

SUBJECTIVE EXPERIMENT ON VISUAL FATIGUE CAUSED BY LEDs

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Introduction

LEDs have been used for displays or traffic lightings. Recently, LEDs with white color have been developed and they are becoming to be used as general lighting for some their advantages, such as long useful life, low heat emission etc. Also energy efficiency of LEDs is now comparable to those of the other traditional light sources.

However, the spectral power distribution of LEDs is quite different from that of fluorescent tubes or the other usual artificial light sources. It may cause some visual problems in applying LEDs to general lighting.

The purpose of this study is to identify the visual effects of LEDs. In this paper, the results of the subjective experiment comparing the visual fatigue caused by LEDs and that by fluorescent tubes are described.

Method

Two experimental chambers with the same furnishing and with the same size were prepared in the experimental house. Figure 1 shows the plan of the experimental chamber with LEDs. LEDs with neutral white color (NW) and those with warm white color (WW) were set on the ceiling. Also in the other experimental chamber, fluorescent tubes (FL) with NW were set on the ceiling with the same positions as the LEDs. Illuminance on the desk in each room was set at two different levels, 350 lx and 700 lx. All six conditions combined with three types of the luminaire and two levels of illuminance on the desk were examined.

All six subjects (5 male and one female, average of age was 22.8) participated in the experiment. Each subject experienced all condition three times each. Two subjects in a group entered the experimental chamber at one time and stayed there for 45 minutes while doing VDT tasks. VDT tasks were consisted of three different kinds of task-making sentences task for 15 minutes, text typing task for 20 minutes and triple digit

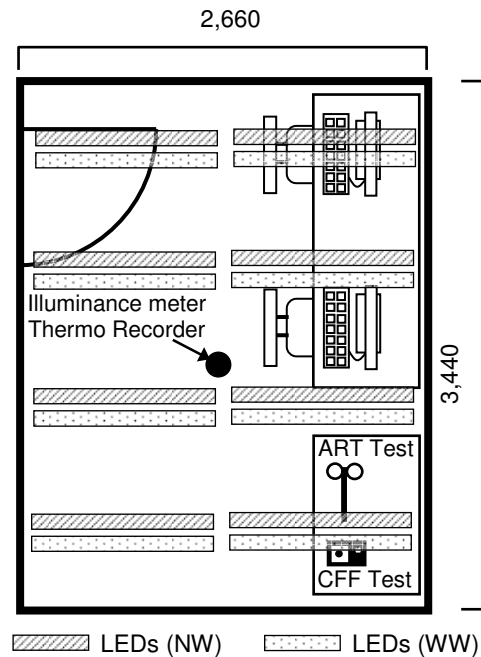


Figure 1 Plan of the experimental chamber

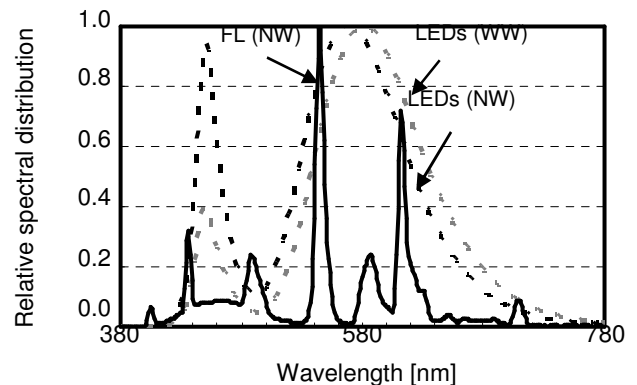


Figure 2 Spectral distribution of the source

multiplication task for 10 minutes. Before and after the VDT tasks, the accommodation response time (ART) ¹⁾ and critical fusion frequency of flicker (CFF) were measured to evaluate the visual fatigue of the subjects. Also after the VDT tasks, questionnaire for evaluation of subjective symptoms of fatigue was carried out. Illuminance on the desk (0.75 m from the floor) and air temperature (1.2 m from the floor) were measured at the center of the experimental chamber during the experiment.

