

EFFECTS OF CHROMATIC COLOUR LIGHTING ON COGNITIVE TASK PERFORMANCES

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Abstract- Recently, the spread of lighting using the LED is progressing. LED light source is able to reproduce most of the chromatic colour, because red, green and blue are the three primary colours of light, and these colours of LED is assembled. The chromatic colour lighting is considered that it is effective physical and psychological impact of human. Therefore, the aim of this study is to investigate the effect of chromatic colour lighting on the cognitive performance. In this experiment, the illuminance of work space was 550lx by LED light source to suit environment for cognitive performance. Lighting colours were white, red, green and blue. Memory tasks, calculate tasks, creative tasks and subjective evaluation tasks were conducted as the cognitive performance. As the results, white light colour was high score than the all other light colours in memory tasks. However, the significant difference was not observed by each light colour. Moreover, green light colour was high score than white light colour, and significant difference was observed in creative tasks. This suggests that green lighting has a positive influence on creative work.

Keywords - Chromatic lighting, Cognitive performance, Green, Creative work.

1. INTRODUCTION

Recently, the spread of lighting using the LED is progressing. LED light source is able to reproduce most of the chromatic colour, because red, green and blue are the three primary colours of light, and these colours of LED is assembled. The chromatic colour lighting is considered that it is effective physical and psychological impact of human. There is such as suicide prevention effect of blue lighting that installation 1) has been promoted to the station. Past studies reported that colour affected the perception judgment and cognitive processing of human. Soldat et al.2) reported that in the problem solving tasks, the participants using blue and white paper outperformed the participants using red paper. Mehta et al. 3) reported that red background colour led to superior performances on detail-oriented tasks, and blue background colour led to superior performances on creative tasks. Ishise et al. 4) reported that examined the relationship of work efficiency and the wall colour. It was suggested that there is not relationship between the work efficiency and the wall colour. Kojima et al. 5) reported that the red lighting conditions was higher the accuracy of memory than the blue lighting conditions. In the case of red lighting, there is reported an awakening effect. Some studies reported that long-wavelength (red) light increased alertness in daytime6),7),8). However, in past studies, there is no knowledge that is consistent on the work efficiency and suitable light colour for work. Moreover, the lighting conditions used in past some studies are considered to be unnatural because they were conducted under low illuminance conditions, and those studies did not clarify the effects of chromatic colour lighting on cognitive performance. Chiang et al. 9) reported that 500lx was a standard as the

suitable illuminance under the LED lighting environment. Therefore, the aim of this study is to investigate the effect of chromatic colour lighting on the cognitive performance.

2. EXPERIMENT

In this experiment, the illuminance of work space is 550lx by LED light source to suit environment for cognitive performance. Work space is the A4 size area on the desk. The partition that created paste the white wallpaper in white styrene board was installed on the desk in order to eliminate the influence of the surrounding colours. The light source was adjusted to a height of 1.0m from the desk surface. The illuminance was adjusted to 550lx by DC power supply. Table 1 shows the experimental conditions. In this experiment, the subjects were asked to perform four different tasks. Memory tasks are tasks to memorize the vocabulary presented in matrix Table (5×5). Each word is shown in “hiragana”, “katakana”, “kanji” and “alphabet”. The subject memorizes both the positions and vocabularies visually. Calculate tasks are “addition”, “multiplication”, “linear function” and “quadratic function”. Calculation time and correct answer rate are measured. Creative tasks are creating new applications. The subject is given a topic, and is asked to suggest a lot of ideas in 4 minutes. This task is evaluated the number of ideas. Subjective evaluation tasks are evaluated by SD method. Eight pairs of words (able to concentrate/not able to concentrate, bright/dark, easy to read/difficult to read, tireless/tire, not oppressive/oppressive, not sleepy/sleepy, calm/restless, easy to learn/difficult to learn) are employed in this study.

