The Influence of Blue Light in Maintaining Alertness in Tropical Country: A Preliminary Study

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Abstract. Several studies have discussed the influence of blue light on cognitive activity. This study aims to determine the effectiveness of blue light in increasing alertness at night in tropical countries. Twelve healthy young males joined in this study. All participants were asked to do a monotonous activity that is reading activity. The experiment was a within-subject design with the independent variable is lighting condition (normal light and blue light) and duration of exposure (30 minutes and 60 minutes). Electroencephalography (EEG) signals were recorded continuously during the experiment. Alertness was measured based on theta, alpha, and beta activity. The result is the light condition not significantly affected the theta (F(1,11) = 0.608, ρ = 0.452), alpha (F(1,11) = 1.561, ρ = 0.237), and beta (F(1,11) = 0.608, ρ = 0.700) activity. This shows that blue light is not effective in increasing alertness at night in the tropical country both in short and long duration of exposure.

1. Introduction

Blue light is light with wavelengths of natural light between 446 and 483 nm with an optimum wavelength of 468 nm [1]. Several studies have discussed the influence of blue light on cognitive activity, especially at night where the melatonin hormone plays a role in regulating the wake and sleep cycles to the maximum, resulting in increased drowsiness and decreased alertness.

Vigilance is a cognitive process related to the ability to maintain a continuous focus of attention when viewing signals over a long period [2]. Factors that can reduce alertness are the monotonous or low workload. The level of alertness can be known through physiological changes in the body, one of which is by using measurements of brain wave activity. Brain waves are measured using an electroencephalograph (EEG) device. Theta and alpha brain waves, with band frequency 4 Hz – 8 Hz and 8 Hz - 13 Hz, were associated with alertness [3]. Moreover, beta brain wave, with band frequency 13 Hz - 30 Hz, was associated with alertness [4].

One way to maintain vigilance is by providing the exposure of blue light, as in some studies that have been done in nontropical countries. A study explained that blue light for 6.5 hours was able to increase alertness at night by significantly reducing theta activity [5]. A study explained that blue light for 6 hours proved to be effective in increasing alertness at night by being able to reduce theta activity, but did not significantly affect alpha activity [6]. A study explained that blue light for 1 hour was able to increase alertness at night by significantly reducing alpha activity and increasing beta activity [7]. A study explained that blue light for 30 minutes can increase alertness at night by significantly reducing alpha activity [8].
In tropical countries, 60 minutes of blue light can increase alertness at night during monotonous activities, as explained in the research of Lisdiani and Yassierli [9]. Research of blue light in tropical countries is still rarely studied. Besides, the exposure of long duration blue light can make uncomfortable in eyesight [10] and cause retinal damage [11]. Thus, to reduce the negative impact of blue light, this study will discuss the exposure of blue light with a short duration of exposure, is there a difference with the exposure of long duration blue light as in the research Lisdiani and Yassierli [9].

2. Method

2.1. Participants
Twelve healthy young males with a mean (±SD) age of 21 years (±0.56) participated in this study. Participants were directed to sleep before 11.00 pm in the night before the experiment. Participants were informed to not consuming caffeine and cigarettes.

2.2. Procedure
The experiment was a within-subject design, conducted to evaluate the effects of two different lighting conditions that are normal room lighting (white light) and normal room lighting with a blue light enriched as additional lighting. Besides that, the experiment was conducted to evaluate the effects of duration with short duration (30 minutes) and long duration (60 minutes) of light exposure. The experiment was held in a simulation room from 18:00 until 21:00. Before the experiment begins, the participant was given a brief explanation of the experiment. After that, EEG electrodes were placed in the participant head skin.

The experiment was started with 5 minutes of baseline condition (dark condition). After that, all participants were instructed to do a monotonous activity that is reading activity. The EEG was measured from beginning to the end of the experiment, including 5 minutes of the baseline condition. In total, the participants took 35 minutes (for 30 minutes duration of lighting exposure) and 65 minutes (for 60 minutes duration of lighting exposure) to complete the experiment. Each trial was carried out on different days, so participants had adequate rest and were able to reduce the carry over effect. The procedure of the experiment can be seen in Figure 1.

