International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

PO130

HUMAN VISUAL RESPONSE TO OFFICE LIGHTING THROUGHOUT THE DAY

Yinqiu Yuan et al.

DOI 10.25039/x46.2019.PO130

from

CIE x046:2019

Proceedings
of the
29th CIE SESSION
Washington D.C., USA, June 14 – 22, 2019

(DOI 10.25039/x46.2019)

CIE Central Bureau
Babenbergerstrasse 9
A-1010 Vienna
Austria
Tel.: +43 1 714 3187
e-mail: ciecb@cie.co.at
www.cie.co.at

HUMAN VISUAL RESPONSE TO OFFICE LIGHTING THROUGHOUT THE DAY

Yuan, Y.[1], **Huang, H.**[2], Ou, L.[2]
[1] Giant Lighting Solution Co., Ltd., Taipei, TAIWAN, [2] National Taiwan University of Science and Technology, Taipei, CHINESE TAIPEI
D10222502@mail.ntust.edu.tw

DOI 10.25039/x46.2019.PO130

Abstract

A psychophysical experiment was carried out to investigate visual response in a lit environment. During the experiment, the illuminance level will vary at different times of a day. Five colour-normal observers (2 males and 3 females), between 22 and 29 years of age, participated in the study. They were asked to assess the room in terms of 5 scales, liking, comfort, excitation, safety, and brightness, using a 6-point forced-choice categorical judgement scaling method. The experimental results show that the scale value tends to decrease in the morning until midday and tends to increase in the afternoon. Based on evaluation results obtained at each timeslot, high correlation was found between brightness and safety at the start of timeslot. For the end of timeslot, the perceived brightness is highly correlated with liking rather than safety.

Keywords: Office environment, Human visual response, Lighting illuminance

1 Introduction

A wide variety of factors can affect office environment, such as interior temperature, interior lighting, interior design and style of furniture. Undoubtedly, lighting plays an important role in human visual response to office environment. Many studies have reported the influence of ambient lighting on visual performance and comfort (Xu and Zue 1990, Lin and Huang 2006, Lee et al 2011, Ou et al 2015, Huang et al 2017). Little is known, however, as to whether our visual response in a lit environment will vary at different times of a day, e.g. whether the office feels less bright, or less comfortable, in the afternoon than in the morning at the same room where the lighting conditions remain unchanged. To answer this question, a psychophysical experiment was conducted in a real office space, as will be described in more detail in the following sections.

2 Methods

A psychophysical experiment was conducted in an office room, 238cm (height) by 200cm (width) by 300cm (depth) in size. The outdoor light was completely blocked using a black curtain. The only light source in the room was 4 tunable LED panel lights on the ceiling, which generated uniform light in the room at a correlated color temperature of 5000K. There were 5 task tables in the room where observers were seated during the experiment. The LED panels had a vertical distance of about 168cm to the task tables. On each task table was a computer display for the observers to do their routine tasks during the experiment. All displays had a peak white luminance of 100 cd/m^2. Figure 1 shows the experimental room.

Five colour-normal observers (2 males and 3 females), between 22 and 29 years of age, participated in the study. They were asked to assess the room in terms of 5 scales, liking, comfort, excitation, safety, and brightness, using a 6-point forced-choice categorical judgement scaling method, e.g. ‘like it very much’, ‘like it’, ‘slightly like it’, ‘slightly dislike it’, ‘dislike it’ and ‘dislike it very much’. The working hours from 9am to 6pm were divided into 9 timeslots, each taking one hour.

For each timeslot, the observers were asked twice to assess the room using the 5 scales, one at the start of the timeslot and the other at the end of the timeslot. At the start of each timeslot, prior to the assessment the observers were asked to look around the room for 2 minutes for adaptation. The observers then rated the room using the 5 scales, followed by their routine work

for 50 minutes using computers and displays on the tables. At the end of the timeslot, the observers assessed the room again using the 5 scales. Thus, each observer evaluated the room twice using the 5 scales for each timeslot, including an evaluation at the beginning and another evaluation at the end of the timeslot. After all procedures of each timeslot were completed, the experimenter changed the illuminance level of the entire room into one of the following, 60, 150, 300, 600, and 1080lx, measured as horizontal illuminance on the task table using a Konica Minolta CL200A illuminance meter. This was followed by the same set of procedures for the next timeslot. The change of the illuminance level was made in random order throughout the day. Each observer was asked to perform the evaluation for all the timeslots and for all the illuminance levels. This resulted in 50 hours of experimental time for each observer in this study, i.e. 5 illuminance levels x 9 timeslots + 5 repeated illuminance levels = 50 hours. The entire experiment took more than two months to complete.

