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Evoke of The Motoric Brain Waves of Driver in Car Simulator at Night by Blue Light Exposure and Visual Distraction

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Abstract. Driving at night need high levels of concentration for respond any visual stimulation by motoric coordination. Such concentration while driving can be mounted using blue light inside the car’s compartment, since it can inhibit the secretion of melatonin hormone, to increase drivers’ alertness and prevent drowsiness at night. This study was aimed to evaluate the effect of blue light exposure on µ brain waves while driving at night in the simulator as a response to visual distraction. Brain waves data were recorded using electroencephalograph in brain motor areas from 7 men with predetermined criteria. Data were taken at night (7-9 pm) for 330 seconds in dark condition and blue light exposure, followed by the appearance of visual distraction automatically at 120 and 270 seconds and should be responded by braking. In blue light condition, µ brain waves were fluctuated in both motor areas since the first appearance of blue light exposure and was significantly different when compared to dark condition (p<0.05). It is concluded that blue light exposure at night in a driving simulator may increase drivers’ brain activity in the motor areas when responding to visual distraction, especially in the first appearance.

Keyword: blue light, braking, electroencephalograph, reaction time, visual distraction

1. Introduction
The present of environmental light can affect the human circadian rhythm and influence the level of alertness when human doing their daily activities [1]. Sunlight may trigger the reduction of melatonin hormone’s production and arouse high alertness level to people. Conversely, when light with specific spectrum is absence at night, it may suppress melatonin production and then sleepiness will appear in accordance with decreasing of alertness level [1]. Driving in highway at night is one of the frequent human activities. In which driver required long-term and high level of concentration to deal with various stimulus, such as avoiding some dangers with quick and appropriate response [2,3]. Accidents at night is mainly caused due to driver’s drowsiness [4]. In addition, some stimulus from highway appear to become secondary activities other than driving, such as using of emergency lights while braking or using headlight flashing to other drivers. Advanced Driver Assistance Systems (ADAS) are accessories within vehicles that can help the driver to interact with other drivers [5], but may appear as distractions. The use of these accessories are categorized as visual distractions and commonly used by
drivers at night, since it considered to be an effective way for communication between drivers on highway [6]. Distraction such as headlight flashing, is highly regulated in some countries because it can cause temporary blindness for other drivers [7]. The common response of driver who receives this type of visual distraction is emergency braking [8]. The latency between visual distraction and driver’s braking response is strongly influenced by the level of driver’s alertness. Therefore, exposure of blue light while driving at night is expected to help increase the level of driver’s alertness, so driver is more alert to respond the distraction and the reaction time (latency) needed to respond the distraction is also shorter. Blue light is one component of the solar spectrum that serves to inhibit secretion of melatonin hormone in the pineal gland [9,10] and has been used as additional equipment while driving inside the car simulator increased driver’s alertness and preventing drowsiness at night. Therefore, this study was aimed to evaluate the effect of blue light exposure on μ (mu) brain waves as specific indicator for motor activity in brain motor areas of driver while driving at night in the simulator as a response to visual distraction.

2. Materials and methods

2.1. Study Participants
Study volunteers consisted of seven males, aged 19-24 years old and they had to passed several criteria such as: excluded with visual impairments or corrected with glasses, had driver’s license (minimum 2 years) and experienced with manual transmission, did not consume caffeine within 24 hours, free from alcohol and drugs, and slept at least 8 hours at night before the experiment.

2.2. Study Protocol
All the selected participants experienced under different lightning conditions at night from 19.00 to 21.00 and drove in driving simulator set (figure 1), located at Laboratory of Instrumentation and Control, Department of Engineering Physics, Faculty of Industrial Technology, Institut Teknologi Bandung. This set is a combination of several components: a chair simulator, set of racing wheel from Logitech G27 with manual transmission, and LED TV 40 inches as media for displaying highway environment from games Euro Truck Simulator 2. Brain waves data were recording by electroencephalograph (EEG) from Emotiv EPOC and the electrodes were placed on participant’s scalps according to International 10-20 system, specifically at FC5 (left) and FC6 (right). These channels are located infronto-central region of brain that represent the participants’ motoric activities represented by μ (mu) brain waves.

