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

PO183

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SIGNAGE IN URBAN AREAS AND VISUAL COMFORT OF
PEDESTRIANS**

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DOI 10.25039/x46.2019.PO183

from

CIE x046:2019

**Proceedings
of the
29th CIE SESSION
Washington D.C., USA, June 14 – 22, 2019
(DOI 10.25039/x46.2019)**

The paper has been presented at the 29th CIE Session, Washington D.C., USA, June 14-22, 2019. It has not been peer-reviewed by CIE.

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CORRELATING THE PARAMETERS OF COMMERCIAL SIGNAGE IN URBAN AREAS AND VISUAL COMFORT OF PEDESTRIANS

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DOI 10.25039/x46.2019.PO183

Abstract

With the development of urban economy, the number of people liking going around at night has increased significantly and commercial lighting at night has also flourished. But at the same time, night-time commercial lighting also caused light pollution. This study mainly explores the effects of commercial signage on pedestrians' visual comfort. In the outdoor survey, comfortable and uncomfortable commercial signage was proposed. Fourteen potential parameters that may affect visual comfort were found in the two types of commercial signage. In laboratory experiment, all selected commercial signage was sequenced by side-by-side ranking task, to choose the least comfortable one in comfortable commercial signage and the least uncomfortable one in uncomfortable commercial signage. Values of parameters affecting visual comfort were based on the parameters of the two selected commercial signage. Five parameter thresholds of comfort commercial signage were found. The results of this study can provide scientific basis of lighting standard of commercial signage for local government.

Keywords: Visual Comfort, Commercial Signage, Side-by-side Ranking Task, Influence factors, Technology parameters

1 Introduction

In contemporary society, the boundary of day and night time gradually becomes blurred. As the improvement of residents' living conditions and consumption level, night activities become more and more common. The leisure activities at night have formed an indispensable part of daily life. Merchants, for both advertising and informational purposes, have taken artificial commercial lighting at night. But at the same time, flourished night-time commercial lighting also causes light pollution (Bashiri et.al 2014, Jari et.al 2012, Fabio et.al 2011). The luminance of some commercial signage exceeds the human eye comfort zone, leading to visual discomfort of pedestrians (Roberts et.al, 2013).

Quite a few studies shown that commercial signage will cause visual discomfort on drivers (Zalesinska, 2018). Dispersed attention is one of the main factors increasing collision rate of traffic accidents (Dukic et.al 2013, Farbry et.al 2001). The commercial signage with high brightness, dynamic images and large amount of advertisement information is easy to cause driver distraction and accident. Excessive commercial lighting is certainly harmful not only to the driver, but also to the passing pedestrians. However, few studies (Thomas et.al, 2009) have paid attention to pedestrian visual discomfort caused by commercial signage.

Many studies indicated that the selected influence factors on commercial signage are inconsistent and the technical parameters of influence factors are different (Lin et.al, 2014). It caused the lack of regulation on commercial lighting and the government monitoring.

Therefore, it is critical to study the technical parameters of commercial signage, which can improve commercial lighting environment in urban areas, and thus prevent light pollution. In order to improve the visual environment of pedestrians at night, this study explores the influence of commercial signage on the visual comfort of pedestrians.

2 Methods

This study mainly explores how commercial signage affects pedestrians' visual comfort. In the outdoor survey, nine commercial streets were chosen randomly. The subjects subjectively evaluated comfortable and uncomfortable commercial signage while walking on the selected streets. Fourteen potential parameters that may affect visual comfort were proposed in the two groups of commercial signage. In laboratory experiment, all selected commercial signage was sequenced by side-by-side ranking task, to choose the least comfortable one in comfortable commercial signage and the least uncomfortable one in uncomfortable commercial signage. Values of all parameters affecting visual comfort were based on the parameters of these two commercial signage.

2.1 Outdoor Survey

Figure 1 – Commercial Lighting Area in Shenzhen Urban Lighting Planning

Figure 1 is commercial lighting area in Shenzhen urban lighting planning. Nine commercial lighting areas were randomly selected in the commercial light area. Nine commercial streets were selected from the nine commercial districts respectively, each of which had more than 100 commercial signage in a 100-meter-long street. It turned out that two of the selected commercial lighting areas didn't satisfy the density condition and two had unfinished commercial lighting area construction. Another four commercial lighting areas were selected instead.

Nine selected streets are HAC Street in Nanshan, HQB Street in Nanshan, DM Street in Luohu, SJ Street in Baoan, YFTD Street in Longhua, GM Street in Guangming, WKL Street in Longgang, WXTD Street in Nanshan, HSSJ Street in Nanshan. Walk paths of all streets are shown in figure 2.

Figure 2 – Walk Path in Nine Commercial Lighting Area Street

Ten subjects joined the experiment. The average age of them was 23 years old, and all had good visual acuity and normal psychological state. Before the experiment, they read task description and street map. Subjects walked freely on the street to find out two groups commercial signage. Considering the inter-rater reliability, commercial signage provided by at least two people were considered as target samples and 70 commercial signage images were chosen. Excluding controversial commercial signage, 68 commercial signage remained. 36 comfortable and 32 uncomfortable commercial signage photos were regarded as target examples of commercial signage.

