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Based on Creative Thinking to Museum Lighting Design Influences to Visitors Emotional Response Levels Theory Research

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Abstract. This paper expounds the synthetic design process of artificial lighting, and emphasizes that the key of museum lighting design is based on the visual factors of visitors. Combining theories of architecture, design, optics and psychology, this paper studies the emotional response level of museum visitors through the interdisciplinary integration and creative thinking. At the same time, creative thinking is applied to put forward the theoretical model of “SVOE” lighting design based on visual factors. As a function of the evolution of spatialization, visualization, optical indexing, and emotionalization, the theoretical model of lighting design innovates on the thought processes and evaluation of lighting design. Based on research related to LED light source lighting design methods, it is an urgent problem to combine functional reasonable lighting design with human emotion. This paper discusses the design and practice of emotional lighting by using the theory and research system of psychology and the design method of emotion analysis based on spatial, visual, optical engineering and psychology.

1. Introduction

Creative thinking is a way of thinking which, through the process of understanding, promotes the generation of new ideas and perspectives through analysis, synthesis, comparison, abstraction, and reasonable imagination [1]. The formation of new concepts in traditional lighting design methods is the key to innovative lighting design. The environmental lighting of architectural spaces has been called the fourth dimensional space of architecture. However, one of the key reasons for this is the invention of artificial light sources. With the development of the LED light source, its excellent characteristics of volume, color temperature, brightness, color rendering and controllability make it the most ideal light source carrier. Thus, as lighting technology is rapidly developing, lighting design concepts and methods should also be improved and promoted.

Creative artificial lighting design with interdisciplinary integration takes human visual factors as the core element. The effects of rods and cones on visual factors in dark and light conditions are studied through emotional responses to the environment, including comfort assessment, visibility assessment, warmth assessment and preference assessment. Based on the conceptual optimization of emotional response level in theory, this paper proposes the definition and theme of the whole standard artificial lighting design result, as shown in Figure 1.



2. Interdisciplinary integration of creative thinking

Kruithof proposed an interior lighting design method to achieve the “pleasure effect” related color temperature (CCT). The conclusion of the study on the optimization of light source in commercial psychology experiment is that the most suitable natural light source produces more color gamut with more uniform appearance and symmetry than the preference proportion [2]. A visual phenomenon in which light stimuli of different wavelengths act on visual organs in two brightness ranges. When the brightness of light stimulation is above 3cd/m^2 , the vision acquired by human cone cells is called light vision or cone cell sense. In the case of dark adaptation, the vision mainly acquired by the stem cells is called dark vision or stem cell vision.

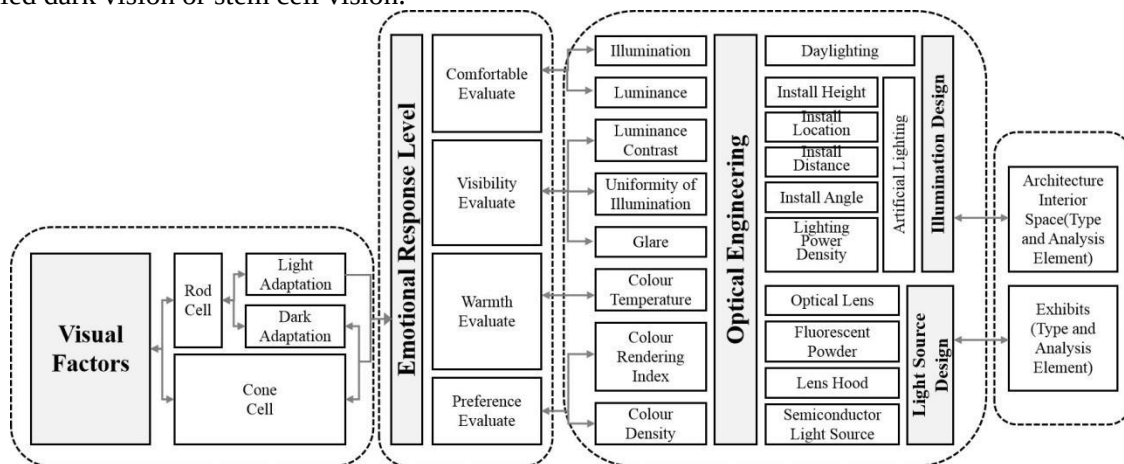


Figure 1 Schematic of interdisciplinary research framework

Appreciation of feelings is an important behavior in human social activities, which act on “lighting design” and involve the whole process of behavior. The viewer's feelings are divided into three basic stages: First, the quantity of feelings. People are looking for exhibits that they can view easily and clearly. Second, the stage of quality must be considered. People have begun to demand a certain quality of light in the environment space. In these two stages, the needs of the viewers remain at the most “basic” level, with the aim of obtaining more material-level performance in the exhibits. The third stage is that of emotional feeling.

