

# Comparative Analysis on the Effect of Illumination Color in Clinical Environment of Preventive Care

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## ABSTRACT

Conventional lights used in house were only white and the industrial standard that has recommended the optimal usage of lights have based on the color temperature. Illumination used in daily life these days has extended to provide the capability of using full color lights thanks to recent progress of LED lighting technology, but the standard mentioned above has not considered the effect of color lights on humans yet. Here we investigated the effect of colored lighting conditions on human cognitive performance by conducting an experiment where the subjects from multiple elderly generations executed cognitive tasks under several specific illumination conditions with color to see how the task score and their biological responses would vary among the conditions.

## 1. INTRODUCTION

Humans have nature for adopting to their environment and keeping social balance with others by using all their senses, *i.e.*, vision, auditory, olfactory, gustatory, and tactile. From a different point of view, the environment including other people that surround a person may change the way of affecting him or her so that he or she could enhance the ability for doing tasks. Cheering in a sport event is one of the examples where the audience plays the role of surrounding environment of a sport player that

could empower him or her by sending cheers. So is the case in the working environment where intellectual performance is required except for physical one.

Recent progress in lighting technology using LED has enabled to use full color lights in daily life. However, no scientific evidences support what color lighting stimuli could be another cheering environmental factor because conventional room lights were only white with a variety of color temperatures and industrial standards for lighting have all based on them [1]. Not only houses but also workplaces these days pay much attention to the environmental conditions so that to maximize the performance of workers in them by improving the quality of their lives, which is critical under the circumstances of shortage of workers in Japan.

In this paper, we report an experimental result where the subjects executed cognitive tasks under a specific set of colored illuminations to see how they affect the task score and the biological responses of humans.

## 2. EXPERIMENTS

### 2.1 Cognitive tasks

We exploited *CogEvo* that is widely used in research institutes as, so to speak, *de facto* standard [2]. It divides a measurement task for cognitive performance into five categories, 1) spatial awareness, 2) orientation, 3) memory, 4) attention, and 5) planning. Every task is a kind of game and takes fifteen to twenty minutes in total to finish.

### 2.2 Subjects

Three elderly generations across fifties to seventies with twelve subjects (six for both males and females) were instructed to do the task explained in Section 2.1. They are healthy and cognitively clear. They understand the experiment and the task and are able to do the task without any accidental mistakes.

### 2.3 Experiment room and illumination conditions

Fig.1 shows the experiment room where the subject sits next to the instructor who teaches the subject how to do every task. A camera system that has thermo-camera and optical camera stuck together locates in front of the subject, and another video camera diagonally behind the

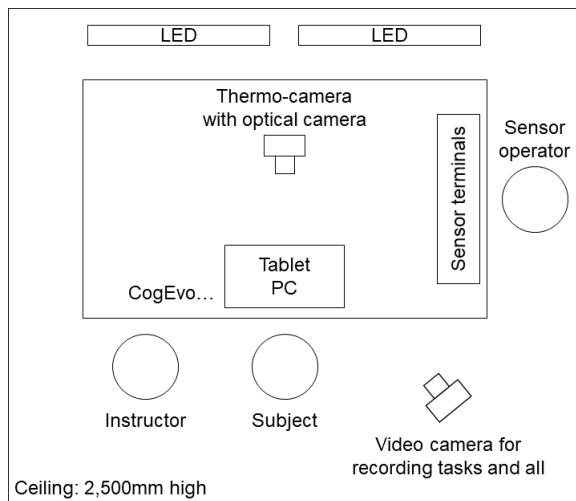


Fig. 1 Experiment room

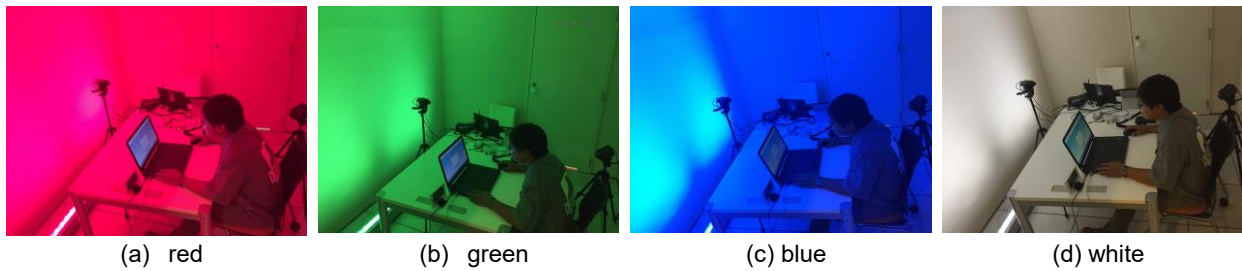


Fig. 2 Color conditions for calculation task.

subject that takes the scene of doing tasks and all. The subject puts on heart beat sensor (myBeat [3]) at the beginning.

Two LED lights locates under the wall facing the subject that illuminate the whole wall and the ceiling over the wall, which is the entire view of the subject in other words. The illumination of every color was set to the maximum illumination of red. Each subject did the task under a single illumination condition assigned.

### 2.4 Measurements

The thermo-camera captures the temperature of the skin around root nose that correlates with the concentration (the optical camera detects face region and facial components from the image). The heartbeat sensor captures heartbeat wave whose specific frequency components correlate with nerve activities [4]. Also, the optical camera gives the number and the timing of eye-blinking that is known to be an indicator of memory process in brain activity [5][6].

Those measurements were later analyzed with respect to the age, the task score, and the illumination conditions where three subjects for each generation (fifties, sixties, and seventies) conducted the task under the same illumination condition.

### 2.5 Results

As the subjects got older, the score for every task got worse just as anticipated. Illumination condition did not affect fifties and seventies in every cognitive task. Only in sixties, a significant difference was found in the planning task (see Fig.3). The score under blue lighting condition topped those in green and white with 1% and 5% significance level respectively. Blue light would enhance the ability of planning (planning ability decreased in

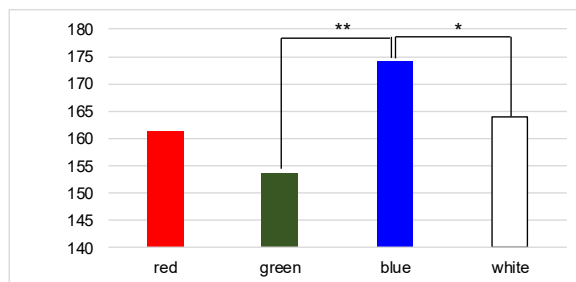


Fig. 3 Comparison of task scores between illumination conditions (Planning for sixties).

seventies compared with fifties and sixties).

Blinking rate counted the highest number in seventies. In addition, it counted higher in red light compared with green and blue when significantly different (spatial awareness for fifties and sixties, and memory for fifties). Red light might have forced difficulty in memorization and getting aware of space.

### 4. CONCLUSION AND FUTURE WORK

We conducted an experiment that varied illumination colors when subjects did cognition tasks. The task scores correlated with the age, the biological metrics of heartbeat rate and eye-blinking rate, and the illumination colors. The result demonstrated that planning task for sixties enhances under blue light. In addition, red light seemed to give load to cognitive task that led to higher rate of eye blinking.

Future work include extending the experiment to cognitive performance in younger generation and also human communication that could be affected by colored illumination.

### Acknowledgement

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