

Visual Responses of Visitors towards Daylighting in Museums: A case study of Malaysia

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ABSTRACT

Daylighting in historic buildings is not easy to manage as natural light fluctuates. This study aims to evaluate visitors' visual responses and opinions towards daylighting in four selected galleries in museums. Intensity of illumination and visitors feedback were obtained through fieldwork. Instruments employed were data logger management system and light sensors at test points on showcases and display panels. The questionnaire was on the respondents' perception of daylight conditions at two different display panels (against window wall-*AWW* and opposite window wall-*OWW*). The illuminance assessment and evaluation indicated that the display placement affected daylight distribution pattern while the daylighting pattern affected the visitors' viewing satisfaction. The study examines daylight distributions and the visitors' visual perception and satisfaction in relation to the exhibits and interior configuration of the museums. The study found significant effect of exhibit condition and interior design parameters on indoor daylight performance and visual comfort. The results of this study contribute to the planning of appropriate lighting to minimise visual discomfort in museums.

Keywords: Daylighting, display placement, historic museum galleries, visual comfort

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INTRODUCTION

Museums' lighting are aimed at enhancing the display of its objects, while ensuring conservation needs are met. However, the lighting condition which increases the brightness of the objects to enhance visibility can damage them and thus at odds with conservation efforts (Mueller,

2013; Pinilla et al., 2016). Earlier studies have indicated that artifact damages due to lighting are mainly due to direct sun penetration over the display areas (Ahmad, Sh Ahmad, & Talib, 2013; Ahmad, Ahmad & Talib, 2012; Osterhaus, 2005; De Graaf, Dessouky & Müller, 2014). Glare and reflection from daylight, are the most commonly encountered problem that caused environmental discomfort (Hua, Oswald, & Yang, 2011). Interior daylight can differ sharply according to external obstruction, building area and orientation, floor level, glass type, shading and window area (Xue, Mak, & Cheung, 2014).

Glare and Visual Discomfort

Daylight can cause visual discomfort such as glare, reflections, light veiling or shadows (Alrubaih et al., 2013). Glare is a major concern of for buildings that faces east and west (Hua et al., 2011). Menzies and Wherrett (2005) reported that Boubekri and Boyer (1992) found that facades with window to wall ratio (WWR) of between 40 and 55%, reported above average visual discomfort due to glare. Osterhaus (2005) explained that glare from windows are the result of direct sunlight or sunlight reflected off exterior surfaces that “enter a room and shine into the eyes of occupants or reflected off visual tasks and surrounding surfaces”. Hua et al. (2011) found that horizontal shadings on the east and west facades of buildings are effective in supporting visual comfort and satisfaction of daylighting environment compared with vertical shading elements.

Wilson (2006) explained that the objects displayed against windows are against a high luminance (very bright) background. The surface colour and reflection could also have a key impact on the level of illuminance in an interior (Wilson, 2006). He explained that very bright light sources produced reflections on the glass of display cabinets, thus affecting the visibility of objects within the cabinet; resulting in veiling. Our sensitivity to veiling reflections depends on the balance between brightness of the reflection and the object. A low reflection surface in the background of the glass cabinet may reduce the adaptation of the eye, and improve visibility of the exhibits (Wilson, 2006).

According to Hopkinson (1972) as cited by Dahlan (2005), there are four basic criteria of glare that can be highlighted under a series of different conditions of surrounding brightness: i) Perceptible glare; ii) Acceptable glare; iii) Uncomfortable glare and iv) Intolerable glare (Hopkinson; 1972). In this research, the above-mentioned criteria are used to rate the user’s glare experience.

This study assessed the visitors’ visual responses and satisfaction levels of daylighting in selected museums in Malaysia. Field investigations were conducted in order to measure vertical and horizontal illuminances on display panels in different galleries: balcony, corridor, compartments and open areas. Results showed the effects of the exhibits’ condition and interior design parameters on indoor daylight performance and visual comfort.

METHODS

This study measures indoor illuminance levels and visitors' visual responses of the daylighting conditions at four selected museums in Malaysia. These buildings share similar characteristics: lighting of highly sensitive materials (printed materials), and orientation; east and west facing galleries allowing for comparison but with different display types and placements. The performance of daylighting was assessed based on side lighting design in four types of linear gallery space: balcony, corridor, compartments and open areas.