3. Spatial research on museum lighting design

This research focuses on innovative theoretical research related to museum lighting design, which generally considers four elements: spatialization, visualization, optical engineering, and emotionalization. “Spatialization” research in innovative lighting design focuses on the physical analysis and categorization of space and exhibits.

3.1 Spatialization

At present, there are different perspectives related to the relationship between Lighting Design and the Spatial Environment, and between the understanding of architecture and interior design [3]. The museum building belongs to a public building. The functional division and traffic flow layout in the building space are complex. The museum building space is divided into display and auxiliary spaces, based on the function of the display. The exhibition space is divided into permanent exhibition space and temporary exhibition space. The auxiliary space is the area that connects the display space, and generally includes the entrance hall, the preface hall, and the corridor space. The lighting design of these auxiliary spaces has a close correlation with the lighting environment of the exhibition space. The visual lighting design of the auxiliary space can affect the light environment of the exhibition space. Faced with such diversity within the building space, the light environment requirements of the building space are also high, and each space must be provided with a light design that meets the specific environmental requirements of that space.

The exhibition space design needs to fully consider the characteristics of the exhibits, making it more stereoscopic and comprehensive to shape and highlight the main body of the exhibition. In the museum exhibition space, we pay great attention to the spatial scale. The scale of different exhibition space will bring different visual and psychological feelings to the audience. The suitable space can increase the comfort of the exhibition, and vice versa. The specific display space structure in the exhibit area is shown in Figure 2.

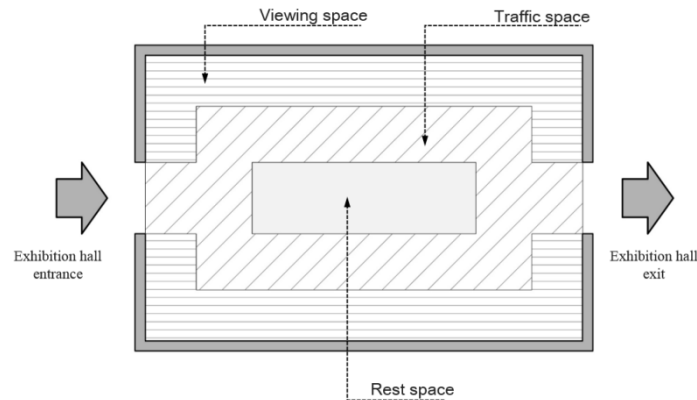


Figure 2 Typical display space structure.

3.2 Visualization and optical engineering

Consider the lighting design of visual factors from the perspective of the layout and design flow of the building space. Vision is divided into bright vision, intermediate vision and dark vision[4]. The time required for the various visual transformations is different. The layout of the space structure is planned and a suitable light environment is created through the transformation of the bright, dark and middle vision, to allow the visitors to feel more comfortable. Vision is the process of observing things through the eyes, Visualization is the recognition and understanding of human physiological indicators[5]. In terms of illumination, vision is the sensation of light passing through the rod and cone cells in the retina and are the most critical components. This information then passes through the optical nerve to the visual center and the brain for final image processing[6]. The color in the light is very important for evaluation of quality lighting. The evaluation of light in optical engineering primarily depends on illuminance, color temperature, color rendering index, and color tolerance.

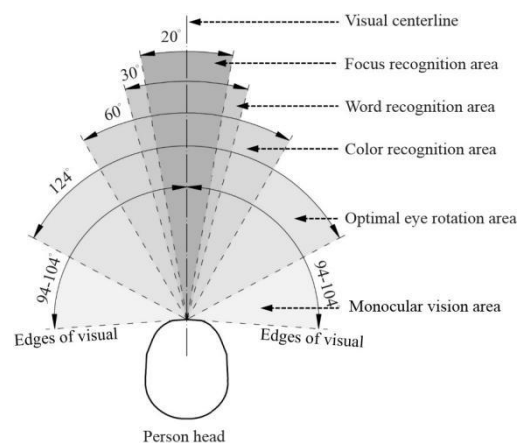


Figure 3 Person's flat visual angle analysis.

Figure 3 is a person's plane view analysis. The figure shows the human visual centreline as the axis. The distance from the centre is 10° which is the focus recognition area, 15° is the text recognition area, 30° is the colour recognition area, 62° is the eye's optimal range of rotation, and 94°~104° is the visual range of a single eye.

3.3 Emotional

The impact of the visual sense on psychological feelings has been confirmed in other spaces. For light in classrooms, hospitals, and offices, it has been proven that light environments can change people's emotions and have an important impact on learning, work, and health[7]. The museum is a public place for visitors to obtain cultural information. There are many types of exhibits in this space. Therefore, logically, this space needs to be adjusted to meet the psychological needs of human beings using the technical parameters provided by optical engineering.

