

Natural and Controlled Lighting as Determinants of Emotional Perception of Museum Spaces in Port Harcourt

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Abstract: Museums are among the few building types where emotional experience is a key design consideration. This paper examines how natural and controlled lighting shape users' emotional perception of museum spaces. Using a qualitative research approach (systematic literature review and qualitative case study analysis), this research finds that lighting variables (intensity, color, and distribution) have noticeable effects on users' emotional responses in a space. The three case studies (Jewish Museum Berlin, Germany; the Yad Vashem Holocaust History Museum, Jerusalem, Israel; and the National Museum of Egyptian Civilization, Cairo, Egypt) support these findings. Findings are discussed in relation to their implications for museum design in Port Harcourt, Rivers State, Nigeria.

Keywords: Museum Lighting, Daylighting, Emotional Perception, Lighting and Emotion, Architectural Lighting.

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I. INTRODUCTION

➤ Background of the Study

Lighting in a museum functions as both a visual and experiential design variable. It can be critical to the space's emotional experience. It influences what visitors see, how much they see, and, consequently, what they feel when they are in the space.

A growing body of empirical research supports the relationship between lighting and human emotion. Mohammad-Moradi et al. [1], in a systematic review of 15 experimental studies, found that lighting conditions directly affect the three dimensions of emotional response identified in the Pleasure-Arousal-Dominance (PAD) model. High illuminance raises pleasure, arousal, and the user's sense of control. Low illuminance reduces all three. Cool colour temperatures increase arousal. Combined direct and indirect lighting consistently raises interest.

In museum design, these principles are actually not new. However, limited research examines the translation of these principles into design strategy: how specific lighting decisions produce specific emotional outcomes in visitors. This paper addresses that gap through literature review and case study analysis and situates the findings in the context of Port Harcourt, Rivers State, Nigeria.

➤ Statement of the Problem

Museum design has largely emphasized the preservation and display of historical artifacts. While the emphasis is necessary, it often overlooks the role of the architecture in shaping how users perceive or connect emotionally with history. Globally, research indicates that lighting is among the most powerful instruments by which architectural spaces affect occupants' emotions [1] [2]. Reduced emotional engagement limits the depth of visitor interpretation or museum narratives. Port Harcourt's cultural institutions show limited evidence of a structured framework for emotionally intentional lighting design, which this paper seeks to provide.

➤ Aim of the Study

This paper aims to analyze how natural and controlled lighting in museum spaces shapes users' emotional perception and to establish implications for museum design in Port Harcourt.

➤ Objectives of the Study

- To examine the empirical relationship between lighting variables and emotional perception.
- To analyze how three museums used lighting to produce specific emotional outcomes.

➤ Research Questions

- What does evidence establish about lighting and emotional perception in indoor spaces?
- How have the three selected museums used lighting to shape visitor emotion?

➤ Significance of the Study

This paper contributes in two ways. It analyzes global evidence on lighting and emotional perception in museum contexts in a practically applicable form. It also establishes an evidence-based case for emotionally intentional lighting design in Port Harcourt memorial institutions. It is useful for architects designing museums in Port Harcourt. It also provides a basis for future research on the mechanisms to harness lighting to enhance users' emotional connection with memorial spaces.

➤ Area of Study

Port Harcourt sits within the tropical rainforest climate zone. It receives between 4.5 and 6 peak sun hours daily. Solar radiation is intense and consistent year-round. Previous studies in Port Harcourt show that climatic variables such as temperature, wind, and solar radiation significantly influence building performance and occupancy patterns [3]. The primary challenge is not the availability of daylight but its control. Unmanaged solar penetration produces glare and thermal discomfort. Managed daylighting, by contrast, can produce the tonal variation and contrast associated with positive emotional engagement [4].

Existing museums in Port Harcourt are marked by infrastructural neglect and limited experiential innovation [5]. Contemporary museum theory, however, emphasizes the deliberate design of emotionally engaging visitor experiences. Within this gap, there is limited documented evidence that museums in Port Harcourt employ lighting as a deliberate instrument for shaping visitors' emotional experiences. Recent research in Port Harcourt reports that daylighting significantly influences occupant satisfaction, residential preference, and behavioral patterns [6]. This study aligns with a growing body of research that positions the built environment as an active agent in shaping human experience [7], extending this discourse into the domain of emotional perception in museum spaces.

II. LITERATURE REVIEW

➤ Lighting and Emotional Perception

Gharib and Shohdy [8] identify three levels at which lighting affects human experience: lighting psychology, which governs cognitive and emotional responses to light; environmental cognition, which determines how users interpret their surroundings through light cues; and emotional response, which describes the affective states that light directly produces. The PAD model organizes these affective states into pleasure, arousal, and dominance. Mohammad-Moradi et al. [1] report that all three PAD dimensions are directly correlated with illuminance.