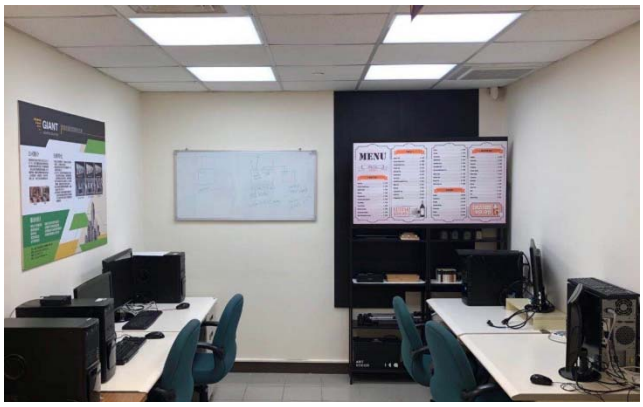

Figure 1 – Experimental set-up in a real office space

3 Results and discussions

The inter- and intra-observer variability values were 0.876 and 0.856 respectively, in terms of root mean square value. With the range of each scale being 5, these values indicate good data reliability in this study.

It is interesting to find that the visual response of all the 5 scales show similar trends for the 9 timeslots throughout the day, as shown in Figure 2 and Figure 3. For each scale, the scale value tends to decrease in the morning until midday and to increase in the afternoon. This indicates that the room tended to feel less exciting, less comfortable, less safe, less bright, and less liked at midday, than in the morning and in the afternoon.

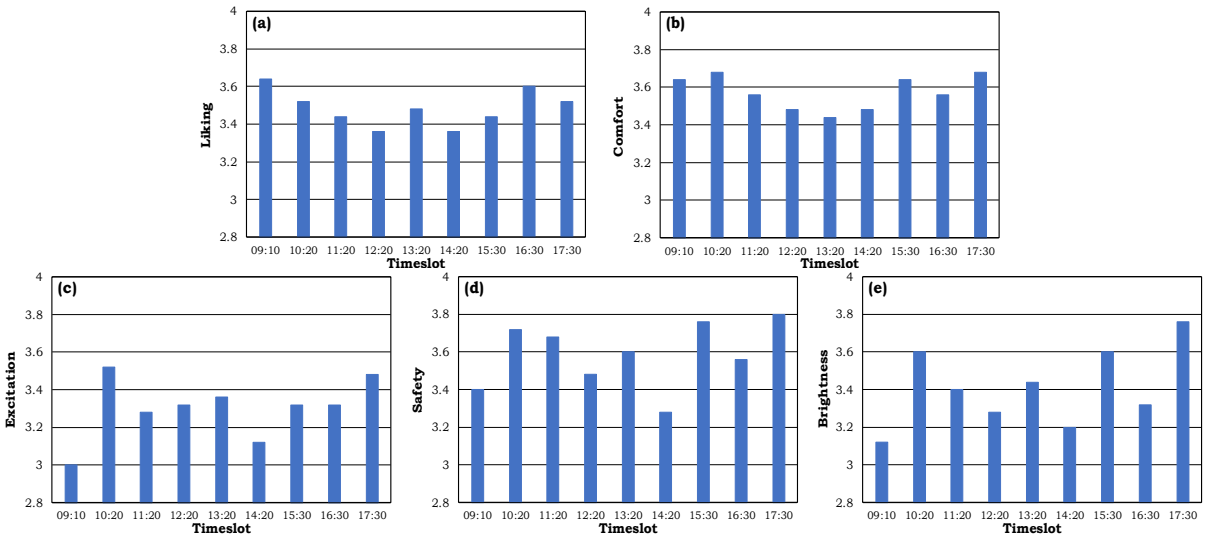

Figure 2 – The scale value at the start of each timeslot (a) Liking; (b) Comfort; (c) Excitation; (d) Safety; (e) Brightness