The following procedure was used in the experiment:

- (1) The subject is given 3 minutes to adapt to a chromatic lighting in the laboratory.
- (2) The memory task is presented for 3 minutes.

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- (3) The subject performs calculate task.
- (4) The subject performs creative task for 4 minutes.
- (5) The subject performs memory task for 3 minutes.
- (6) The subject performs subjective evaluation task by Semantic Differential (SD) method.

Steps (1) to (6) are repeated each light colour at random to avoid the order effect.

The subject performs memory task after performing calculate task and creative task in order to examine the difference in the long-term memory.

Table 1 Experimental conditions

Light source	LED
Illuminance of work space	550 lx
Uniformity ratio of work space	0.8
The height of light source	1000 mm
Desk size	H:750 mm × W:1040 mm × D:730 mm
Chromaticity	White : (0.29, 0.29) Red : (0.69, 0.30) Green : (0.22, 0.62) Blue : (0.16, 0.12)
Subjects	14 males in their 20s

3. RESULTS

The one-factor analysis of variance (ANOVA) was performed in this study. The factor was light colour and the multiple comparisons were performed by fisher’s LSD (Least Significant Difference) method. The analysis was performed a significant difference between white colour and other colours.

Figure 1 shows the score of memory tasks at the correct answers with both position and word. Figure 2 shows the number of correct answers. These results showed the white light colour was high score than the all other light colours. As shown in the figure 1, red light colour was the lowest score. It is thought that red is reminded “danger” and motivate behavior such as attention to detail. However it is considered that these motivations are the inhibition of memory tasks, and become reduced performance. The significant difference was not observed in memory tasks by each light colour.

Figure 3 shows the calculate time. Figure 4 shows the correct answer rate. As shown in the figure 4, blue light colour was slightly lower correct answer rate than the all other light colours. The significant difference was not observed in calculate tasks by each light colour.

Figure 5 shows the result of creative task. Fluency shows the number of answer. This result showed the green light colour was the highest score than the all other light colours, however the significant difference was not observed.

Figure 6 shows the subjective evaluation scores. The all evaluation scores of white and green light colours were positive evaluation. The evaluation scores of white light colour were significantly higher than the red and blue light colours at “tireless/tire” “not oppressive/oppressive”. The evaluation scores of white light colour were significantly higher than the other colours at “bright/dark” “easy to read/difficult to read” “easy to learn/difficult to learn”. The evaluation scores of white light colour were significantly

higher than the red light colour at “able to concentrate/not able to concentrate”. The evaluation scores of white, red and green light colours were significantly higher than the blue colour at “not sleepy/sleepy”. The evaluation scores of white, green and blue light colours were significantly higher than the red colour at “calm/restless”.

