Lighting Design for Artifacts Preservation Purposes and Visual Comfort in Museums

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Abstract. Histories mark the making of nations and traditions of a country, nevertheless Indonesia. Artifacts displayed in a museum has to follow recommended guidelines for preservation purposes. Unfortunately, the visual comfort of visitors is often neglected. On the one hand, displayed exhibits require minimal exposure from UV light for preservation, and on the other hand, human eye need a decent amount of brightness to keep their visual comfort. This paper focuses on maintaining overall brightness for artifacts preservation purposes while at the same time, keep the acuity of visitors’ visual comfort. Museum Keramik; and Museum Wayang in Jakarta were chosen as case studies in this paper. Lighting intensity towards artfacts will be measured and to be compared with a questionnaire by visitors and respondents. Comparisons of both data will be used to determine the effect of perceived brightness towards the use of lighting throughout the artifacts in the museums. By presenting visual comfort in a museum environment and at the same time preserving the artifacts, a substantial increase in visitors’ satisfaction is to be expected.

1. Introduction

Indonesia has a total of 428 museums managed by either the government or private sector in 2018 [1]. As a comparison, in 2013, China has a total of 3.859, with 3.054 managed by government, and 535 managed by the private sector [2]. Artifacts made of textile or paper need lower intensity lighting to prevent degradation. Thus, visibility is one of the crucial factors to be considered while designing lighting in museums [3]. Guidelines for lighting in historical museum classified the minimum level of illuminance towards artifact by its material. High sensitivity, medium/low sensitivity, and no sensitivity, with maximum illuminance level of 50, 200, and 1000 lux, respectively [4]. Level of illuminance does not necessarily determine the amount of brightness felt by human eyes. According to Innes, an identical pair of exhibits, both illuminated by dimmed and undimmed LV TH sources with same illumination level of 50 lux, with a difference of CCT (2,600 K and 3,000 K) produced different brightness when viewed with human eyes. As Innes said, “It was clear to me that the higher color temperature was preferable, in as much as it made the exhibits appear brighter” [5]. The study above showed that brightness is not measly measured by the illuminance factor. It is widely known that a higher color temperature made the object appear ‘cooler’ while lower color temperature made the object appear ‘warmer’. In low illuminance level, the human visual system is much more accustomed and sensitive towards the green-blue wavelengths of the light spectrum, namely Purkinje effect. Thus in a case of low illuminance level, a set of light sources with similar illuminance level, the human eye will react better toward sources with higher color temperature (cooler), as a result, ‘CCT value source will appear much
brighter [6]. Adaptation is one of many perks of human, nevertheless the visual adaptation system. The invention of camera lense is based on the capability of the human eye about its ability at adapting to different lighting conditions. Pupil changes its sizes to admit more or less light to enter the eye [7]. Concerning adaptational abilities, age is one of the factors that affect it the most. As human age, the maximum sensitivity of the eyes regressed much further after mid forties. A 45-year-old human may need an illuminance level of 300 lux to replicate a 50 lux brightness seen by a 25-year-old [8].

2. Method
Illuminance level towards exhibits is measured with lux meter and to be compared with maximum illuminance guidelines from Illuminating Engineering Society of North America (IESNA). High contrasting lighting with visible bright and dark spot will be the criteria of a selected sample of the exhibit to be measured. These exhibit samples will consist of different material types about its tolerance towards illumination level. Thus 6-7 samples will be selected on each museum used as case studies. Measurement will be done to different illuminance level on exhibit, namely bright, medium, and dark spots. Illuminance level of exhibit’s background and standing position of viewers towards exhibit will also be measured for comparison purposes. 2 samples from each museum with the highest contrast between bright, medium, and dark spots, will be selected for questionnaire subjects to study the perceived brightness and visual comfort of visitors. Fifteen respondents will be selected for each sample with a total of 60 respondents. The questionnaire is paper-based, and done with Likert’s scale to provide qualitative assessment towards selected exhibits. Respondents are then tasked to focus on bright, medium, and dark spot, for several seconds and assess the overall brightness of each exhibits respectively. Questionnaire’s data are then paired with measured illuminance, results which showed that brightness perceived by adjusting to brightness situation would make exhibits appear much brighter regardless of illuminance are to be expected.

3. Results and Discussions
3.1. Illuminance Factor
Most museums in Indonesia managed by the government, rarely use adequate lighting design plan. Resources encountered by the author throughout the site visits stated that both museums use similar luminaires for all of the exhibits regardless of its material.

![Figure 1. Measured illuminance from each museum](image-url)
Figure 1 shows that most exhibits measured at Museum Keramik fall below the maximum illuminance level from IESNA guidelines, with exhibit number 3 from Museum Keramik as an exception. Exhibit 3 shows that bright, and medium spot measured at >50 lux, slightly above maximum illuminance guidelines, with a sharp drop of illuminance level measured at the dark spot, thus causing visible contrast and a bright spot on exhibit. Exhibit 3 also shows that the illuminance level of the standing position is measured to be much lower than the exhibit itself, making it accentuated from the surrounding space. Exhibit 4, 5, 6, and 7 in Museum Keramik are not susceptible to UV damage, but exhibit 5 will also be chosen as sample for questionnaire for its contrast value.