The experimenters went to the selected streets to measure the parameters of 68 commercial signage. The luminance photos were measured by imaging luminance meter. The position of commercial signage is in the one quarter area of the overall image scene. The ambient light was measured by illuminometer, and the size, height, observation distance, and observation angle of the commercial signage were measured by rangefinder. The luminance photos were used to recreate the luminance distribution and analysis the parameters of target commercial signage in lab.

2.2 Laboratory Experiment

The experimental design was side-by-side ranking task which had been used before (Fotios & Cheal 2008, Houser et.al. 2009). In the side-by-side ranking task, two stimuli were presented simultaneously in adjacent displays. Subjects were asked to make a forced choice about the visual comfort of the stimuli.

20 commercial signage (10 comfortable and 10 uncomfortable) provided by two people was considered as target sample. The selected commercial signage was sequenced by side-by-side ranking task. Two special commercial signage were selected, the least comfortable one in 10 comfortable commercial signage and the least uncomfortable one in 10 uncomfortable commercial signage. Values of all parameters affecting visual comfort were based on the parameters of these two commercial signage.

The illuminance in the lab room was set at the level of the average illuminance of the 68 commercial signage. The illumination range of 68 commercial signage was 3.93-255.99lx. The

surrounding illumination of the environment in the room was 61.18lx, achieving similar visual environments to those commercial streets at night.

Since the luminance of conventional display cannot reach the range of luminance that outdoor commercial signage can achieve. Therefore, two 1.2m*1.2m LED displays were used. The maximum luminance of each LED was 10000 cd/m². In order to preserve the fidelity of actual luminance of the target commercial signage, luminance photos were exported directly into the LED displays.

Figure 3 – Laboratory Experiment

Ten subjects with good corrected vision took part in the experiment. Subjects were escorted to the experiment room. Eye height was approximately 150cm above the floor (Houser et.al, 2009). Two commercial signage with different luminance photos were presented on the LED displays simultaneously. Subjects needed to make a binary choice of the one with more visual comfort, between one of the two presented commercial signage. The experimenter prompted the subject after 5 seconds, but the subject was allowed as much time as necessary to judge which commercial signage was comforter. Subjects experienced 0.5s of darkness between every two trials. For each subject, all possible pairs (190 in total) of target commercial signage were presented in counterbalanced sequence.

3.1 Commercial Signage

Table 1 – Result of result of Independent Sample T-Test

		Significance
Maximum brightness	Equal variances assumed	0.000
	Equal variances assumed	0.001
Average brightness	Equal variances assumed	0.161
	Equal variances assumed	0.155
Minimum brightness	Equal variances assumed	0.862
	Equal variances assumed	0.862
The ratio of max and min brightness	Equal variances assumed	0.309
	Equal variances assumed	0.285

Independent sample t-tests were carried out on the four influencing factors of comfortable billboards and uncomfortable billboards: maximum brightness, average brightness, minimum brightness, and the ratio of max and min brightness. The result of first t-test was rejecting the initial hypothesis ($p < 0.05$), indicating that maximum brightness of comfortable billboards had significant difference from that of uncomfortable ones. The t-tests of average brightness, minimum brightness and the ratio of maximum and minimum brightness accepted the initial hypothesis ($p > 0.05$), indicating that these three factors didn't significantly influence visual comfort in Table 1.

Table 2 – The color proportion of comfortable and uncomfortable commercial signage

Comfortable signage		Uncomfortable signage	
White	78%	White	16%
Multicolor	3%	Multicolor	22%
Blue	3%	Blue	19%

78% of comfortable commercial signage was white, while only 16% of uncomfortable commercial signage was white. 41% of commercial signage in uncomfortable commercial signage was blue and multicolour, and only 6% in comfortable commercial signage was blue and multicolour. It could be found that white commercial signage was more likely to cause visual comfort, while multicolour and blue commercial signage was more likely to lead to visual discomfort in Table 2.

37.5% of discomfort commercial signage had brightness uniformity problems, while in the comfortable commercial signage, only 5% were non-uniformity. It showed brightness uniformity may be one of the factors that caused visual discomfort.

31.2% of the uncomfortable commercial signage had dynamic flash problems. Half of them were multicolour dynamic flash, and the other half was LED flash display. But only 3% of the comfortable commercial signage was flashing state.

When pedestrians closed observation, the unclear present content of LED light source was lower the visual resolution of pedestrian. It was found that 34.3% uncomfortable commercial signage could cause visual comfort, while 95% of the comfortable commercial signage couldn't.