The three different dimensions of “visceral, behavioral, and reflective” are intertwined in any design. It is impossible for one of the dimensions to be absent[8]. They appropriately define the three existing forms of emotion in lighting and highlight human emotions[8]. After introducing the ideology of “human emotion based” into the field of emotional lighting, the “SVOE” model of innovative lighting design is perfected, and it becomes apparent that the feelings and emotions of the viewer can be influenced by a change in the lighting. The essence of lighting design is to solve the relationship between lighting, space, and people, to enable people to experience the most suitable lighting in a given space, and to appropriately address the functional needs of people. The most “Visceral” element in lighting is the human visual function; the lighting design should, therefore, also be designed to meet the most visceral needs of mankind, which is the pursuit of light, as shown in Figure 4.

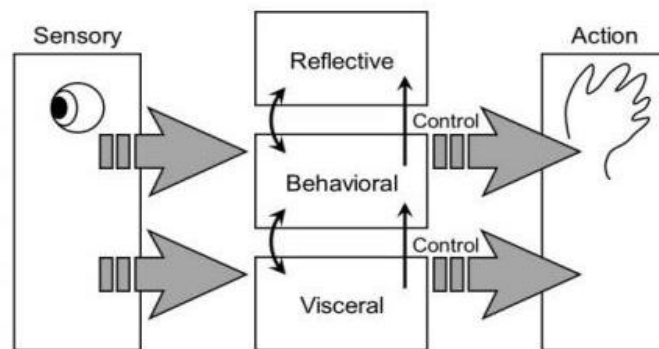


Figure 4 Visceral, behavioral, and reflective analysis

4. Museum research

In this experiment, lighting design and tourists' feelings in different functional areas of Liaoning museum were investigated by means of lighting index detection and questionnaire.

4.1 Illuminance test

The illuminance test uses the central distribution method in which the illuminance measurement area is divided into grids. The grids must be square and the illuminance must be measured at the center of each grid.

$$E_{av} = \frac{1}{M \cdot N} \sum E_i \quad (1)$$

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 (Equation 1)

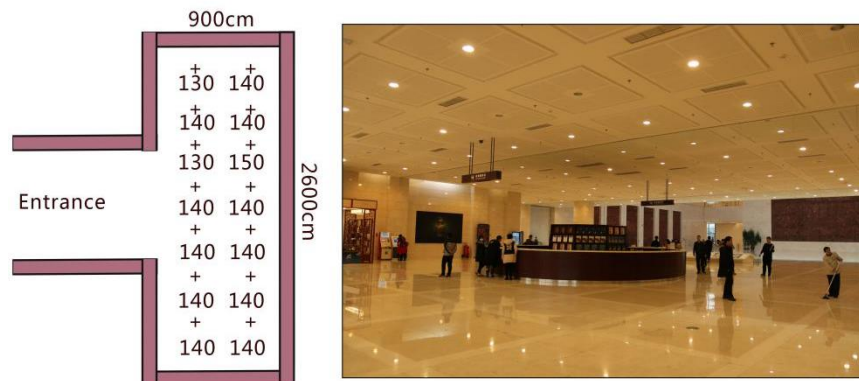


Figure 5 Illuminance distribution and real scene map of lobby illuminance test

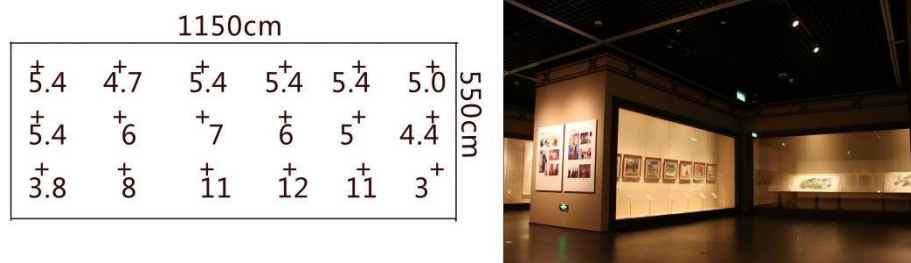


Figure 6 Local ground illuminance distribution and real scene of exhibition hall 2

By substituting the data measured in the lobby into the formula: $e = 1 / (27) \sum E_i$, the horizontal average illuminance is 139.30 Lx and the horizontal illuminance uniformity is 0.933. Hall 2 has an illuminance of 101.89 Lx, an illuminance uniformity of 0.491, as shown in Figure 5 and 6

4.2 Measurement of color temperature and color rendering index

From the perspective of the museum's simple and omitted function, there are three basic functions with higher requirements for the quality of light and color of lighting. One is the exhibition function, which requires lighting to achieve a higher definition of exhibits. This requirement is related to illumination, fidelity, and color gamut of lighting. Secondly, the preservation and maintenance function of cultural relics or artwork, which requires the lowest light-induced damage of illumination to the target object[9]. The third is to study the educational function. Besides the fidelity index, color gamut, and relevant index mentioned above, the spectral characteristic parameters that affect the apparent color quality of LED lighting in the museum primarily include illuminance and color temperature.