Ioannou [4], using physical scale models tested with 20 participants, found that different daylight distributions

produced by different facade geometries at identical illuminance levels generated distinctly different emotional responses. Critically, participants who felt positive emotions in a space also perceived it as brighter, even when illuminance was objectively equal. This shows a relationship between perceived brightness and emotional state. Honrao [9] found, in a survey, that 80% of participants reported mood enhancement under appropriate lighting. These findings suggest a correlation between lighting quality and emotional state [9].

➤ Lighting in Museum Design

In the museum context, lighting serves both to preserve artifacts and to enhance narrative and emotion. Wang et al. [10] argue, through the SVOE model (spatialization, visualization, optical engineering, and emotionalization), that museum lighting must move beyond visual clarity and conservation compliance to address the emotional stage of the visitor experience. The stage at which lighting produces affective responses that determine the depth of engagement with exhibits. He argues that lighting in each space should reflect the story of that particular space at that time.

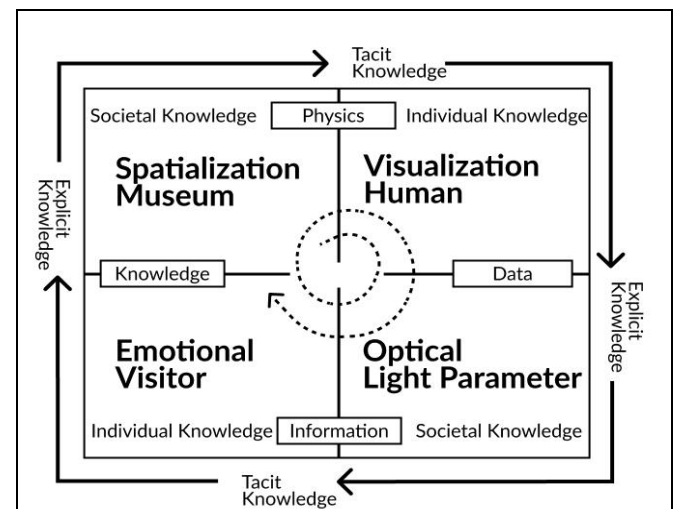


Fig 1 "SVOE" Mode Lighting Design Analysis Chart.

Source: Wang et al. [10]

Zhang et al. [2] provided direct empirical evidence of this at the Jewish Museum Berlin, where PANAS scores from 102 visitors demonstrated that specific lighting decisions, specifically the quantity and character of natural light admitted into different spaces, produced measurably different emotional outcomes in the same visitors across the same building.

Li et al. [11], in a neurophysiological study using EEG and ECG across 18 lighting conditions, found that low-illuminance environments generally diminish emotional regulation capacity, while specific color-illuminance combinations produce distinct neurophysiological signatures. This finding has direct implications for museum spaces designed to sustain difficult emotional content. This is seen in both the Jewish Museum Berlin and Yad Vashem.

➤ Research Gap

Existing research establishes clear relationships between lighting variables and emotional perception, with growing

application in museum contexts, particularly in Europe and Asia [2] [11]. However, these studies are rarely situated within the climatic realities of tropical climates. Frameworks such as the PAD and SVOE models offer structured approaches to emotional and experiential lighting design, yet their application to context-specific design strategies remains limited.

In Nigeria, specifically Port Harcourt, there is limited documented evidence of lighting being used as a deliberate tool to shape visitors' emotional perception [5]. This study addresses that gap by analyzing museum precedents and translating these insights into design implications for Port Harcourt.

III. METHODOLOGY

This study adopts a qualitative approach combining a systematic literature review with qualitative case study analysis. Together, these facilitate a comprehensive understanding of how lighting variables shape emotional perception in museum spaces and how those findings can be translated into design strategy for Port Harcourt.

➤ Secondary Data Collection (Systematic Literature Review)

Secondary data for this study were drawn from peer-reviewed journals and empirical studies. The literature review focused on establishing the relationship between lighting variables and emotional perception, using the following search terms: “museum lighting,” “emotional perception,” “lighting and emotion,” “daylighting,” and “affective response.” Sources were retrieved primarily from Scopus-indexed journals. The review targeted publications that addressed lighting variables and their documented effects on users' emotional responses in interior spaces, with particular attention to museum environments.