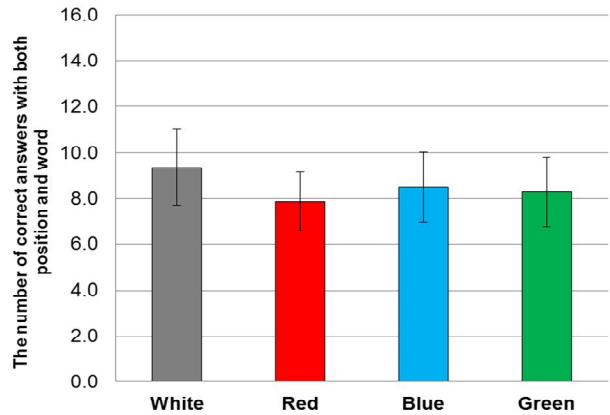


Fig. 1 Score of memory tasks at the correct answers with both position and word

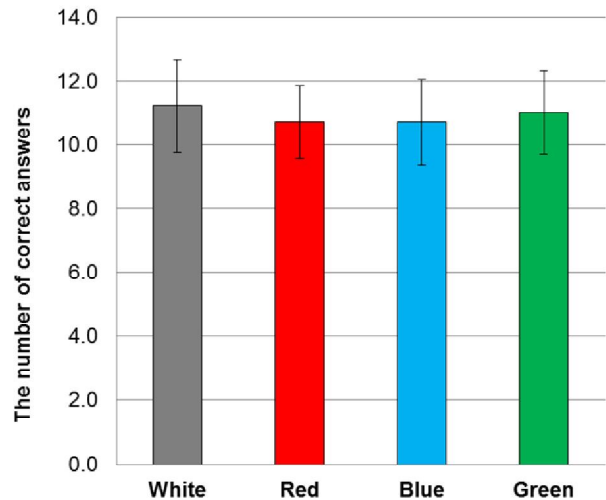


Fig. 2 Number of correct answers

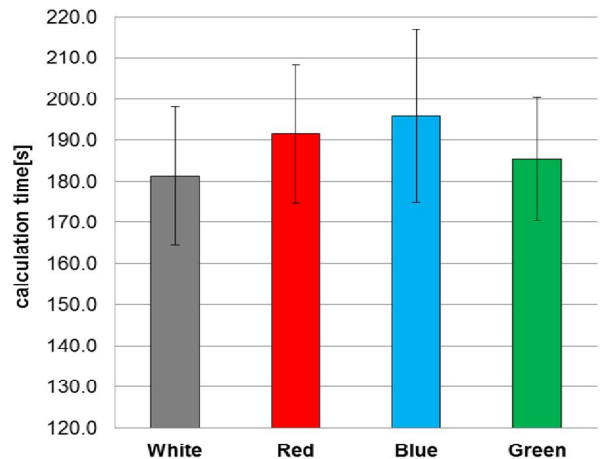


Fig. 3 Calculate time

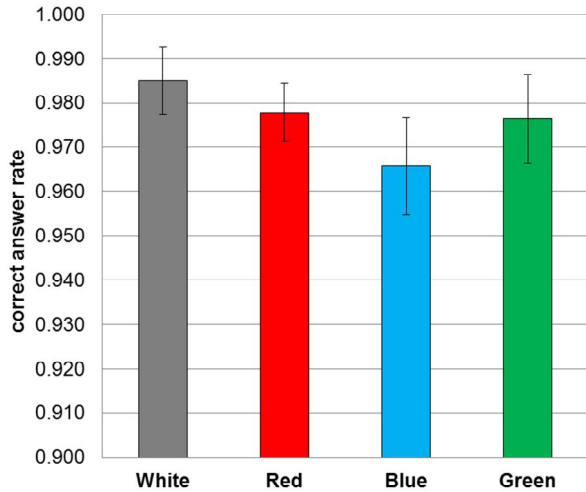


Fig. 4 Correct answer rate

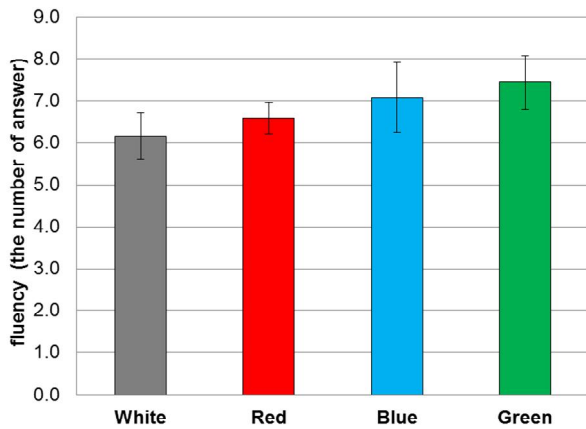


Fig. 5 Score of fluency

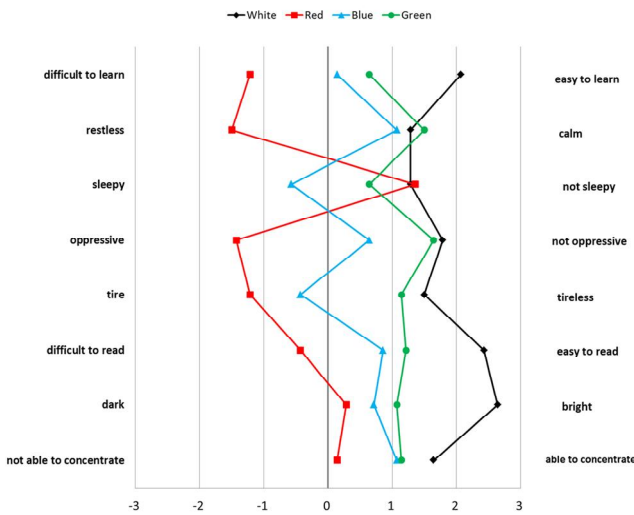


Fig. 6 Subjective evaluation scores

4. DISCUSSION

Figure 5 showed the fluency and here, discuss the concreteness and flexibility. Concreteness shows the number of answer that daily use and flexibility shows the number of answer that various viewpoints. Figure 7 shows the score of concreteness. Green light colour was the highest score than the all other light colours, however the significant difference was not observed.

The flexibility was evaluated by performing categorization. Each topic was created five categories, and the answers of the subject were evaluated whether could be classified into how many categories. Figure 8 shows the score of flexibility. Green light colour was the highest score than the all other light colours, and the significant difference was observed between Green light colour and White light colour.