Results

Spectral distribution of the source

Figure 2 shows the relative spectral distribution of each source used in the experiment measured at eye level of the subjects. It can be seen that the peak wavelength of LEDs with NW and that of LEDs with WW was almost the same.

Variation in ART and CFF

Figure 3 shows the ratio of ART/CFF measured after VDT tasks to that measured before the VDT tasks (after this, describe as "ratio-ART" and "ratio-CFF"). The results are shown in the average of the all 18 measured values for each condition (6 subjects * 3 times). The longer ART means the stronger visual fatigue and the smaller CFF means the stronger visual fatigue.

It can be seen that the ratio-ART in the case of 350 lx (●) was higher than that in the case of 700 lx (○) and ratio-CFF in the case of 350 lx (▲) was lower than that in the case of 700 lx (◻) for each light source. It can be said that the lower illuminance caused stronger visual fatigue. Comparing the ratio-ART/the ratio-CFF of FL and those of LEDs with NW, it can be seen that ratio-ART of LEDs was higher than that of FL and the ratio-CFF of LEDs was lower than that of FL. However, the results of ANOVA showed that the difference between the ratio-ART/the ratio-CFF of FL and those of LEDs was not significant.

Evaluation of subjective symptoms of fatigue

All 19 questions were carried out to identify the feeling of fatigue of the subjects. Figure 4 shows the results of questions concerning about the subjects' fatigue. It can be seen that the subjects felt stronger fatigue in the case of 350 lx than in the case of 700 lx except for LEDs with WW. Also it was found that LEDs with NW caused stronger fatigue than FL with NW for each levels of illuminance. However the results of ANOVA showed no significant difference in the evaluation of the subjects' fatigue under different types of luminaire nor with different levels of illuminance on the desk.

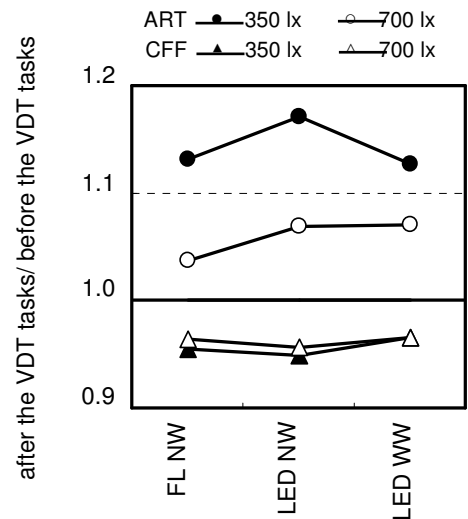


Figure 3 Variation in ART/CFF

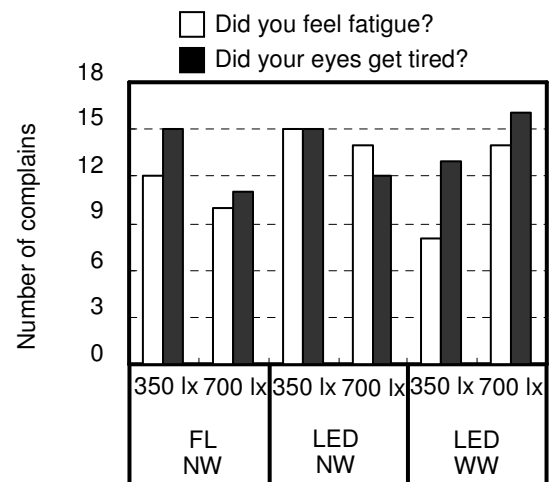


Figure 4 Subjective symptoms of fatigue

Conclusion

Subjective experiment was conducted to compare the visual fatigue caused by LEDs and that by fluorescent tubes. The results of the experiment showed that the difference between the subjects' visual fatigue caused by LEDs and that by fluorescent tubes was not significant.

1) H. Higashi, et al.: The relationship between eye strain and light sources (1), p. 165, Proceedings of 2008 annual conference of the illuminating engineering institute of Japan, 2008 (in Japanese)