The galleries selected are: Admiral Cheng Ho Gallery, Melaka, M1; The Kuala Kedah Old Fort Museum, Kedah, M2; The Kota Ngah Ibrahim Historical Complex, Perak, M3 and The War Memorial, Kelantan, M4 (Table 1) which are located in Southern, East, Central and Northern parts of Peninsular Malaysia respectively. The study evaluates at two types of showcase and display panel placements; one against the window wall and the other on the opposite of the window wall (Figure 1 and Figure 2).

Table 1
Case study inventory

Case Study	Showcase Design	Exhibit Orientation	Window Orientation	Type of Fenestration	Floor area (m ²)	Room depth (m)	WWR	Exhibit distance to window (m)	Exhibit height (m)
M1	Glass Showcase	West Facing	West & South	Wooden casement w/ adjustable louvers	43	3	0.20	3	1 (h)
M2	Perspex Showcase	East Facing	East & South	Casement w/ adjustable louvers	69.9	6	0.11	2.7	1.5 (v)
M3	Exposed Display panel	East Facing	East & South	Tinted glass window w external roller blind	91.5	3	0.71	3	1 (h)
M4	Exposed Boxed-up display Panel	West Facing	West & North	Clear glass window	42	3.6	0.24	1.7	1.5 (v)

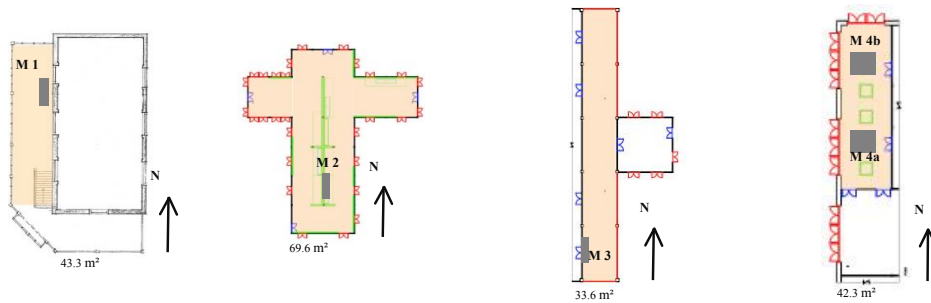


Figure 1. Gallery plans showing side lighting function of museums M1, M2, M3 and M4



Figure 2. Various display arrangements. M1- glass showcases, M2- perspex showcase, wall & top display panels, M3 wall panels and M4- freestanding island display panels

There were two types of exhibit orientation; one horizontal (shelf) at 1m above the floor level and the other vertical (vertical panel) at 1.5m above the floor level. These case studies were selected as they presented the indoor daylighting with similar characteristics: the demand for certain level of lighting, with similar museum exhibits of highly sensitive materials (printed materials), and with similar orientation: east and west facing galleries allowing for comparison but with different display types and placements.

Data Collection

Field work was carried out between March and December 2010 to assess the daylight illuminance levels based on visitors' perception and visual responses

of the indoor environment. During the experiment, artificial lights were switched off and indoor illuminance values at major points were recorded using the light sensors and data logger system. This system was programmed to record measurements at one-minute interval and subsequently, further calculations based on the hourly average illuminance were performed. All the measurements were conducted under overcast and intermediate sky conditions.

Observations were made under three consecutive daylight conditions; 09.00h to 11.59h (morning); 12.00h to 14.59h (afternoon) and 15.00h to 16.59h (evening). A total of 86 respondents participated in the questionnaire survey to evaluate the exhibit condition and indoor illuminance levels.

RESULTS AND DISCUSSION

Figure 3 shows the average illuminance level for the showcases and display panels at M1, M2, M3 and M4. Results indicated that the illuminance level in each museum between 09.00h and 16.59h (M1 & M4)

and between 08.00 and 17.59h (M2 & M3) differed significantly, where most lighting conditions exceeded the maximum recommended light limits of 50lx for Category I- Highly responsive materials (Ahmad et al., 2012).

