Influence of Color Combination Pattern Considered Usability to Mental Workload

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Abstract. About color combination using general VDT works, to clarify that feature color combination patterns considered usability are favorable color combination for human from the view point of fatigue, physiological data change during 30 min VDT works with low cognitive load were measured and subjective evaluation was carried out. In this experiment, as feature color combination patterns located on each quadrant in color combination image scale, black, blue, green and pink are used, and as fatigable color, cyan is used. As physiological data, ECG, pupil meter and GSR is measured. From the results of experiment, feature color combination patterns considered usability got higher evaluation from the view point of physiological data and subjective evaluation than a fatigable color combination. Therefore, we concluded that feature color combination patterns considered usability are no significant difference about fatigue and human can use these colors without fatigue.

Keywords: Color combination pattern · Mental workload · Usability

1 Introduction

Personal computer was spread widely with the advent of the information society, and it has become essential in a variety of fields of any industry. Information also in the context of daily life such as computer screen, of course, mobile phones and car navigation systems began to appear on the LCD (liquid crystal display) screen. Some tasks became convenient by the spread of the computer. On the other hand, the complaints on the physical symptom such as fatigue and psychological symptoms such as frustration and reduction of attention are rapidly increasing [1]. One of the causes of mental workload by VDT work, which it may have to continue watching the LCD screen. The elements of screen design have a variety such as character size, the entire layout, especially screen color combination is an essential element [2]. The element of color combination in VDT work is a factor of mental workload (MWL).

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Our previous research [3] was reported that the difference of the background color of the screen influence the MWL, difference of color combination of central vision and peripheral vision appears at physiological and psychology responses, and MWL is low on color combination in the central region with black characters on a white background using the peripheral color of blue series. However, the actual business type screen is not necessarily only color of bluish, is used color combination that matches its operations or the customer requirements. MWL is high when these color screen are used. There are variations between the color combination, such color scheme is not suitable as a design guideline.

In this study, we have created feature color combination patterns to refer to the color combination pattern, which is provided as a design guideline. About color combination using general VDT works, to clarify that feature color combination patterns considered usability are favorable color combination for human from the view point of fatigue.

2 Method

To examine the MWL due to a difference in color combination patterns, physiological data change during 30 min VDT works with low cognitive load were measured and subjective evaluation was carried out.

2.1 Color Combination Pattern

In this experiment, as feature color combination patterns located on each quadrant in color combination image scale, black, blue, green and pink are used, and as fatigable color, cyan is used. These color combination patterns were used in our previous research [4] (Fig. 1).

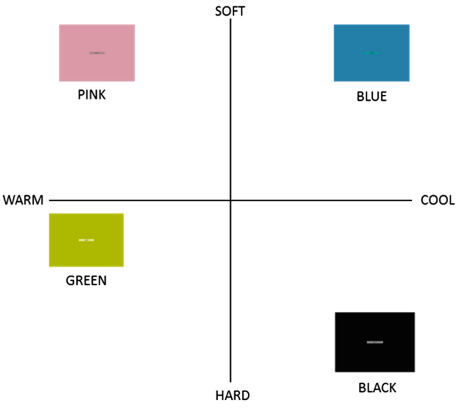

Fig. 1. The color combination patterns (Color figure online)

2.2 Measurement Indices and Evaluation Items

As physiological data, ECG, pupil meter and GSR is measured. These data are analyzed as LF/HF, change in diameter and change in potential, respectively. Two subjective evaluations are also carried out. One is VAS (Visual Analog Scale) evaluation by using a questionnaire and another is an emotional/sensitive evaluation by using 15 items and seven scales questionnaire. Table 1 shows VAS evaluation items and Table 2 shows 15 items of an emotional/sensitive evaluation.

2.3 Experimental Task

The experimental task was two-digit addition mental arithmetic task. Formula was presented in the center of the screen. This is a summation of task without the carry, is very low cognitive load. The participants performed this calculation in mental arithmetic when formula of task appeared on the screen, and enter using the numeric keypad. This task was repeated for 30 min. In order to avoid the effects of fatigue due to task, color combination conditions that can a participant attempted in a day, it was up to two conditions. Moreover, inter-color conditions were taking one hour or more break at least. Figure 2 shows an example of screen.

Table 1. Five items of VAS evaluation

5 items of VAS evaluation
Concentration
Monotony
Dazzling
Sleepy
Bored

Table 2. Fifteen items of an emotional/sensitive evaluation

Item	Item
Friendly-uncompanionable	Responsible-doubtful
Kindly-unkindly	Dependable-less dependable
Feel calm-exciting	Active-passive
Considerate-no considerate	Simple-decorative
relax-look worried	Urban-archaic
Safety-dangerous	Beautiful-ugly
Refreshing-darkish	Favorite-dislikable
Clear-jumble	

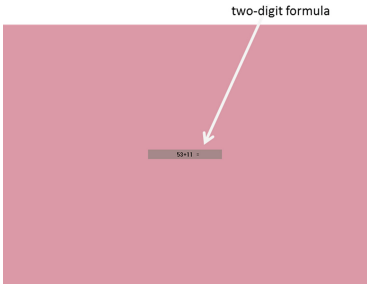

Fig. 2. An example of task screen

2.4 Participants

The participants were ten (4 male and 6 female), and average age was 22.5 ± 1.71 age. Color vision characteristics were not observed.

