IOP Conf. Series: Earth and Environmental Science **197** (2018) 012051 doi:10.1088/1755-1315/197/1/012051

Blue Light Exposure and Visual Distraction Effect of The Cognition Brain Waves of Driver in Car Simulator at Night

L L Fitri[1]*, C Chusnia[1] and Suprijanto[2]

[1] Department of Biology, School of Life Sciences and Technology, Institut Teknologi Bandung, Jalan Ganesha No. 10, Bandung 40132, Indonesia
[2] Department of Engineering Physics, Faculty of Industrial Technology, Institut Teknologi Bandung, Jalan Ganesha No. 10, Bandung 40132, Indonesia

*E-mail : lfitri@sith.itb.ac.id

Abstract. Driving is a complex activity and driver must respond quickly and accurately to any visual distraction. Accidents are high while driving at night, may due to drivers' drowsiness which is caused by the environmental light that affect the circadian rhythm. Blue light is a component of the solar spectrum and inhibit the secretion of melatonin hormone that can prevent drowsiness at night. This study is aimed to evaluate the effect of blue light exposure on β brain waves while driving at night in the simulator as a response to visual distraction. Brain waves data were obtained from electroencephalograph in brain cognition area from 7 men with predetermined criteria. Data were taken from 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. The result showed than β brain waves increased under blue light which was associated with area of cognition and was significantly different when compared to dark condition ($p<0.05$). It is concluded that blue light exposure at night driving in simulator increase drivers' alertness and attention when responding to visual distraction, especially in the first appearance.
Keyword: blue light, brain waves, driving at night, visual distraction

1. Introduction

In daily life, light is used as energy source and available in nature as sunlight or can be produced artificially by human for specific use [1]. Blue light is one of popular artificial light with specific wavelength between 446nm-483nm [2]. In previous research, it was found that blue light affected mammalian physiological function through non-visual or non-image forming/NIF pathway, which has been demonstrated in rodents [3]. Non-visual pathway is a physiological pathway, closely related to human circadian rhythms and has particularly function to increased alertness and decreasing of sleepiness [4]. In this pathway, photons of blue light are received by specific photoreceptor cells in the retina of *intrinsically photosensitive retinal ganglion cells* (ipRGCs), which are containing photopigment melanopsin [3]. Then, these photons are converted into electrical impulses and projected through axons-extended to specific area in *suprachiasmatic nuclei* (SCN) at thalamus via *retinohypothalamic tract* (RHT). At the end it will sends signals to pineal gland and suppressing the production of melatonin hormone and can affect the human circadian rhythms [5]. Circadian rhythms are specific physiological functions to respond several environmental light [3]. During the day, sunlight will regulate melatonin production so people can do their activities with high alertness level.

However, at night, function of body circadian rhythms will respond to absence of sunlight, so these absence of specific light could suppress melatonin production and sleepiness will appears [3]. Therefore, many human activities occur at night will be affected due to changes of body's circadian rhythms and one example of this activity is driving at night. Therefore, this study is aimed to evaluate the effect of blue light exposure on β (beta) brain waves, which indicate alertness cognition while driving at night in the simulator as a response to visual distraction.

2. Materials and methods

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

2.2 Study Protocol
The experiment was start at night, from 19.00 to 21.00 and the volunteers drove in driving simulator set within two different lightning conditions (figure 1). The driving simulator is located at Laboratory of Instrumentation and Control, Department of Engineering Physics, Faculty of Industrial Technology, Institut Teknologi Bandung. This instrument is consisted of: a set of racing wheel from Logitech G27 with manual transmission, a chair simulator, and LED TV 40 inches as media for displaying highway environment from games Euro Truck Simulator 2. From these experiment, participants' brain waves were recording by electroencephalograph (EEG) from Emotiv EPOC. Electrodes from the EEG were placed on volunteers' scalps, according to International 10-20 system, specifically at F3 and F4 channels. These channels are located in frontal lobe of the brain and represent the participants' cognition activities. The blue light component used in this study were two lamps from Phillips GO LITE. Blue light emitted blue-wavelength spectrum in optimum wavelength about 467nm with total intensity of 17 lux and 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.

Figure 1. Driving simulator set.

2.3 Designs of Experiment
All participants drove the simulator for 120 seconds for baseline data and brain waves were measured (table 1). Next, participants would drive in 3 different situations for 330 seconds: (1) faced the visual distraction at 120", (2) drove for 150 second, and (3) faced the second distraction at 270" with two experimental lightning conditions, in dark and blue light condition. At first 120" and 270" in each

IOP Conf. Series: Earth and Environmental Science **197** (2018) 012051 doi:10.1088/1755-1315/197/1/012051

condition, visual distractions appeared automatically and conducted by flare instrument which were consisted of white LEDs as stimulus for visual distraction.

Table 1. Experimental designs at simulator for driver in two different lightning conditions and visual distraction.

