Application of Information Science in Museum Lighting Design and Psychophysics

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Abstract. This paper mainly discusses the influence of different lighting methods and building height on visitors in the museum environment. This study takes Ningbo Art Museum as the experimental site. Four exhibition areas with different floor heights and different lighting methods were selected for objective field measurement, and subjective scores were given according to the types of lamps, lighting methods and the atmosphere created by control methods. Objective data measurement and subjective questionnaire survey were used in the experiment. In the subjective part, 20 visitors were selected to investigate the emotion of visitors through questionnaire survey. Finally, SPSS is used to analyze the data. Through field investigation and subjective information analysis, this paper closely combines electrical engineering with information science research, which lays a solid foundation for improving the integration of Museum electrical lighting design and visitors' psychological information.

1. Introduction
Over the course of the past 150 years, exhibition design has shifted from the unmediated display of objects to the creation of interpretive environments [1]. Considerable resources are expended in the planning, design, and construction of museum exhibitions, with an increasing emphasis on the creation of environments with immersive, themed, and theatrical elements [2,3]. Exhibitions are the product of interdisciplinary teams, bringing together a range of specialists, each having distinct theoretical traditions and conventions of practice [4]. For example, when we design the light environment of the art gallery, we should not only consider the influence of light on the works and tourists' mood, but also consider the influence of the building structure on them. Literature indicates that lighting can influence emotions, mood and cognition as well as atmosphere and spatial impressions, although at times the collected findings are inconclusive [5]. Some studies have pointed out that bright light environment is easy to produce more pleasant mood [6]. Atmospherics is now widely acknowledged as an important component of experience quality in a wide range of leisure settings [7,8]. However, there is not much research on the influence of story height on the emotion of the characters. Therefore, this paper combines lighting environment and floor height to explore the impact of both on visitors' emotions.

2. Field research
In this experiment, the light environment of Ningbo art museum was investigated. The survey is mainly divided into two parts: objective data (illumination, color rendering index, etc.) measurement and subjective questionnaire. The relationship between human emotions and light environment is brought into the real-world experiment, which can make tourists get a stronger subjective experience.
2.1. Objective data measurement

The experimental research area is mainly four areas, namely the central hall, photography exhibition area, painting and calligraphy exhibition area and display area. Each area has different lighting modes, and the key lighting sources are halogen light sources with the same color temperature. Except that the central hall adopts the combination of natural lighting and key lighting, other exhibition halls use artificial light sources to protect cultural relics from direct natural light. Objective data collection is mainly divided into three aspects: illumination, CRI and lighting method in the exhibition area.

2.1.1. Central Hall.

The central hall lighting adopts the combination of natural light and key lighting. Adjustable shade shall be installed under the glass roof. We can easily control and filter through the gap between the shade and the natural light. The exhibition booth and the central seating area are illuminated with guide rail spotlights to create an atmosphere for various activities.

![Fig.1. real scene picture and illuminance distribution of hall and platform](image)

The central distribution method is adopted for the field illumination measurement of the central hall, 5 * 5 points are taken for the hall, 4 * 2 points are taken for the exhibition booth, and the average illumination is 358lx (see Eq 1 for calculation).

\[
E_{av} = \frac{1}{M \times N} \sum E_i
\]  

\(E_{av}\) is the average illuminance value, the unit is Lux (Lx), \(E_i\) is the illuminance in the lobby, \(M\) is the longitudinal measuring point, and \(N\) is the transverse measuring point (Eq 1).

2.1.2. Photography exhibition area.

In this exhibition area, the type of works to be displayed is photography, and the key lighting is rail spotlight. Take 5 * 3 points for measurement according to the method of center distribution. The average illuminance of the exhibition area is 73.31lx (Eq 1), and Ra is 99.8.

![Fig.2. real scene picture and illuminance distribution of Photography exhibition area](image)
2.1.3. painting exhibition area.
The exhibition hall of calligraphy and painting shows gouache, ink painting, oil painting, calligraphy, etc. all of which are nude exhibitions. The height of the exhibition hall is 8m, and the mixed mode of key lighting and direct lighting is adopted. This is a modern exhibition hall that can display various art forms. It is suitable for different types of exhibitions. It can be used reasonably and flexibly according to different requirements. The picture shows the real picture and illuminance distribution of the painting and calligraphy exhibition area, with an average illuminance of 60.21lx.

![Fig.3. real scene picture and illuminance distribution of painting exhibition area](image)

2.1.4. display area.
The display area is 5m high. No lighting. LED display backlight is mainly used for static display of photographic pictures, combined with the stray light of other exhibition areas to ensure the illumination of the ground. 7 * 3 points are taken for measurement according to the central point arrangement method, and the average illumination is 12.94lx.