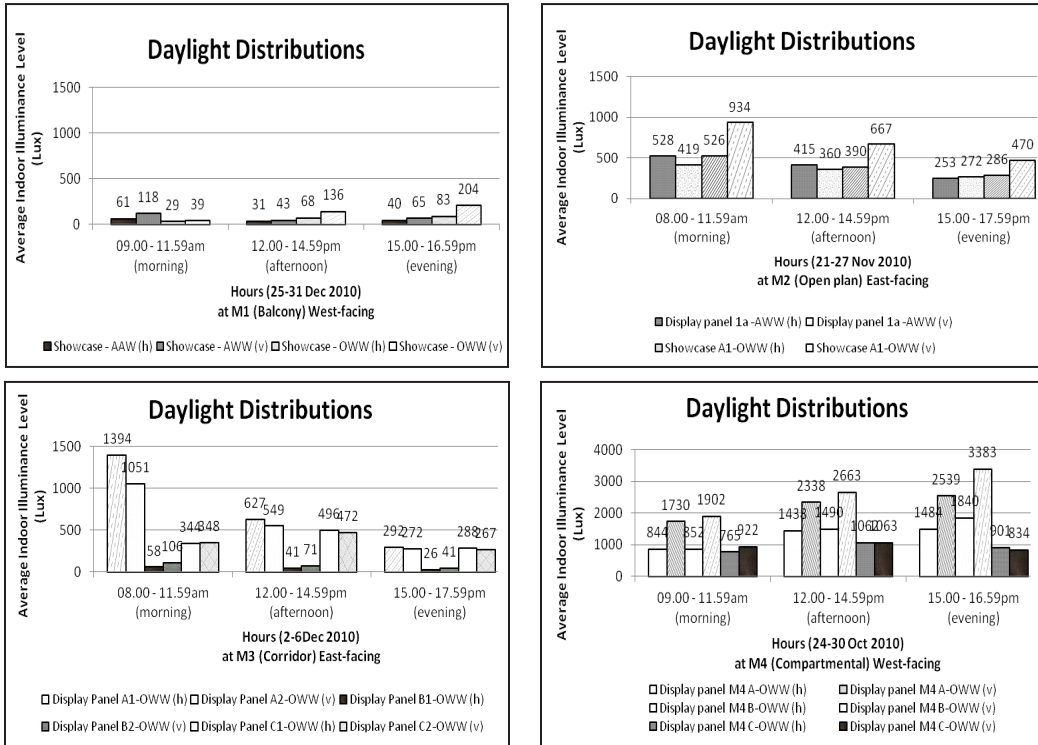


Figure 3. Average illuminance levels at horizontal and vertical points at M1, M2, M3 and M4

The display panels at M2, M3 and M4 were over lit above 200 and 300lx of average illuminance level, which exceeded the maximum recommended illuminance level for Category II - Moderately responsive and Category III - Non-responsive materials respectively (Ahmad et al., 2012). Results showed that the average illuminance of the three daytime periods in M1 ascended from morning till late afternoon at all placements; M2 for the east facing windows

showed a different trend in illuminance distributions, which registered a decrease in level of illuminance in the afternoon and late afternoon. Similar pattern of daylight distributions was observed at M3 with the same east facing orientation. Based on the case studies in Table 1, both M1 and M2 showed higher average illuminance registered opposite the window wall compared with against of the window wall, obviously due to the direct side lighting

from the windows. M2, M3 and M4 showed a higher mean illuminance compared with M1 due to different room orientation and their large operable window to wall ratio (WWR), namely 0.11, 0.71 and 0.24 respectively.

Illuminance levels based on Exhibit Orientation (Horizontal, Vertical)

Figure 3 shows the illuminance levels in each museum's exhibit orientation between 09.00h and 16.59h (M1 & M4) and between 08.00 and 17.59h (M2 & M3) differed significantly. In each daytime period, the average illuminance levels for both M1 and M2, ascended as the day progresses. Whereas, both M2 and M3's average illuminance levels were widest in the morning, but decreased in the late afternoon, due to the decreasing external horizontal illumination in the late afternoon. During each daytime period, higher illuminance level was detected at vertical orientations compared with horizontal exhibit orientations in all museums.

The vertically exhibit orientation in M4 showed higher average illuminance compared with M3 with larger operable window to wall ratio (WWR) of 0.71, due to the changes in sun orientation as the day progressed and higher transmittance of clear glass windows in M4. This also showed that M3 with larger WWR of 0.71 received less vertical light distribution compared with M4 with WWR of 0.24, due to the external roller blinds projected along the tinted glass

windows and the existing balcony located at the centre of the gallery, which diffused the light.