Total Duration	120”	330”				
Time	Baseline	0” - 120”	At 120 seconds	120” - 270”	At 270 seconds	270” - 330”
Conditions		Dark or blue light				
Activity		Driving	1st VD[a] → Braking	Driving	2nd VD[a] → Braking	Driving

[a] VD = Visual Distraction

2.4 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 β (beta) brain waves power, at F3 (left hemisphere) and F4 (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, with significant level of 95%.

3. Results

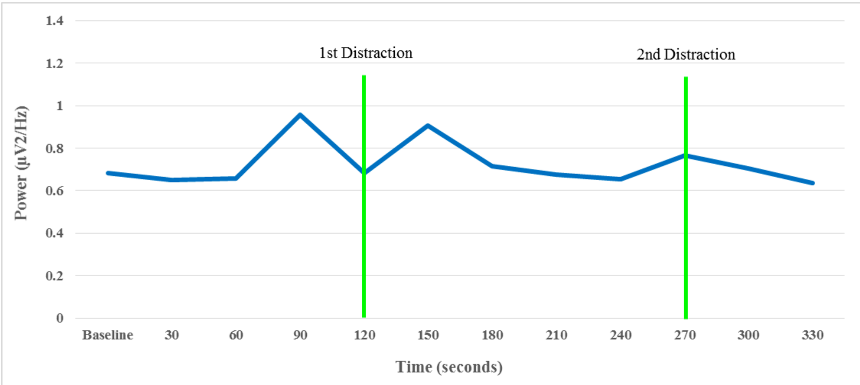
The β brain waves power of participants while driving in a simulator under blue light (a) and dark (b) condition at figure 2 for F3 channel and figure 3 for F4 channel. Based on these results, it is showed that the blue light exposure proved significantly higher ($p<0.05$) than the dark condition when participants were driving for 330 seconds.

When participants received the first visual distraction at 120 seconds, the β brain waves power at F3 and F4 channels were increased for 30 seconds, in both lightning. It was showed in figure 2 and 3 that first visual distractions increased the cognition part of the participants' brain, including alertness while driving in both lightning conditions (dark and blue light). However, after the participants' β brain waves power increased as a response to first visual distraction, there was a decline in β brain waves power for 90 seconds, especially in blue light exposure (figure 2 and 3). Furthermore, when participants were given the second visual distraction at 270 seconds while driving, their cognitive activities were significantly different ($p<0.05$), compared to the first visual distraction (figure 2 and 3).

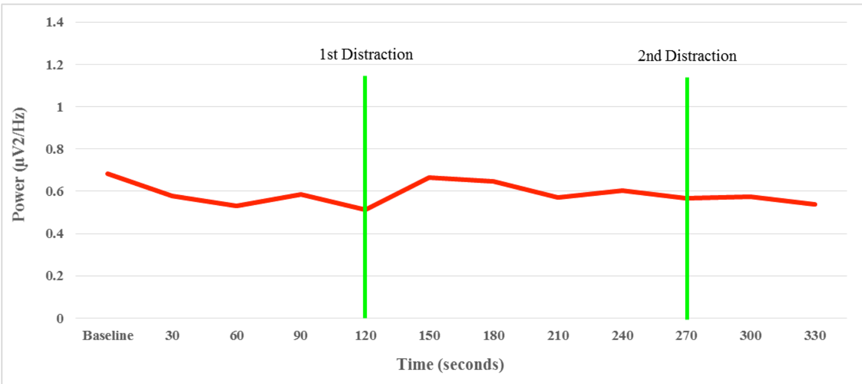
4. Discussion

At start position, the blue light exposure tend to increasing the driver's β brain waves power after 60 seconds on both of F3 and F4 channels (figure 2 and 3). This phenomenon occurred since the specific blue light photoreceptor cells (ipRGCs) have slower latency to respond when compared with other photoreceptor cells in retina (rods and cones) [6]. These ipRGC photoreceptor cells will specifically respond to the presence of blue light with specific wavelength and induce the increasing of cell membrane conductance as well as facilitate membrane depolarization, until reaching its threshold to trigger the action potential. The change of membrane conductance in ipRGCs are very slow and their latency against blue light can reach hundreds of milliseconds up to more than 1 minute [6].

When participants received the first visual distraction at 120 seconds, the β brain waves power at F3 and F4 channels were increased for 30 seconds, in both lightning (dark and blue light). In figure 2 and 3 it is showed that first visual distractions increased the cognition part of the participants' brain which include alertness. The visual distraction applied in this study was similar to ADAS (Advanced Driver Assistance Systems) that can help drivers in real life to communicate with other drivers on the highway, so they will not lose attention when dealing with highway conditions [7,8]. The appearance of distractions increase cognition activity when the participants deal with mental workload and influent secondary activities, such as complexity of decision making to respond at any distractions by doing motoric activity, for example emergency braking [9].