➤ Primary Data Collection (Qualitative Case Study Analysis)

Three international museum case studies were selected and analyzed to examine how lighting decisions produce specific emotional outcomes in real-world settings. Each case study was analyzed using published empirical data, architectural documentation, and visitor response records. The analysis focused on lighting conditions (illuminance levels, colour temperature, natural vs. artificial light, and spatial contrast) and their corresponding emotional outcomes. The Pleasure-Arousal-Dominance (PAD) framework was applied across all three cases as a consistent analytical tool for interpreting emotional responses to lighting.

➤ Methodology Analysis

• Strengths:

The systematic literature review synthesizes empirical evidence across multiple studies, providing a reliable theoretical basis for the PAD framework analysis. The case study method allows for close, context-sensitive examination of how lighting strategies are applied in practice and what emotional outcomes they produce. The combination of both methods strengthens the validity of the design implications drawn for Port Harcourt.

• Limitations:

The study does not include primary empirical data collected directly from museum visitors in Port Harcourt. The case studies are drawn from Europe, the Middle East, and North Africa, and cultural differences in emotional response to lighting [4] mean the findings cannot be uncritically transposed to a Nigerian context. Additionally, the absence of on-site illuminance measurements limits precise technical comparison across the cases.

• Justification:

Given the absence of locally grounded empirical studies on museum lighting in Port Harcourt, a qualitative method is appropriate for this study because it provides a theoretical and precedent-based framework for users' emotions. It allows this study to harness existing global evidence and apply it directly to Port Harcourt, where primary research has not yet been conducted. The PAD and SVOE frameworks provide structured, replicable tools for that application.

➤ Criteria for Selection of Case Studies

Three case studies were selected based on the following criteria:

• Empirical Evidence of Emotional Outcomes:

The case study must have documented, measurable evidence linking its lighting design to visitor emotional responses. The Jewish Museum Berlin and Yad Vashem both meet this criterion through published PANAS scores and neurophysiological data.

• Deliberate Lighting Design:

The selected museums must show an intentional use of lighting as a narrative or experiential design tool, not merely as a technical provision. All three selected cases satisfy this criterion.

• Climatic Relevance:

At least one case study should be situated in an environment prone to high solar radiation similar to Port Harcourt's tropical climate. The National Museum of Egyptian Civilization (Cairo) was selected as a regional analogue on this basis.

• Diversity of Emotional Intent:

The case studies should represent a range of intended emotional outcomes, from grief and reflection (Jewish Museum Berlin, Yad Vashem) to wonder and cultural pride (NMEC), to show a more expressive range of museum lighting design.

IV. FINDINGS AND DISCUSSION

➤ Case Study One: Jewish Museum Berlin, Germany

Designed by Daniel Libeskind and opened in 2001, the Jewish Museum Berlin uses four principal spaces to demonstrate the full emotional range achievable through deliberate variations in lighting within a single building, as shown in Figure 2. Zhang et al. [2] measured illuminance and colour temperature in each space and collected PANAS scores from 102 visitors.

The Holocaust Tower admitted minimal natural light through a single narrow aperture, with illuminance ranging from 2.7 to 5.7 lux at a colour temperature of 4,918 K. It produced the highest visitor scores for fear (3.80), nervousness (3.94), and jitteriness (3.68). The Garden of Exile admitted abundant natural daylight between 2,940 and 18,400 lux alongside vegetation and produced the highest scores for inspiration (3.59), interest (4.06), and activeness (4.02). The same visitor, in the same building, experienced radically different emotional states because of radically different lighting conditions.

In PAD terms, the Holocaust Tower caused low pleasure, high arousal, and low dominance: anxious, helpless alertness. The Garden of Exile caused high pleasure, moderate arousal, and high dominance: engaged, hopeful control. These match predictions based on illuminance and colour temperature data from [1]. The case indicates that natural light control alone, without detailed curation, can produce specific emotional outcomes in visitors.

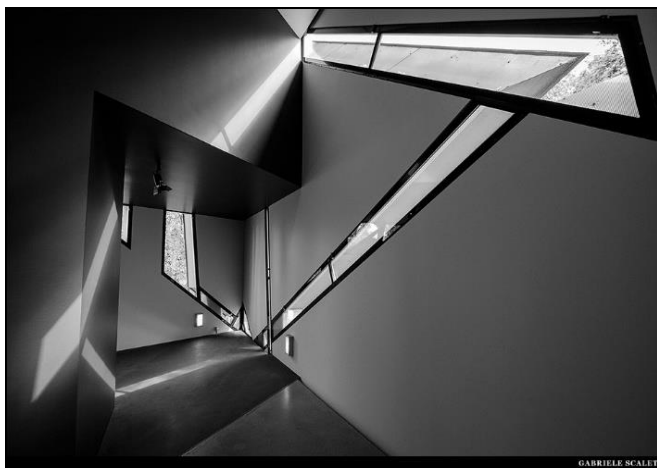


Fig 2 Showing Different Lighting Conditions Across Various Spaces in the Museum to Create Drama and Evoke Emotions.
Source: Museo Ebraico di Berlino | Designity.net

