

ORIGINAL ARTICLE**DIGITAL EYE STRAIN EVALUATION AMONG VIDEO GAMERS WITH AND WITHOUT BLUE LIGHT MONITOR FILTER**Nik Fakhri MANSOR¹, Ammar ADNAN¹, Radin Zaid RADIN UMAR², Siby SAMUEL³, Malek HAMID^{1,*}¹Department of Manufacturing and Materials Engineering, Faculty of Engineering, International Islamic University Malaysia, Selangor, Malaysia²Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, Melaka, Malaysia³Department of Mechanical and Industrial Engineering, University of Massachusetts Amherst, MA, USA

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ABSTRACT

E-sports or electronic sports have been attracting a lot of attentions especially younger audience with the promise of wealth just through playing video games. Staring into monitor screen regardless of devices for an extended amount of time will lead to Digital Eye Strain (DES) in general, more particularly visual fatigue. The study is to explore the effect of extended exposure of blue light wave while playing video games to gamers, focusing on DOTA players. This study will investigate visual fatigue with and without blue light monitor filter. From a total of 20 participants who were recruited, 10 participants performed the experiment with blue light monitor filter and the remaining without blue light monitor filter. Visual fatigue was measured by the perceived frequency of light observed by each participant using critical flicker frequency (CFF) before and after the experiment. Participants were also required to perform subjective evaluation (SE) by answering questionnaire on visual fatigue symptoms that they experienced after the experiment. SE was used to establish correlation between the reading obtained from CFF to determine visual fatigue. The result shown that With_Filter and Without_Filter scored a positive and negative average difference in CFF score respectively. Teary eye was discovered to be the most common symptom in With_Filter and Without_Filter group although Without_Filter group experienced more symptoms than With_Filter group such as red eyes, twitching eyelids, blurred near and distant vision, and pain in and around eyes.

Keywords: Critical flicker frequency, eye strain, visual fatigue, blue light, monitor filter, DOTA

INTRODUCTION

Online games allow people to enjoy themselves while socializing with friends. MOBA (Multiplayer Online Battle Arena) genre games have since then attracted a lot of gamers due to the fact that these games motivate them by pitting gamers against one another (Funk, 2013). Famous titles such as DOTA (Defense of the Ancient) and LOL (League of Legend) have been attracting players from across the globe with prize pool of its tournaments have reach as much as 20 million dollars (Yee, 2006). The rise of e-sports surely has its downside as professional players usually spent up to 12 hours staring into computer screen practicing (Stanton, 2015). Prolonged usage of computers may lead to computer vision syndrome (CVS) or digital eye strain (DES). DES is a condition affecting the eyes and indirectly the upper limbs such as neck and shoulder (American Optometric Association, 2016); (P. Ranasinghe, et al., 2016); (Comeau & Godnig, 1999)). Visual fatigue is one of the effects of DES and is caused due to prolonged exposure to blue light emitted from LCDs display screen of the computer screen (Isono, Kumar, Kamimura, Noguchi, & Yaguchi, 2013).

METHODS

Twenty participants were recruited for the study. They were: (i) undergraduate students

from International Islamic University Malaysia (IIUM), (ii) between 18-25 years of age, (iii) casual players of DOTA online game. The decision to include only undergraduate students of 18-25 years of age is to make sure participants recruited to have a similar workload, daily activities, and time spent working with computers.

The apparatus and stimuli will be classified into six items: (i) computer workstation, (ii) blue light monitor filter, (iii) DOTA software, (iv) critical flicker frequency (CFF) device, (v) subjective rating questionnaire, and (vi) administrative documents. The computer that will be used to run the game should be powerful enough to power the game graphics on the highest settings. Beside to optimize the graphic resolution of the games, it also will ensure that participants will be stimulated with great amount of lighting, specifically the blue light. Computer screen that were used in the experiment will be a 22" monitor as to conform to standard rules of DOTA tournaments (Valve, 2015). Half of the participants (i.e. 10 participants) were playing the game with a blue light monitor filter as shown in **Error! Reference source not found.**

DOTA software were downloaded and installed on the computer workstation. Critical flicker frequency test was used to determine the degree of visual fatigue. CFF index depends on the visual

analyzer pathology, however, healthy adult CFF was determined to be from 45-50 Hz (Bogachyov & Pavlova, 2016). This device was fabricated by using an Arduino kit as shown in **Error! Reference source not found.**