Museum Wayang in Figure 1 shows that 3 out of 6 measured samples surpasses maximum illumination guidelines. These exhibits fall under medium/low sensitivity category with a maximum illuminance of 200 lux, and further exposure will lead to a duller color of dye. Exhibits with high contrast value in Museum Wayang will also be chosen as sample for qualitative assessments. Exhibit 2 and 6 in Museum Wayang showed a significant readings of illuminance level compared to other exhibits measured in Figure 1. Exhibit 2 showed background illuminance appear to be brighter than the dark spot measured on exhibits itself. This difference causes certain parts of the exhibit to appear much darker, as the human eye constantly adapt and adjust to different light condition. The appearance of a contrasting bright light source, causes the pupil to shrink, limiting the amount of light entering the eye, thus causes parts of the exhibit that were not lit enough to appear much darker. Exhibit 6 also showed that a significant drop occur in corner parts of exhibit with contrast on its center. As mentioned above, these contrast causes eyes to adapt continuously and causes several parts of the exhibit to appear darker.

Background illuminance affects the way visitors view the exhibit; higher background illuminance causes exhibit to appear much darker. Constant eye adjustment is also the main issue; high contrast causes eyes to adjust more frequently, resulting in eye strain and fatigue, hindering viewing experience in the museum. On the other hand, correct use of background illuminance causes exhibit to be highlighted through the room, creating a visual accent and could be used as a strategy to intrigue curiosity of visitors, raising visual experiences.

3.2. Perceived Brightness
4 sample was chosen from Figure 1, namely, exhibit 3 and 5 from Museum Keramik, and exhibit 2 and 6 from Museum Wayang. Questionnaires were handed to visitors randomly, and results are separated by age, to compare assessments result in relation towards declining adaptation capability of human eyes as they age.

Figure 2 and 3 shows the result for exhibit 3 in Museum Keramik. The exhibit shows a significant brightness on the upper left corner and darker parts appear on the lower right corner, and questionnaire results show that 8 out of 15 respondents rate upper part of the exhibit as bright, and 6 out of 15 rated lower part of the exhibit as dark. As seen on Figure 2, questionnaire results on bright, medium and dark spot show that on bright, assessment ranged from 2 to 8, 1 to 8, on medium, and 3 to 8 on dar. These show that an increase on perceived brightness value occurs when respondents are tasked to focus eyesight on dark spot and after assessment, the bright spot on exhibit seems to appear brighter due to adaptation, thus causing an increase of overall brightness assessment by respondents.
Figure 3 shows the brightness perceived by respondents aged 25-65 years old. Similar graph reading, as shown in Figure 2 occurs in Figure 3 where the three measured spots, show that the graph is slightly moving right towards higher perceived brightness value. The highest value of brightness occurs on 6, slightly above the median, with the brightest value of 9 achieved when respondents are tasked to focus on the medium, and dark spot. These show that contrast value affect the way respondents assess brightness level. Figure 3, in contrast of Figure 2, shows that respondents aged <25 years old provide a wider range of brightness value, ranging from 1 to 8, when compared to the other age group, as seen in Figure 3, brightness value is ranging from 4 to 9 with the highest average to be on 6. These numbers show that age indeed is a factor that determines the way human eyes perceived brightness. Similar results occur on 3 other samples measured on this section, with every sample shows an increase in brightness perceived, and a wider range of assessment achieved only by respondents <25 years old.
3.3. Perceived brightness and its relation to contrast
As seen in Figure 1, 2, and 3, exhibit 3 shows that brightness perceived assessed by respondents, appear to be above the median level of 5. These results appear to be possible when there is a contrast between the exhibit and its surrounding space. As seen in Figure 1, illuminance reading on background and standing position appear to be much lower than the exhibit itself. This illuminance difference causes contrast between the exhibit and its background, furthermore between the exhibit and its space in the museum. This contrast causes exhibit to stand out, and appear much brighter as assessed by respondents seen in Figure 2 and 3.

4. Conclusions
Lighting design plan holds an important role in visitors visual experiences in museums. Poor lighting quality causes exhibit to appear boring or even dull. Nonetheless, museums have to follow illuminance guidelines to preserve artifacts on display. Illuminance recommended by guidelines does not necessarily give the right amount of light for the visual acuity of visitors; thus through this paper, contrast may be one of many solutions to tackle this dilemma. Clever use of contrast between the exhibit and its space may cause exhibit to appear brighter than its supposed illuminance level. 9 out of 15 respondents assess brightness value as above median level. Through the experiments and surveys, done in this paper, it is concluded that contrast level affects brightness perceived by visitors regardless of the illuminance level.

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