(a)

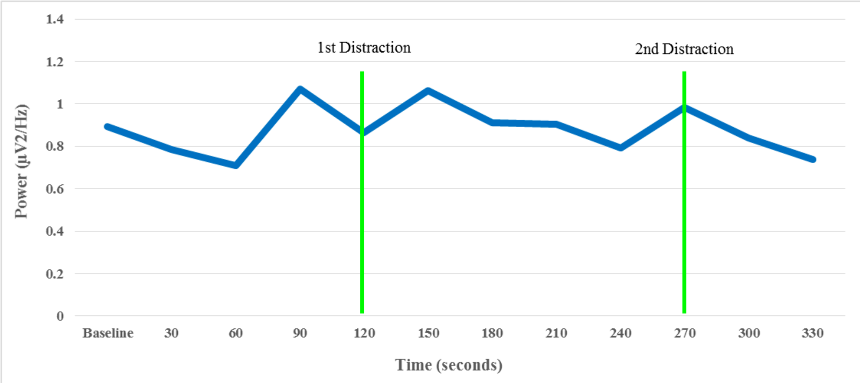


(b)

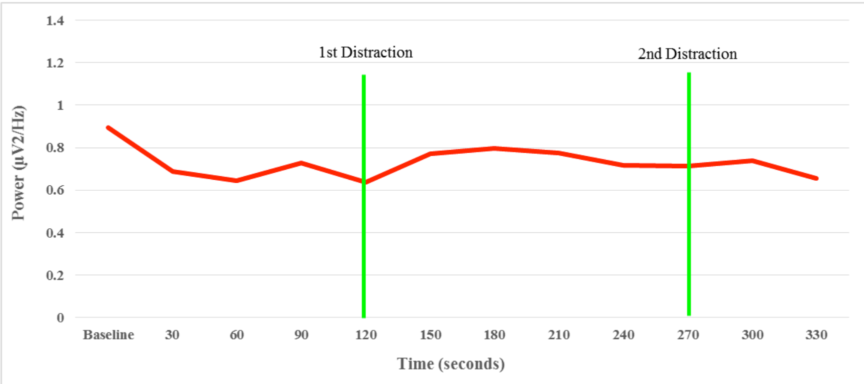
Figure 2. The β brain waves power for F3 channel in: (a) blue light exposure and (b) dark condition.

From figure 2 and 3, after the participants' β brain waves power increased as a response to visual distraction, there was a decline in β brain waves power for 90 seconds, especially in blue light exposure. This phenomenon can be associated with decrease in cognition activity of subjects while driving, since between 150s and 270s there has been a sensory adaptation against blue light exposure and allowed a reduction of sensitivity in ipRGC cells [10]. Subjects' cognition level declined while driving also occurred in dark conditions, though it does not appear regularly.

The second visual distraction decreased β brain waves power, which arose in both lighting conditions, this phenomenon prevailed since the participants have experienced habituation or adaptation to the driving simulation environment [10]. In addition, participants have experienced the formation of skill memories due to the learning process from facing repetition of stimulus emergence as distractions, which was accompanied by braking as the motoric activity response [11]. In general, blue light exposure on cognition areas of the brain (F3 and F4 channels) have been proven to improve cognitive activity and alertness due to increasing power of β brain waves power, compared to dark condition. The appearance of the first visual distraction during driving activity in the simulator was shown to improve attention, under the exposure of both lightning.



(a)



(b)

Figure 3. The β brain waves power for F4 channel in: (a) blue light exposure and (b) dark condition.

5. Conclusion

It is concluded that blue light exposure at night in a driving simulator increase drivers' alertness and attention when responding to visual distractions, especially in the first appearance.

Acknowledgements

This research was fully financialy supported by DIKTI Grant 2016. We would like to show our gratitude to all of our participants who were willing to help for this research. We also say thank you to technicians and student member of Laboratory of Instrumentation and Control, Department of Engineering Physics, Faculty of Industrial Technology, Institut Teknologi Bandung, for assisted this study.

References

[1] Rea M S 2000 *IESNA Lighting Handbook* (USA: Illuminating Engineering Society of North America)
[2] Chellapa S. L, Steiner R, Blattner P, Oelhafen P, Gotz T and Cajochen C 2011 *PLoS One* **6** e16429
[3] Cajochen C, Munch M, Kobialka S, Krauchi K, Steiner R, Oelhafen P, Orgul S and Wirz-Justice A 2005 *J. Clin. Endocrionol. Metab*. **90** 1311-16
[4] Figueiro M G, Bierman A, Plitnick B and Rea M S 2009 *J. BMC* Neurosci. **10**
[5] Gooley J J, Lu J, Chou T C, Scammel T E and Saper C B 2001 *Nat. Neurosci*. **4**
[6] Berson D M 2007 *Pflugers Arch.* **454** 849-55
[7] Harms L and Patten C 2003 *Transportation Research* **6** 23-36

[8] Armentrout D B and Boyer T R 2013 *Infrared Communication System and Method* (*United States Patent Application Publication*)
[9] Ryu C S, Song Y S, Nam S H and Yim T G 2005 *Apparatus and Method for Controlling Vehicle Brake Using Brain Waves* (USA: Patent No. 6,928,354 b2)
[10] Campbell N A and Reece J B *Biology: Eight Edition* (San Fransisco: Pearson Benjamin Cummings) p 1089
[11] Martini F 2010 *Fundamentals of Anatomy and Physiology* (San Fransisco: Pearson) p 537