	White	*Blue*
Mean	6.1	7.2
Variance	6.544444444	8.177777778
Pearson Correlation	0.801931675	
t stat	-2.012045511	
P(T<=t)	0.07507983	

In Table 2, we considered that yellow, blue, and green background colors have significant differences with white background colors of young people, while yellow and blue background colors have significant differences with white background color of elderly people for circle counting task score. The authors then observed the significant differences for the hemoglobin (Hb) concentration changes that have been recorded by wearable NIRS for these background colors. However, the examination results demonstrated that only blue background color has significant differences with white background colors for several channels of both young and elderly people. The examinations results are shown in Table 3.

Table 3. Examination results of t-tests for the hemoglobin concentration changes: (a) Young subjects and (b) Elderly subjects.

(a)

CH6	*White*	*Blue*
Mean	0.461193828	-0.493492429
Variance	2.024625191	7.359081418
Pearson Correlation	0.744439438	
t stat	2.238841494	
P(T<=t)	0.0373299	
CH11	*White*	*Blue*
Mean	0.191159191	-0.129853895
Variance	0.143307341	0.323463662
Pearson Correlation	-0.040345946	
t stat	2.063243186	
P(T<=t)	0.053024906	
CH13	*White*	*Blue*
Mean	0.759871795	0.038191876
Variance	2.863350923	3.857662165
Pearson Correlation	0.642750304	
t stat	2.062525518	
P(T<=t)	0.053099798	
CH16	*White*	*Blue*
Mean	0.626395112	-0.015585704
Variance	1.779278869	0.214141032
Pearson Correlation	0.225630936	
t stat	2.192407357	
P(T<=t)	0.041003601	

(b)

CH6	*White*	*Blue*
Mean	0.19605214	-0.061971213
Variance	0.108397248	0.055496484
Pearson Correlation	0.509046462	

t stat	2.799814157	
P(T<=t)	0.020718924	
CH12	White	Blue
Mean	-0.008760631	-0.254698111
Variance	0.13516668	0.358818353
Pearson Correlation	0.787247374	
t stat	2.026821402	
P(T<=t)	0.073309924	
CH14	*White*	*Blue*
Mean	0.3698326	-0.140543528
Variance	1.077769007	0.328786187
Pearson Correlation	0.587210717	
t stat	1.918858739	
P(T<=t)	0.087215782	

In Table 3, we considered that, for young people, CH6, CH11, CH13, and CH16 showed significant differences for Hb concentration changes from white and blue background colors, while for elderly people, CH6, CH12, and CH14 showed significant differences for Hb concentration changes from white and blue background colors out of all 16 channels.

DISCUSSION & CONCLUSION

In this study, the brain activity of elderly and young subjects was analyzed to investigate background color effects of a tablet screen. The results demonstrated that blue were the best background color to perform the circle counting task. NIRS measurement result showed that some areas on the frontal cortex of the brain were highly activated when the subjects performed the circle counting task with a blue background color compared to a white background color for both young and elderly subjects. These results suggest that a white background color with black symbols may not be the best choice for elderly and young people. In the future, we need to analyze in detail about brain regions to find which region that corresponded with the activated channel. Then, the working memory area also should be focused in the future as working memory is responsible for the processing of new and ready stored information. The reading span task also will be conducted in order to investigate the working memory area of the young and elderly people. The number of subjects also need to be increased, since brain functions are known to vary among individuals.

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