2.3. Measure
Blue light apparatus, Philips goLITE BLU Light Therapy Device HF3332 7 × 7 inches, was used as the illumination source. EEG was measured using a Muse Brain Sensing Headband, with 7 electrodes (4 Channels and 3 References). Muse Headband Sensing can be seen in Figure 2. The electrodes were placed at frontal left (AF7), frontal right (AF8), temporal left (TP9), temporal right (TP10) and FPz, Fp1, Fp2 (as reference sensors). All data are transmitted via Bluetooth to a smartphone running the application that is Muse Monitor.
2.4. Data Analysis
Based on Phipps-Nelson et al. [6] and Figueiro et al. [7], only EEG theta (4 Hz-8Hz), alpha (8Hz – 13 Hz), and beta (13-30 Hz) activity were examined. EEG absolute band power was recorded for each channel (frontal left, frontal right, temporal left, and temporal right). EEG absolute band power was transformed into relative band power before being normalized to the power obtained during the baseline. The formula of relative band power is [12]:

\[
S_r = \frac{10^{\theta_{abs}}}{10^{\delta_{abs}} + 10^{\theta_{abs}} + 10^{\alpha_{abs}} + 10^{\beta_{abs}} + 10^{\gamma_{abs}}}
\]

(1)

in which \(S_r\) is the relative value of frequency range (delta, theta, alpha, beta, gamma) being calculated and \(S_{abs}\) is the absolute value of range frequency.

All data were analyzed using ANOVA repeated measure, with “lighting condition” (white and blue light enriched) and “duration” (30 and 60 minutes). All analyses were performed using SPSS ver. 20

3. Result
Theta, alpha, and beta activity as a function of light condition and duration can be seen in Figure 3, 4, and 5. The result of significance analysis can be seen in Table 1. The lighting condition not significantly affected the theta (F (1, 11) = 0.608, \(\rho = 0.452\)), alpha (F (1, 11) = 1.561, \(\rho = 0.237\)), and beta (F (1, 11) = 0.608, \(\rho = 0.700\)) activity. The duration significantly affected the theta (F (1,11) = 51.378, \(\rho < 0.05\)), alpha (F (1, 11) = 18.378, \(\rho < 0.05\)), and beta (F (1, 11) = 51.378, \(\rho < 0.05\)) activity. And, there is no interaction between light condition and duration to the theta (F (1, 11) = 3.056, \(\rho = 0.520\)), alpha (F (1, 11) = 0.441, \(\rho = 0.237\)), and beta (F (1, 11) = 0.3.056, \(\rho = 0.503\)) activity.
Table 1. The Result of Significant Analysis

| Brainwave Activity | Factor                        | Sign   | Conclusion   |
|--------------------|-------------------------------|--------|--------------|
| Theta              | Illumination condition       | 0.452  | Accept H0    |
|                    | Duration                      | 0.000  | Reject H0    |
|                    | Illumination condition*Duration | 0.108 | Accept H0    |
| Alpha              | Illumination condition       | 0.237  | Accept H0    |
|                    | Duration                      | 0.001  | Reject H0    |
|                    | Illumination condition*Duration | 0.520 | Accept H0    |
| Beta               | Illumination condition       | 0.700  | Accept H0    |
|                    | Duration                      | 0.001  | Reject H0    |
|                    | Illumination condition*Duration | 0.533 | Accept H0    |

4. Discussion

This study aimed to observe the effectiveness of blue light in a tropical country compared with a subtropical country. Besides that, this observed study will discuss the exposure of blue light with a short duration of exposure, is there a difference with the exposure of long duration blue light. The results show that blue light is not effective in increasing alertness in the tropical country seen from the wave activity of theta, alpha, and beta at night both in short and long duration of exposure. Blue light tends to reduce theta activity during 30 minutes of exposure, but the results are not significant. Blue light is not significantly in reducing alpha activity. It is in line with Phipps-Nelson et al. [6] that blue light did not significantly affect alpha activity. Blue light tends to increase beta activity during 30 minutes of exposure, but the results are not significant.

The result is contrary to Lisdiani and Yassierli [9] that discuss 60 minutes of blue light with the ability to increase alertness at night. This difference in results is due to the research of Lisdiani and Yassierli [9] using the comparison value \((\theta + \alpha) / \beta\) as an alertness parameter.

This study contradicts the research of Iskra-Golec et al. [8] in the subtropical country which explains that blue light for 30 minutes can increase alertness at night by significantly reducing alpha activity. This result also contradicts the research of Figueiro et al. [7] which blue light for 1 hour was
able to increase alertness at night by significantly increasing beta activity. This result can happen because in tropical countries with high exposure to sunlight (which is a main source of blue light) throughout the year, the high exposure of sunlight can affect the degeneration of macula in retina that was the most sensitive part of eye to light at the shorter wavelengths including blue light [13]. Therefore, the high exposure of sunlight can reduce the sensitivity of blue light.

This study has several limitations worth noting. First, only one measurement was conducted that is brainwave activity. Further research should be conducted with different measurements, such as using task measurement and subjective measurement. Second, the respondents are limited. Enlarging the number of samples and enlarging the sample to include not only a student sample might enrich the result.

5. Conclusion
This study shows that blue light is not effective in increasing alertness at night in the tropical country both in short and long duration of exposure.

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