Figure 1: Blue light monitor filter



Figure 2: Arduino based CFF device

Participants were required to place their eyes onto the eye slot of the device. The device will then show a white light with frequency ranging from 20 to 80 Hz with 1 Hz increment (Bogachyov & Pavlova, 2016). The participants were able to control the frequency of the light themselves by rotating the knob. The participant will see the light to be flickering faster as the frequency increases, and they will inform the experimenter when they do not see the light flickers anymore. Participants were given a questionnaire to evaluate their self on the level of visual fatigue before and after playing game as usually practiced in other studies (e.g. (Sen & Richardson, 2007)). The score obtained will later be used in correlation with CFF data collected.

Participants in this study are classified into two groups - With_Filter and Without_Filter. Thus, from the 20 participants recruited, 10 participants were assigned into With_Filter and the other 10 into Without_Filter group. With_filter group is asked to play the game with the blue light monitor filter. On the other hand, the Without_Filter group is asked to play the game without the blue light monitor filter. This assignment is done pseudo-randomly e.g. the first participant was assigned into With_Filter group, the second participant was assigned into Without_filter group, and this pattern is continue until the last participant of the experiment completed the study. A participant is required to spend approximately 1 hour and 30 minutes to completed the study - 10 minutes for filing out administrative forms, 10 hours for pre-test CFF

test, 1 hour for playing game, and another 10 minutes for post-test CFF test.

RESULTS

The result for the Effect of Blue Light Monitor Filter on Average CFF Scores Difference, and the Prevalence of Digital Eye Strain Symptoms will be discussed in this chapter.

Average differences of CFF scores (overall): The descriptive statistics are given in **Error! Reference source not found.** and **Error! Reference source not found.** With_Filter group average differences exhibits positive values while Without_Filter group exhibits negative values. In order to analyze this finding, the Independent Sample Test (t-test) was utilized. It can be seen in that there are significant different between mean of With_Filter ($M=6.12$, $SD=6.6124$) and Without_Filter ($M=-0.35$, $SD=2.0490$).

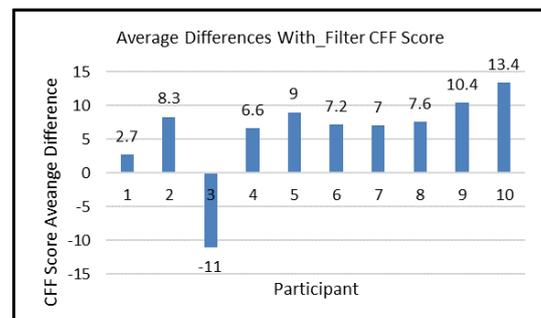


Figure 3: Average Differences With_Filter CFF Score

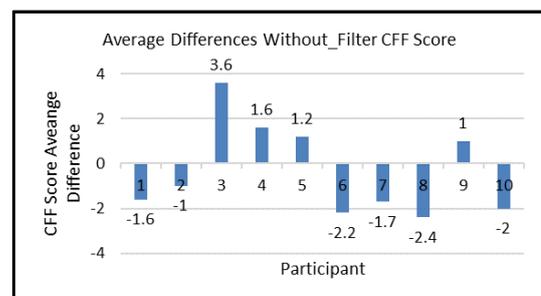


Figure 4: Average Differences Without_Filter CFF Score

It can be seen in **Error! Reference source not found.** that there are significant different between mean of With_Filter ($M=6.12$, $SD=6.6124$) and Without_Filter ($M=-0.35$, $SD=2.0490$). **Error! Reference source not found.** illustrated two results from two different t-test, one assumed equal variance and the other unequal variance. **Error! Reference source not found.** illustrated two results from two different t-test, one assumed equal variance and the other unequal variance. Which result to use depends on the result of Levene's Test. The p-value of Levene's test is 0.160, we can assume that the variance of two groups are the equal. The result for t-test for equality for average CFF score

difference is 0.008. The result shows that there are significant different between using blue light monitor filter and not using blue light monitor filter. The significant value is 0.008 which shows that the difference between using blue light filter and not using blue light filter is significant.

