論 文 の 内 容 の 要 旨

論文題目　Fundamental Research on Psychological Evaluation of Dynamic Lighting in Urban Space
（都市空間における動的照明の心理評価に関する基礎的研究）

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With the development of Solid-state lighting (SSL) and the new control technology of lighting system, an abundance of new lighting products have been used, consequently, varied kinds of dynamic lighting can be widely found in urban nightscape nowadays. Although it is believed that when light is blinking, it takes less energy but works much more effectively[1], it's worth highlighting that there will be more problems and potentially dangerous in this field with widely use of dynamic lights. Such as, inappropriate design can cause visual stress, what is more, the repetitive flashing lights are capable to induce a photosensitive epileptic seizure[2].

This thesis mainly forces on the dynamic lighting, based on studying correlated academic literature and academic documents, researching cultural background and analyzing related regulations and guidelines. The original motivation of this research is to find out the influence of dynamic lighting in urban nightscape and improve the visual environment of dynamic lighting from the perspective of urban planning and lighting design. However, the research on psychological influence of dynamic lighting is a relatively new field. Therefore, the fundamental research on psychological evaluation of dynamic lighting is significant.

The main tasks of this research is to summarize the related regulations (Chapter1) and the present situation (Chapter3) of dynamic lighting in urban nightscape, and give a new point view classification of dynamic lighting (Chapter2), and then try to exam the psychological impact of dynamic lighting through psychological experimental studies (Chapter4-7).

As the variation of dynamic lighting is quite complicated and to do the classification by variation action and pattern is also a new viewpoint, so psychological evaluation experiment of classification could do the help to support the new theory. Then the present situation of dynamic lighting in Beijing and

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[1] CIE (International Commission on Illumination), 1999. Report on the CIE Workshop: Photometry of Flashing Lights. <http://cie2.nist.gov/meetings/1999_Warsaw/ Workshop_Proceeding4.htm>.
[2] Takahashi Y, Fujiwara T. Effectiveness of broadcasting guidelines for photosensitive seizure prevention [J]. Neurology, 2004, 62(6): 990-993.

Tokyo can be classified and summarized by the variation action and pattern through field survey. In order to gather more information and find the main existing problems of dynamic lighting in urban nightscape, questionnaire investigation had been taken in Beijing and Tokyo. According to the questionnaire, it can be found that more than half respondents believe they have been brought interferences from dynamic lighting in the daily life in Beijing and Tokyo. Despite some problems, from their opinion that few respondents dislike the dynamic lighting, especially for female. Meanwhile, field survey had been done in the representative and dominated commercial area in Beijing and Tokyo to gather the field data. It can be drawn that large amount of dynamic luminaries are used in the surveyed commercial areas, among these, the running effect and flash effect is the common type. Then brainstorming about the issue of dynamic lighting had been carried out to discuss the existing problems, the sites where can commonly see dynamic lighting and the relevant adjectives which can describe people's feeling raised by dynamic lighting.

Chapter 4 is about the most basic psychological experiment of dynamic light-spot. This chapter is conducted to investigate implied emotion of dynamic light-spot by designing a psychological experiment to evaluate different dynamic lights-spot CG samples. It is a valid approach to explore and understand people's feelings of different kinds of dynamic light-spot. The aim of this basic experiment is tried to figure out the psychological effects of the most important variables (frequency, visual solid angel and luminance) of a dynamic light-spot under laboratory environment and compare the difference between the flash effect variation action and the gradually change effect variation action of a dynamic light-spot. The results of this experiment show that for both the flash effect and the gradually change effect of dynamic light-spot, the most significant variable for impacting people's emotions is the frequency of dynamic light-spot, the luminance is not the significant variable on the feeling of preferable and if the luminance and the luminance contrast is in a relatively high level people's emotion will show little change with the increase of luminance. Then the ANOVA analysis results between the two variation actions point out that the difference between the flash effect and the gradually change effect on the seven emotion scales of the dynamic light-spot is not significant, which means in the subsequently psychological experiment it is possible to just focus on the flash effect. This psychological evaluation experiment can offer some advices that in order to obtain more appropriate visual environment the high luminance of a dynamic light-spot is not required, but it is necessary to design the frequency according to different application purposes.

After studying the simplest dynamic luminary the light-spot, it is necessary to do the further study of the dynamic lighting signboard which is very important and widely used in the nightscape. In order to invite more people to attend the experiment, the psychological evaluation experiment of dynamic lighting signboard is designed to operation on the network through a professional website. To ensure this kind of psychological experiment can be operated on the network, the chapter 5 begins with a preparatory experiment. The preparatory experiment suggest that to compare with the influence of the experimental computer (different size and brightness of the screen) and the experimental condition (different

surrounding environment when doing the evaluation experiment), the influence of target evaluated dynamic samples is more significant. Consequently, this evaluation experiment of dynamic lighting signboard can be performed online.