It is thought that green light is reminded “natural and safe” and relaxed, and then lead to improvement of performance in creative work that requires a free idea. It is suggested that Green lighting has a positive influence on creative work.

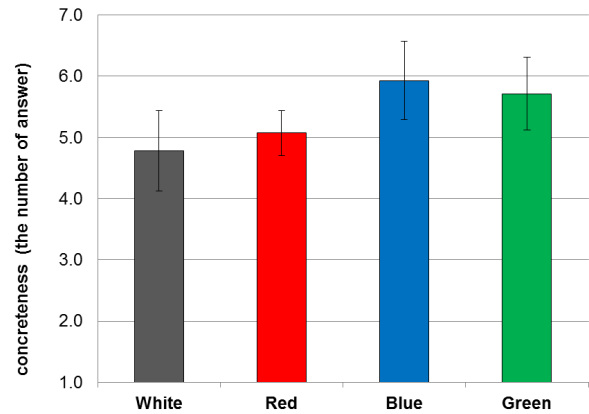


Fig. 7 Score of concreteness

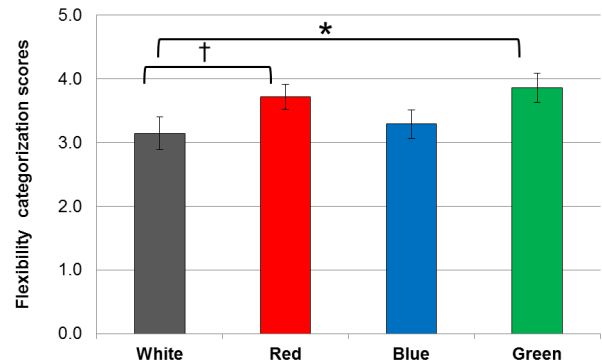


Fig. 8 Score of flexibility
(*represents a $P < .05$, † represents a significant trend)

It was considered the colour adaptation was in progress during the memory task because the colour adaptation is 3 minutes in this study. Therefore, as the next step, it is necessary to conduct the experiment after colour adaptation for 10 minutes.

5. CONCLUSION

In this study, the effect of chromatic colour lighting environment on cognitive performance was investigated. The results are summarized as follows:

- (1) Chromatic colour lighting might not affect the accuracy of the memory.
- (2) Chromatic colour lighting does not affect the simple calculation.
- (3) Green lighting has a positive influence on creative work.

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