3 Results and Discussion

3.1 Physiological Indices

At first, the standardized data was analyzed on LF/HF. ANOVA on color combination patterns was carried. There was no significant difference between color combination patterns. Stimulus that a clear change appears in the HF is pretty strong. Therefore, it stands to reason that there is no difference on these color combination patterns that was friendly usability on this experiment. Moreover, for cyan used as a color tired easily, it had been found that it was not intended effect on the indicator in 30 min work.

Next, the result of pupil diameter shows on Fig. 3. As the result of ANOVA on color combination patterns, there was a significant difference ($p < 0.05$) on patterns. Then, multiple comparisons were carried. There were significant differences between black and pink ($p < 0.05$), and between black and cyan ($p < 0.01$). Black pattern is low

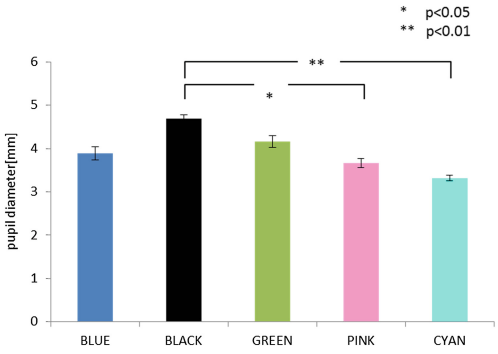

Fig. 3. The result of pupil diameter

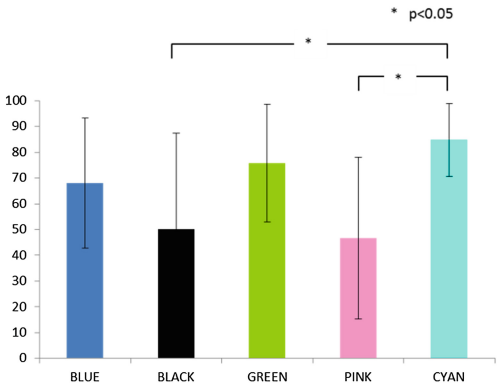

Fig. 4. Dazzling on VAS evaluation

brightness, and pupil diameter on black pattern increases. On the other hand, cyan pattern is high brightness and color contrast and pupil diameter decreases. Thus, the difference occurred between black pattern and cyan. The difference also occurred between black pattern and pink, however there was no difference on them between rest and task execution. This clarified the influence of the task execution on cyan. This was considered to be data to support that it was a color pattern that tired easily.

As the result of GSR, the standardized data was analyzed as similar with LF/HF. ANOVA on color combination patterns was carried. There was no significant difference between color combination patterns. GSR was concluded to be an effective indicator to evaluate the MWL on color pattern on our previous result. This was caused by the follows; the contrast of color combination patterns in this study was lower than the previously including cyan and it was weak as a color stimulus.

3.2 Evaluation Items

ANOVA on color combination patterns was carried for 5 items of VAS evaluation. There was a significant difference between color combination patterns on dazzling ($p < 0.05$). As the result of multiple comparisons, there were significant differences between cyan (Fig. 4). The score of cyan was higher than other patterns. This result was similar tendency as it of pupil diameter.

The factor analysis was examined to integrate the variables for 15 items. The result of cumulative contribution ratio (maximum-likelihood method, promax rotation) was 74.242 %. Three factors were extracted as the follows (Table 3); factor 1 was “gentleness”, factor 2 was “refreshing feel”, and factor 3 was “civilization”. The factor score was calculated and plotted on factor axis. This result shows that the factor score of cyan pattern was lowest. Also in the evaluation of emotional/sensitive aspects, evaluation of cyan, which be tired easily was the lowest. This was corroborated the conventional results.

Table 3. The result of factor analysis

	factor		
	1	2	3
considerate	.866	.634	.199
kindly	.854	.556	.161
favorite	.839	.459	.233
friendly	.828	.640	.259
feel calm	.823	.582	.083
safety	.822	.587	.029
relax	.809	.511	.026
beautiful	.799	.585	.284
responsible	.754	.727	.289
clear	.676	.993	.127
simple	.624	.776	.164
refreshing	.521	.591	.164
urban	-.117	.135	.781
dependable	.564	.405	.773
active	.017	-.174	.452
cumulative contribution ratio	54.556	66.625	74.242

4 Conclusion

This study examined the influences by screen gaze task using color combination patterns which was designed by considered usability and was tired easily from the view point of physiological and emotional data.

From these results, feature color combination patterns considered usability got higher evaluation from the view point of physiological data and subjective evaluation than a fatigable color combination. Therefore, we concluded that feature color combination patterns considered usability are no significant difference about fatigue and human can use these colors without fatigue.

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