![Fig.4. real scene picture and illuminance distribution of display area](image)

2.2. Subjective questionnaire survey
20 tourists were selected to fill in the questionnaire. When tourists visit in different exhibition areas, they can evaluate the light environment of the exhibition area subjectively, and get different psychological perception state of the field space with different floor height and lighting mode.

| No. | Positive - Negative | scores | No. | Positive - Negative | scores |
|-----|---------------------|--------|-----|---------------------|--------|
| 1   | Bright / dark       | 6-1    | 6   | Even/uneven         | 6-1    |
| 2   | Clear / fuzzy       | 6-1    | 7   | Comfortable / Uncomfortable | 6-1 |
| 3   | Colour true / unreal| 6-1    | 8   | Nervousness / relaxation | 6-1 |
| 4   | Dazzling / soft     | 6-1    | 9   | Negative / positive  | 6-1    |
| 5   | Colourful / monotone| 6-1    | 10  | Attractive / unattractive | 6-1 |

Luo et.al [9,10] have done research experiments in the actual Museum, and put forward 10 adjectives to describe lighting environment and atmosphere perception. According to the experimental basis, 11 psychophysical words are selected to describe the psychological feelings of tourists in different levels.
and lighting conditions. As shown in the table, the scores from negative words to positive words are 1-6, which are very negative, negative, relatively negative, relatively positive, positive and very positive. Among them, No.1-6 is tourists' perception of light appearance, and No.7-10 is tourists' psychological perception in light environment.

3. Discussion and analysis of results
According to the 80 subjective data obtained by SPSS single factor analysis, using the calculation method of F test (Eq2), the significance p value is used to determine whether there is significant difference in the evaluation of different evaluation items under different conditions.

$$F = \frac{S_A/\sigma^2}{S_E/\sigma^2}$$

Among them: SA is the sum of the squares of the effect of factor A, SE is the sum of squares of errors, \(\sigma^2\) is the mathematical expectation, r is the number of levels of factor A, and n is the sum of n sub independent tests.

| N   | 5m  | 8m  | F    | P    |
|-----|-----|-----|------|------|
| Bright / dark | 40  | 40  | 1.641 | 0.202 |
| Comfortable / Uncomfortable | 40  | 40  | 4.973 | 0.027 |
| Dazzling / soft | 40  | 40  | 2.079 | 0.151 |
| Clear/fuzzy | 40  | 40  | 0.121 | 0.729 |
| Even/uneven | 40  | 40  | 6.918 | 0.009 |
| Colour true/unreal | 40  | 40  | 1.76  | 0.187 |
| Colourful/monotone | 40  | 40  | 2.311 | 0.131 |
| Nervousness / relaxation | 40  | 40  | 6.522 | 0.012 |
| Negative / positive | 40  | 40  | 2.666 | 0.105 |
| Attractive / unattractive | 40  | 40  | 0.832 | 0.363 |

When the significance p value is greater than 0.010 and less than 0.050, there is no significant difference. When the significance P value is greater than 0.050, there is no significant difference. From table 2, we can see that nervousness / relaxation, even/uneven light, comfortable / uncomfortable have significant difference relationship with floor height.

Fig.5. The relationship between environment and psychological word pairs

Environment 1: 8m, natural light + key lighting; Environment 2: 8m, general lighting + key lighting; Environment 3: 5m, LED display + stray light; Environment 4: 5m, key lighting.

From the figure, we can see that except for the four word pairs of bright, focused, positive and true color, environment 2 scores higher than the other three cases, and the total average score is the highest. However, for bright, positive and color real words, the scores of light environment from high to low are
environment 1, environment 2, environment 3 and environment 4, which have strong relevance. Therefore, we can infer that bright environment will generate positive emotions, whereas dim environment will generate negative emotions. And in a bright environment, people feel that paintings are more realistic. For the aspect of dazzling/soft, environment 3 scores the highest. We infer that because of the low illumination of the surrounding environment and the high brightness of the LED display screen, tourists are in a high contrast environment when viewing works, and their attention is more focused on the high brightness area.

4. Conclusion
This paper mainly discusses the influence of four different lighting modes and building height on visitors' emotion in Ningbo Art Museum. In these four cases, the combination of 8m storey height and mixed lighting mode has the highest average score and is most popular with tourists. For 5m storey height, tourists generally feel nervous and the uniformity of light is not high. At this level, the key lighting mode is significantly different from the combination of LED backlight and stray light in the following four aspects: dazzling / soft, tense / relaxed, clear / fuzzy. The key lighting mode is more gentle and relaxed than the combination of LED backlight and stray light. But the combination of LED backlight and stray light is more clear and more attractive to tourists. For the height of 8m, the mode of key lighting + direct lighting gets the highest score. Although the mode of mixing natural light and key lighting is more active, the dazzling degree is higher. Generally speaking, the mixed lighting mode is more suitable for the lighting of the art museum, which not only prevents the harm of ultraviolet rays in the natural light to the exhibits, but also ensures the comfort of visitors when they visit and presents a more real style of the exhibits.

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