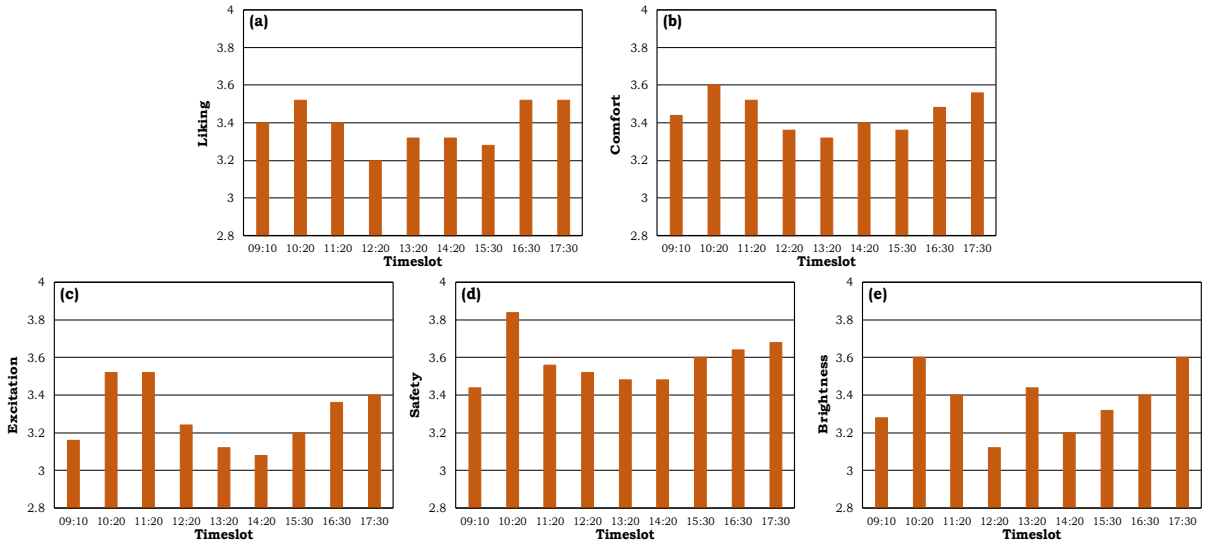

Figure 3 – The scale value at the end of each timeslot (a) Liking; (b) Comfort; (c) Excitation; (d) Safety; (e) Brightness

The two evaluation results, one at the start and the other at the end of each timeslot, were compared. As a result, the two evaluation results were found correlated somewhat closely for the 5 scales, with a correlation coefficient of 0.70 for liking, 0.70 for comfort, 0.61 for excitation, 0.68 for safety and 0.76 for brightness.

High correlation was found between brightness and safety, and between brightness and excitation, with correlation coefficients of 0.917 and 0.857, respectively, as shown in Table 1. Note that these values are based on evaluation results obtained at the start of each timeslot. It is interesting to find that the correlation coefficients become lower at the end of a timeslot. Nevertheless, the correlation coefficient between brightness and liking increases from -0.013 to 0.807, for evaluation at the start and at the end of each timeslot, respectively, as shown in Table 1 and Table 2. The findings seem to suggest that the perceived brightness had an impact on perceived safety and excitation soon after the change of illuminance level of the lighting, whereas the perceived brightness affected liking of the room only after the observer stayed in the room under the same lighting for a while.

Table 1 – Correlation between different scale value at the start of each timeslot

Correlation coefficient				
	Liking	**Comfort**	**Excitation**	**Safety**
Comfort	0.533			
Excitation	-0.084	0.261		
Safety	0.146	0.563	0.794	
Brightness	-0.013	0.523	0.857	0.917

Table 2 – Correlation between different scale value at the end of each timeslot

Correlation coefficient				
	Liking	**Comfort**	**Excitation**	**Safety**
Comfort	0.856			
Excitation	0.643	0.854		
Safety	0.654	0.752	0.765	
Brightness	0.807	0.706	0.639	0.736

4 Conclusions

A psychophysical experiment was conducted using a set of tunable LED panel lights to investigate visual impression of the office space for each hour from 9am to 6pm throughout the day. The findings indicate that the room tended to feel less exciting, less bright, less comfortable, less safe, and less liked at midday than at any other time of the day. Results of the study may help develop new guidelines for lighting design according to the time of a day.

References

Xu W, Zue Z. 1990. The effects of ambient illumination and target luminance on colour coding in a CRT display. Journal of Ergonomics 33:933-944.

Lin C-C, Huang K-C. 2006. Effects of ambient illumination and screen luminance combination on character identification performance of desktop TFT-LCD monitors. Int J Ind Ergon. 36:211-218.

Lee D.S., Ko Y.H., Shen I.H., Shen C.Y. 2011. Effect of light source, ambient illumination, character size and interline spacing on visual performance and visual fatigue with electronic paper displays. Journal of Displays 32:1-7.

Ou L-C, Sun P-L, Huang H-P, Luo M. 2015. Visual comfort as a function of lightness difference between text and background: a cross-age study using an LCD and a tablet computer. Color Res Appl. 40:125-134.

Huang H-P, Ou L-C, Yuan Y. 2017. Effects of age and ambient illuminance on visual comfort for reading on a mobile device. Color Res Appl. 42:352-361.