Figure 1. Driving simulator set.
Prior to experiment, all participants drove at simulator under blue light or dark condition according to experimental design in table 1. Visual distraction appeared automatically two times at 120° and 270° by a flare instrument which are consisted of white LEDs as stimulus for visual distraction. The blue light component used in this study were two lamps from Phillips GO LITE. The lamps emitted blue-wavelength spectrum in optimum wavelength about 467nm with total intensity of 17 lux. These blue lights were placed on the right and left side of volunteers, with 45° of exposure due to optimal human photoreceptive in retina for receiving blue light stimulus.

**Table 1.** Experimental design at simulator for driver in two different lightning condition and visual distraction.

| Total Duration | 120° | 330° |
|----------------|------|------|
|                |      |      |
| Drove manually | 1st distraction | Drove manually | 2nd distraction | Drove manually |
| Time Baseline | Time Baseline | Time Baseline |
| Activity | Activity | Activity |
| Driving | Driving | Driving |

*aVD = Visual Distraction.*

2.3. **Data Processing**

Brain waves data were analyzed using MATLAB application and was integrating with EEGLAB software. Raw brain waves data from the EEG then processed into µ brain waves power, at FC5 (left hemisphere) and FC6 (right hemisphere) channels. These data were then analyzed statistically using Two-Way ANOVA General Linear Model: Repeated Measures for all the participants’ brain waves data while driving.

3. **Results**

The µ (mu) brain waves power data presented motoric activity of participants while driving in a simulator at night is shown in figure 2 for FC5 channel in blue light condition (a) and in dark condition (b) and figure 3 for FC6 channel (a) and (b). Based on these results, it is showed that the blue light exposure proved significantly different to the dark conditions (p<0.05) when participants were driving for 330 seconds.

Prior to drive at baseline condition, the participants brain activity was at the highest µ brain waves power compared when participants in driving activity (figure 2 and 3), which indicated minimal activities of the participants.

![brain waves data](a)
Figure 2. The $\mu$ brain waves power for FC5 channel in: (a) blue light exposure and (b) dark condition.

Figure 3. The $\mu$ brain waves power for FC6 channel in: (a) blue light exposure and (b) dark condition.

In addition, there are differences in distributions of $\mu$ power brain waves between the two hemispheres, FC5 (left) and FC6 (right) in figure 4 and 5 below. The $\mu$ power is always higher on the right hemisphere (FC6) compared to the left (FC5) while participants were driving at simulator.
4. Discussion
Prior to drive at baseline condition, the participants brain activity was at the highest µ brain waves power while in driving simulator (figure 2 and 3), which indicated minimal activities of the participants. According to [11], µ brain waves has special characteristics to show higher value in subjects with no motoric activities or in idle state. The µ brain waves occurred when participants were in start position (figure 2 and 3), when the brain waves amplitude also start to desynchronize due to activities alteration between the baseline condition and driving. Motoric activities can lead to desynchronization of µ brain waves since the activation of some neurons show similar characteristics [12] of having low frequency and low amplitude in sensory-motoric area of the brain or FC5 and FC6 channels. Desynchronization may occur and increase when the number of neurons with similar traits (e.g. µ brain waves) are high while subjects are doing some activities simultaneously [12].

There are some differences in distributions of µ power brain waves between the two hemispheres, FC5 (left) and FC6 (right) (figure 4 and 5). These phenomenon is called asymmetry between brain hemispheres. It seemed the µ power always higher on the right hemisphere (FC6) while participants were driving at simulator. Asymmetry appeared in the brain motor areas, presumably because of difference motor workload between left and right limbs of participants due to decussation between limbs and motor area of the brain [13,14]. While driving, volunteers used manual transmission, so their right foot was responsible for dividing tasks between brake and accelerator pedals, meanwhile the left limb should stand by at clutch pedal. From the experimental design, we knew that the visual distraction was located on the right side of the participants. As a result, the volunteers’ motoric
workload, which were originating from the right side tended to be higher when compared to the left side. An increased level of motoric complexity was the reason why the participants’ right hemisphere is higher than their left µ brain waves power.

5. Conclusion
It is concluded that blue light exposure at night in a driving simulator may increase drivers’ brain activity in the motor areas (FC5 and FC6 channels) when responding to visual distraction, especially in the first appearance.

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