Table 1: SPSS Output - Group Statistic

Group Statistics					
	1 (with filter), 2 (without filter)	N	Mean	Std. Deviation	Std. Error Mean
CFF_diff	1	10	6.1200	6.61241	2.09103
	2	10	-.3500	2.04898	.64795

Table 2: SPSS Output - Independent Sample Test

	Independent Samples Test									
	Levene's Test for Equality of Variances				t-Test for Equality of Means					
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
								Lower	Upper	
CFF_diff	Equal variances assumed	2.143	.150	2.956	18	.008	6.47000	2.18912	1.87084	11.06916
	Equal variances not assumed			2.956	10.713	.013	6.47000	2.18912	1.63587	11.30413

Frequency of DES symptoms: The descriptive statistics is given in Figure 5. Comparing the number of symptoms experienced, Without_Filter group experienced more symptoms than With_Filter group.

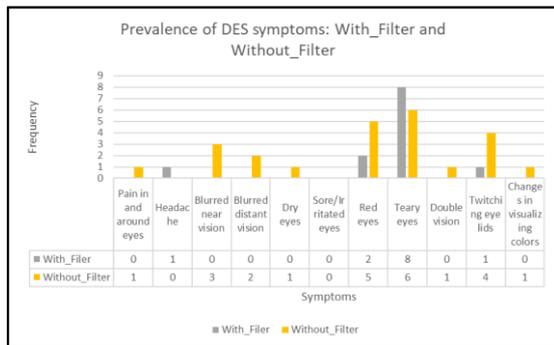


Figure 5: Frequency of occurrence of DES symptoms

Figure 5 above also shows that teary eyes is the most common symptoms for both With_Filter and Without_Filter group although With_Filter group has the higher frequency of teary eyes which is 8 compared to only 6 on Without_Filter group. The symptoms can be ranked by their frequency - teary eyes ranked first with the total of 14 out of 20 participants experienced this.

DISCUSSION

As expected from this experiment, the application of blue light monitor filter proved to reduce visual fatigue. Blue light monitor filter is also very effective in managing DES symptoms. In this experiment, participants are required to play DOTA with and without blue light monitor filter. From the result shown, With_Filter group scored positive values for the average difference of CFF score. This indicates that by using blue light monitor filter, participants in With_Filter group recorded a higher CFF score after playing DOTA for 1 hour. On the other, Without_Filter group scored negative values for the average

difference of CFF score indicating that the group recorded a lower reading of CFF after playing DOTA for 1 hour. Chen, Huang, Lee, & Wang (2016) stated that blue light monitor filter is able to block wavelength from 400 nm to 500 nm. Furthermore, participants who uses blue light monitor filter experienced less DES symptoms than participants who does not. The highest frequency symptom experienced by both group is teary eyes . This may be devoted to the factor that people who focus on something on the monitor screen will blink less than normal (Himebaugh, Begley, Bradley, & Wilkinson, 2009). Therefore, it is better to use blue light monitor filter to reduce visual fatigue and eye strain from prolonged use of computer especially in gaming.

CONCLUSION

First objective of this research is to evaluate the effect of blue light monitor filter on visual fatigue among video gamers. From the findings, it can be found that the usage of blue light monitor filter helps to reduce visual fatigue among video gamers. The data shows significant difference between With_Filter group and Without_Filter group. The second objective of this research is to evaluate the occurrence of DES symptoms among video gamers in relation to blue light monitor filter. The findings show that group who uses blue light monitor filter experience less DES symptoms compared to group who does not use blue light monitor filter. It was also found that the highest symptom in both group is teary eyes, which might be caused of lower blinking activity from the participant. As conclusion, all the objectives of the study were achieved where the average CFF score difference and occurrence of DES symptoms were evaluated and compared. There are different type of dependent variables that could be used to evaluate the effect of blue light monitor filter among video gamers. Electromyogram (EMG) device could be used to further study the muscles that are involved in determining visual fatigue. Next, for this study, the playing duration was only 1 hour due to the limitations that there are no incentives to motivate people to participate in this study. The duration of playing games can be increased more than 1 hour to get a more thorough data. Moreover, this type of study can be conducted with different genre of games or method of playing games - virtual reality. The findings from the study can then be compared.

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