Then a relatively simple and representative signboard is designed to be used in this experiment. In urban nightscape, the various kinds of dynamic effects of a lighting signboard with different variation actions and different variation portion can be easily found. So researching the influence of variation actions and variation portion is very significant. In order to find the influence of variation rate, the psychological experiment of different speed evaluation is also designed. It can be conducted the influence of variation action is stronger than variation portion on the feeling of striking, while the influence of variation portion is stronger than variation action on the feelings of comfortable and legible. And inside the variation actions, the strongest influence on the striking feeling is the flash effect; the strongest impact factor on the feeling of comfortable is the extending model of the running type and the flash effect is also play very important role on this emotion; the differences between the five variation actions on the feeling of legible are not obvious. Inside the variation portions, the frame is the strongest impact element on the feeling of striking; the influence of frame is also the most significant on the feeling of comfortable; the influence of main body is the strongest on the feeling of legible. Then it can be drawn among three independent variables of variation portion, variation action and variation rate, the variation portion is the most significant factor on influencing the feeling of legible, as well as the variation rate is the most significant factor on influencing the feelings of striking and comfortable. From the results of different speed evaluation part, it can be tell the flash frequency and the feeling of striking of the dynamic lighting signboard is fitted as positive linear $Y = 1.3428\lg(f) + 0.8636$; flash frequency and the feeling of comfortable is fitted as downward parabola $Y = -2.2166 [\lg(f)]^2 - 1.254 \lg(f) - 0.1804$; flash frequency and the feeling of legible is also fitted as downward parabola $Y = -1.9206 [\lg(f)]^2 - 0.6246\lg(f) + 0.1065$

In chapter 4 and chapter 5, the study just focuses on the dynamic luminary itself. Actually, it is believe that the quantity, size and spatial relationship of the dynamic luminaries are very important factors, so in chapter 6 the online psychological evaluation experiment of dynamic nightscape is designed to explore that how the spatial relationships of the dynamic luminaries influence people's emotion. Before the formal experiment, a preparatory evaluation experiment is also needed to make sure the research can be performed online. It can be seen the influence of size is stronger than the influence of quantity on the feeling of striking, comfortable and urgent, while the effect of quantity is more significant than the effect of size on the feeling of lively. The online experiment also shows that the difference of distribution of dynamic lighting in the street scenario is only significant on the feeling of comfortable, which indicates if the quantity and size of dynamic luminaries are fixed; the distribution may influence the feeling of comfortable. Although the speed and spatial relationship of dynamic luminaries are both significant impact variables on all emotion scales, it still can be drawn that the effect of speed is more significant than the effect of spatial relationship. The relationship between the speed and the feeling of striking,

lively and urgent is approach to positively linear correlation, as well as the relationship between the speed and the feeling of comfortable is approach to downward parabola.

In order to eliminate the influence of other factors to do the foundational research, the previous laboratory research and the two online psychological experiments are all used CG (Computer graphics) model samples. Therefore, it is still necessary to study the dynamic lighting in the actual scene in chapter 7. One representative actual scene in a street of Ginza commercial area (5-6 Ginza, Chuo-ku, Tokyo), which the environment is relatively simple and representative, is chosen as the real case scenario. The comparison analysis results shows that the P value of size and quantity are all definitely significant (P＝0.000) on the feeling of striking, lively and urgent which reaches the same conclusion with the pervious online psychological experiment. According to the value of F ratio to compare the size and quantity, it can be concluded roughly, the study reach the same results with the online psychological experiment that the effect of size is more significant than the effect of quantity, only except on the feeling of lively. And the mean analysis results of this laboratory actual scene experiment also get close conclusion with the online psychological experiment that the most comfortable and legible variation portion of dynamic lighting is the frame type and the most striking variation portion of dynamic lighting is the main body type. Then the same conclusion can be conducted the evaluated feeling value increases with increasing the quantity and the size of the dynamic luminaries on the feeling of striking, lively and urgent, while the evaluated value of comfortable feeling decreases when the quantity and size is too large or too small. Then, the speed evaluation experiment suggests the differences between the different kinds of effects of dynamic lighting on the limited low speed are not obvious. However the differences between the different kinds of effects of dynamic lighting on the limited high speed and recommended speed are significant. The range of the limited high speed in this scenario is from 1.92Hz to 3.56Hz and the range of the recommended speed in this scenario is from 0.64Hz to 1.44Hz. Among them, it can be noted the recommended speed has strong relationship with the visual solid angle of dynamic lighting. The regression equation of the frame flash effect is linear Y(frequency/Hz) = -3.0606X(visual solid angle) + 1.4283 ; the regression equation of the main body flash effect is also linear Y(frequency/Hz) = -1.7486X (visual solid angle)+ 1.0013

Undoubtedly, the conclusion of the series of psychological evaluation experiments are possible to serve for getting more appropriate visual environment according to different kinds of requirements and purposes. It also can formulate theoretical basis for dynamic lighting study. Furthermore, the results may be able to be used as an indicator or reference for dynamic lighting design or to establish relevant regulations and guideline for dynamic lighting design or to improve the management of dynamic lighting and perfect the regulations of nightscape planning.