A spectral radiometer was used to measure the color temperature and color rendering index of the site. The number of measuring points in each site does not fall below 9, and the arithmetic average value was used for the color temperature and color rendering index of the tested lighting site.

4.3 Sensory test questionnaire

A subjective evaluation was carried out by inviting an audience to scan the QR code on site and to complete a questionnaire, convenient and efficient for statistics. A total of 106 sets of data were collected for more than 20 people. The factors affecting the lighting of the museum's environment, such as the degree of realism of display color, the degree of light source color preference, the display detail expression, the three-dimensional expression, the display texture definition, the display outer outline definition, the display brightness acceptance, the visual adaptability, the psychological pleasure,

and the degree of light artistic preference, were selected, and through it the test questionnaire data were processed.

Through the museum lighting experiment designed by us, we found that: the artistic preference of basic display light is highly evaluated, which needs to be improved in visual adaptability and appeal. Temporary display subjective visual comfort is high, to improve the color preference of light source; The light art of the hall is highly appraised, and the appeal needs to be improved. Corridor subjective visual comfort is better, there is still room for improvement, but the appeal of the degree of preference is general, there is more room for improvement.

5. Innovative Theoretical model

The research and conclusions of the above museums provide a good foundation for us to establish theoretical models. The interdisciplinary and creative thinking merges to create a bridge between architectural space, light source and human psychology. Traditional lighting design only considers the basic lighting requirements of spaces and exhibits and has not considered the influence of spatial visualization conditions and emotional feelings. By using the lighting design theory, “SVOE” mode, to influence the viewer's mood when visually perceiving a space, a solution related to the relationship between people, space, and light will be proposed.

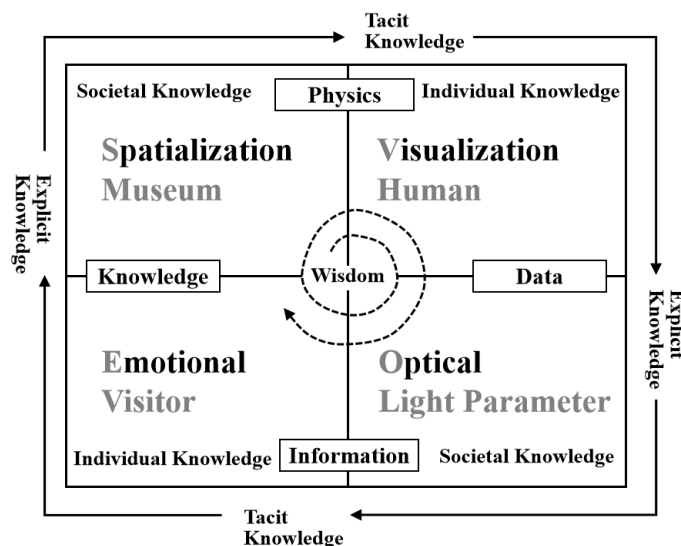


Figure 7 “SVOE” mode lighting design analysis chart

Two kinds of human knowledge, i.e. explicit knowledge and tacit knowledge, are used in this research. Explicit knowledge, also known as direct knowledge, refers to knowledge that can be clearly expressed, and is usually described as knowledge that can be expressed in written words, diagrams, and mathematical formulas[10]. In “SVOE” mode, space and optics are part of the body of explicit knowledge. Knowledge that one cannot clearly express is called tacit knowledge. Visual perception and psychological experience are part of Tacit Knowledge.

6. Conclusion

This paper summarizes a lighting design method based on creative thinking. Through field investigation of Liaoning Museum, the emotional response of museum visitors under different lighting conditions is studied, and a theoretical lighting design model which combines architectural physiology with human emotional factors is innovated. Lighting design is essentially a creative activity. Spatialization, visualization, and optical elements, which emotionally affect the characteristics of creation are the main characteristics of lighting design. Lighting design that is driven by creative thinking and innovative techniques is not limited to traditional functional design frameworks. Considering the elements of emotional lighting design, the use of the creative thinking method reflects

the human-centered innovation lighting design method. This research suggests that the design of the light environment can have a significant influence on the inner feelings of human beings. The internal relationship between the elements exhibited by a comfortable light environment corresponds to human emotional patterns. The research related to innovative lighting design methods, and the theory of spatialization, visualization and optical engineering are used to establish new theories and standards of emotional lighting design; through the use of the theory of explicit and tacit knowledge, they are also used to solve the design problem of the light environment, and most importantly, to influence the emotions of visitors.

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