Visual Comfort

Visitors in general, found the daylighting conditions satisfactory. However, a few of them indicated daylighting in the morning were slightly dimmer and the temperature conditions neutral. Brighter conditions were observed during the afternoon and evening with slightly warm temperatures. Visitors in M1 and M3 found the daylight conditions slightly dimmer throughout the day compared with visitors in M2 and M4. Basically, M1 and M3 visitors opined that both daylight and artificial light sources were important as they increased their visual satisfaction. Meanwhile, M2 and M4 visitors perceived the daylight conditions as slightly brighter and M2 visitors felt that the use of artificial light was unimportant, whereas M4 visitors perceived the conditions to be neutral.

Visitors' feedback also revealed that warmer temperatures were felt by M1, M2 and M4 visitors throughout the day while M3 visitors experienced slightly cooler conditions. Thus, the slightly dimmer conditions were most likely due to smaller WWR 0.2 (M1) and WWR 0.7 with external shading (M3). Moreover, temperature could be affected by external shades (M3). On the other hand, the multi-lateral side lit windows WWR 0.1 (M2) with similar internal reflections and higher height of clear glass

windows WWR 0.2 (M4) have contributed to slightly brighter lighting throughout the day.

All the respondents disagreed slightly that the glare affected the display in the

mornings (Figure 4). However, they agreed that this was the case during the afternoon and evening. All the respondents agreed slightly that the glare affected the display throughout the day.

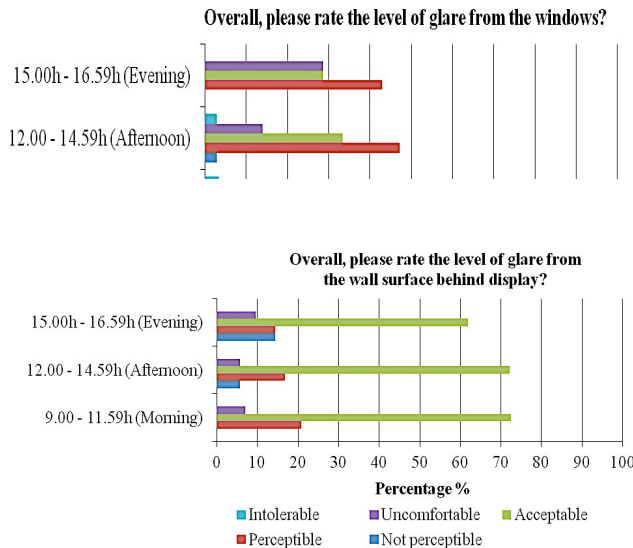


Figure 4. Summary of visitors’ perception on the level of glare at M1, M2, M3 and M4

Additionally, all the respondents agreed that the glare from the wall surface behind the display panels were acceptable throughout the day (Figure 4) and evening. However, the reflections on the displays and exhibits were perceptible during the afternoon. A few respondents in M1 and M2 agreed that the reflections on the displays and exhibits made them feel uncomfortable throughout the day.

Meanwhile, M3 and M4 visitors claimed that the reflections on the displays and exhibits were at an acceptable level throughout the day. Further observations also

revealed that the higher reflective properties of displays such as glass (M1) and perspex (M2) showcases contributed to feelings of discomfort among the respondents compared with lower reflective properties of exposed wooden display panel at M3 and M4 respectively. In addition, lower reflective surface or matte finishes (M3) may have contributed to less reflection. Indeed, the external shades (M3) may have lessened the impact of distribution of day light in the galleries.