3.2 Commercial Signage Background Environment

Independent sample t-tests were carried out on the six influencing factors of comfortable signage and uncomfortable signage: environment illuminance, environment brightness, background brightness of commercial signage (BBCS), the ratio of average brightness of commercial signage and its background (RABB), the ratio of average brightness of commercial signage and overall environment (RABOE), and the brightness contract ratio (max/min) of overall environment (BCROE). The results of the fourth and sixth t-tests were

rejecting the initial hypothesis ($p < 0.05$), indicating that RABB and BCROE of comfort signage had significant difference from that of uncomfortable ones. The t-tests of environment illuminance, environment brightness, BBCS and RABOE accepted the initial hypothesis ($p > 0.05$), indicating that these factors didn't significantly influence visual comfort in Table 3.

Table 3 – Result of Independent Sample T-Test

		significant
Environment illuminance	Equal variances assumed	0.858
	Equal variances assumed	0.861
Environment brightness	Equal variances assumed	0.891
	Equal variances assumed	0.891
Background brightness of commercial signage(BBCS)	Equal variances assumed	0.065
	Equal variances assumed	0.073
The ratio of average brightness of commercial signage and its background(RABOE)	Equal variances assumed	0.028
	Equal variances assumed	0.037
The ratio of average brightness of commercial signage and overall environment(RABB)	Equal variances assumed	0.083
	Equal variances assumed	0.090
The brightness contract ratio (Max/Min) of overall environment(BCROE)	Equal variances assumed	0.038
	Equal variances assumed	0.035

In the analyses above, seven influence factors were found totally. Maximum brightness of commercial signage, brightness uniformity, colour of commercial signage, dynamic flash, visual resolution, the ratio of average brightness of commercial signage and its background (RABB), and the brightness contract ratio (max/min) of overall environment (BCROE) were target alternative parameters. Because of equipment and technical deficit, only five target parameters would be considered in the next indoor experiments, except dynamic flash and visual resolution.

3.3 Laboratory Experiment

For each target commercial signage, the frequency of being chosen by the 10 participants was recorded as raw data. Technically, this frequency may vary from 0 to 190 (indicating a perfect perceived visual comfort). The rank of target commercial signage could be determined according to the order of such frequency.

Commercial signage comfort order ranged from 1 to 20. The comfort degree sequence of 20 commercial signage images were confirmed. The result was shown on Figure 5. The least comfortable one in comfortable commercial signage and the least uncomfortable one in uncomfortable commercial signage were shown in red rectangle. The two commercial signage is shown on Figure 6.

Figure 5 – The Comfort Degree Sequence of 20 Commercial Signage Image

Figure 6 – The Least Comfortable One and The Least Uncomfortable One

The technology parameters of the least comfortable one and the least uncomfortable one are shown on Table 5.

Table 5 – The Parameters of The Least Comfortable One and The Least Uncomfortable One

			Background Environment				Commercial Signage				
	Color	Avg. illuminance	Avg. luminance	Min. luminance	Max. luminance	Max./Min. luminance	Avg. luminance	Max. luminance	Background Luminance	Avg. luminance/background	Max./Min. luminance
the least comfortable one	Yellow & green	13.8	18.25	0.26	1164	4478	22.3	391	13.08	1.7	3.72
the least uncomfortable one	White	11.8	19.68	0.06	3361	56020	1757.7	3361	2.28	770	4.93

The results indicate that the greater the maximum luminance value of commercial signage is, the lower level of visual comfort of pedestrians will be. If the maximum luminance value of commercial signage is lower than 391cd/m², the commercial signage will be regarded as comfort. When it's higher than 3361 cd/m², the commercial signage will be regarded as uncomfortable one.

If the ratio of average luminance of commercial signage and its background (RABOE) is lower than 1.7, the commercial signage will be regarded as comfort. When it's higher than 770, the commercial signage will be regarded as uncomfortable one.

If the brightness contract ratio (max/min) of overall environment (BCROE) is lower than 4478, the commercial signage will be regarded as comfort. When it's higher than 56020, the commercial signage will be regarded as uncomfortable one.

If the brightness uniformity of commercial signage is lower than 3.73, the commercial signage will be regarded as comfort. When it's higher than 4.93, the commercial signage will be regarded as uncomfortable one.

4 Conclusion

The two aims of this study are exploring the impact of commercial signage in commercial city centres on pedestrians' visual comfort and finding the threshold for each target parameter under visual comfort conditions. In outdoor experiment, it was found that maximum brightness, brightness uniformity, colour, the ratio of luminance of commercial signage and its background and the contract ratio of maximum and minimum luminance for overall environment were possible influence factors on pedestrian comfort. In laboratory experiment, it is found that the parameter thresholds of comfort commercial signage: maximum luminance value should lower than 391cd/m², the ratio of average brightness of commercial signage and its background (RABOE) should lower than 1.7, the brightness contract ratio (max/min) of overall environment (BCROE) should lower than 4478, the brightness uniformity of commercial signage should lower than 3.73 and the color of commercial signage is white. Future work still needs to find the threshold for each target parameter under visual comfort conditions.

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