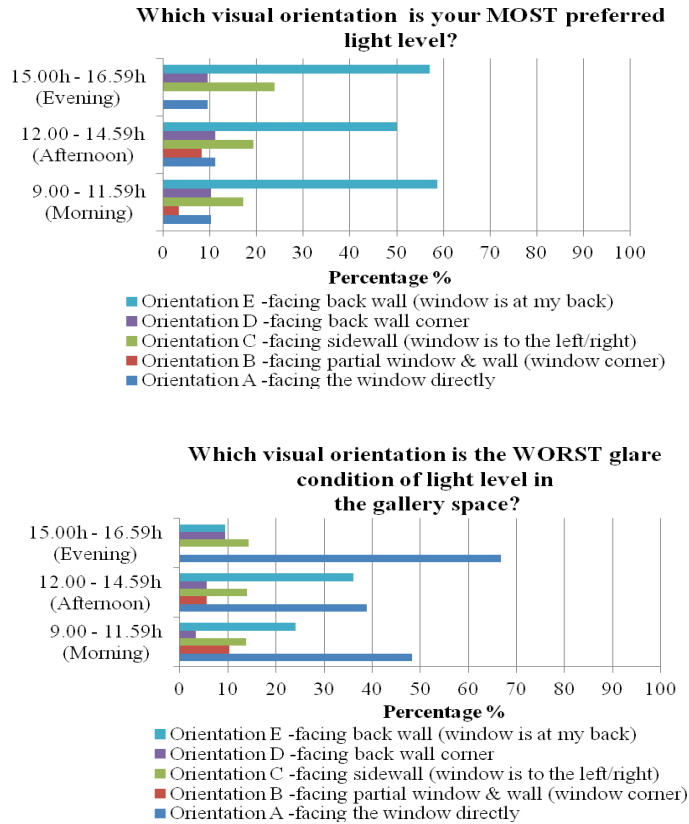


Figure 5. Response vote on visual orientation at M1, M2, M3 and M4

All the respondents expressed that the “Orientation E-facing back wall (window is at my back)” was the most preferred visual orientation and preferred light level condition throughout the day (Figure 5). The “Orientation A-facing the window directly” was the worst visual orientation in relation to glare.

CONCLUSION

A questionnaire survey and field work were conducted to assess visitors’ visual responses towards daylighting in selected museum galleries in Malaysia. The following

conclusions about the effects of exhibit condition and interior design parameters on indoor daylight performance and visual comfort can be drawn.

- i. There were larger variations in illuminance levels in all the galleries; M1 (WWR 0.2); M2 (WWR 0.1); M3 (WWR 0.7) and M4 (WWR 0.2).
- ii. M1 (WWR ratio 0.2) opened windows and M3 (WWR ratio 0.7) with external roller blinds projected along the tinted glass windows indicated slightly dim

conditions. The responses of the vertically pivoted traditional wooden casement with adjustable louver windows and lower internal surface reflectance values served for M1 (WWR 0.2) and the responses of the balcony and external roller blinds projected along the tinted glass windows for M3 (WWR 0.7) had minimised daylight illuminance levels.

- iii. Daylight caused glare, particularly in the afternoon and late afternoon in all the galleries.
- iv. The levels of glare from windows were perceptible throughout the daytime in all case studies. Higher window heights M4 (WWR 0.2) and multilateral side-windows M2 (WWR 0.1) with similar internal reflections affect visual comfort.
- v. Higher reflective properties of the display such as glass (M1) and Perspex (M2) showcases contributed to perceptible reflection and uncomfortable feeling compared with lower reflective properties of exposed wooden display panels at M3 and M4 respectively.
- vi. The levels of reflections were experienced throughout the daytime in M1 (WWR 0.2), M2 (WWR 0.1) and M4 (WWR 0.2). Some respondents claimed the reflections were uncomfortable and intolerable. This was due to higher reflective properties of the exhibits. However, majority of respondents found the reflections on the exhibits were acceptable in M3. This was probably due to their lower reflective surface or matte finishes that contributed to less reflection. Perhaps M3's external shades have lessened the impact of daylight level of illuminance in the galleries.
- vii. M3 (WWR ratio 0.7) with external roller blinds projected along the tinted glass windows needed extra lighting (via electric light) to increase the visitors' level of satisfaction throughout the day; M1 (WWR ratio 0.2) with opened windows indicated higher demand for daylight compared with electric light; M4 (WWR ratio 0.2) with clear glass windows indicated higher neutral responses for both daylight and electric light and M2 (WWR ratio 0.1) multilateral opened side-windows indicated that the daylight was slightly important compared with electric light. Some respondents observed that electric light was slightly unimportant to increase their visual level of satisfactions.
- viii. The orientation E - facing back wall (the window facing the back of the visitors) was the most preferred visual orientation and level of lighting in all the galleries. Meanwhile, orientation facing the

window directly had the worst visual orientation and glare.

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