➤ *Case Study Two: Yad Vashem Holocaust History Museum, Jerusalem, Israel*

Designed by Moshe Safdie and completed in 2005, the Yad Vashem Holocaust History Museum is a 9,000 square meter triangular prism embedded within Mount Herzl, Jerusalem. The visitor experience is strongly structured around a journey from darkness to light, and natural light is the primary architectural instrument through which that journey is expressed.

A 200-meter glass skylight runs the full length of the prism, admitting gleams of daylight that contrast with the deliberate darkness of the below-grade galleries. Individual gallery skylights vary from diffused to clear glass depending on conservation and emotional requirements. The Children's Memorial uses a single candle reflected in mirrors to suggest infinite space from a point of light. The museum's exit opens onto a panoramic view of the Jerusalem hills, flooding the visitor with natural light after the sustained dimness of the interior.

The sustained low illuminance of the historical galleries (shown in Figure 3) is not a failure of lighting design. It is its achievement. Li et al. [11] found that prolonged low-illuminance environments diminish emotional regulation capacity and intensify negative emotional evaluations. Safdie uses this effect intentionally: the darkness sustains the emotional engagement necessary for visitors to fully absorb the historical content. The dramatic exit into daylight then produces a sharp shift toward high pleasure and restored dominance, a moment of architectural catharsis that multiple visitor accounts describe as among the most powerful experiences in contemporary museum design. This emotional arc is largely evoked through the management of natural light.

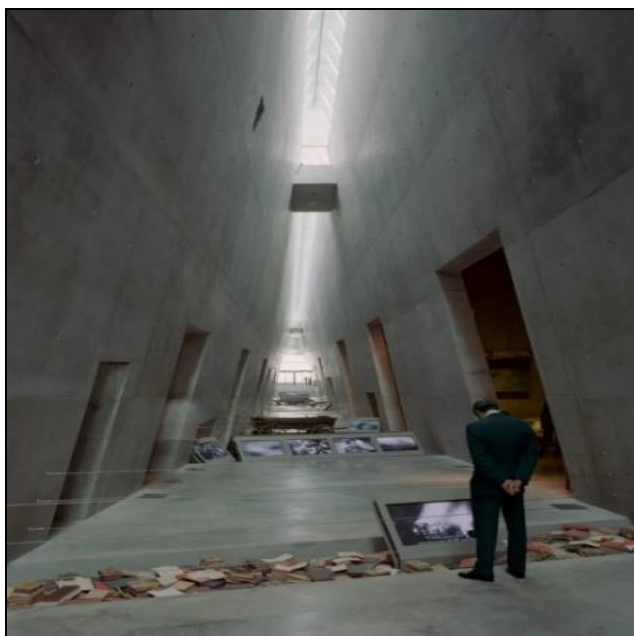


Fig 3 The Historic Gallery with Low Illumination Power, Mainly by Natural Light from Above.
Source: ArchiDaily

➤ *Case Study Three: National Museum of Egyptian Civilization, Cairo, Egypt*

The National Museum of Egyptian Civilization (NMEC), designed by El-Ghazzali Kousseiba and Arata Isozaki and located in historic Fustat, Cairo, presents a contrasting lighting strategy from the two Holocaust museums. While Libeskind and Safdie used light to produce grief and reflection, the NMEC uses light to produce wonder, reverence, and cultural pride.

The main exhibition halls admit generous natural daylight, creating an open, inviting environment that encourages active exploration. The Royal Mummies Hall deploys soft, carefully controlled artificial lighting designed to recreate the atmosphere of an undisturbed ancient tomb. These two lighting systems work separately to produce distinct emotional states: the high-pleasure, active-arousal of the daylight galleries and the low-arousal, reverential calm of the mummies' hall.

Gharib and Shohdy [8] identify the NMEC as a case where lighting achieves the emotional stage of the museum experience described by Wang et al. [10] in the SVOE model. The NMEC demonstrates that a museum in a high-solar-radiation environment can admit generous natural light into general galleries while deploying controlled artificial light in sensitive zones. This produces distinct and appropriate emotional outcomes across a single visit.

➤ *Cross-Case Analysis*

Three findings are consistent across all three museums. First, lighting is a primary medium through which each building communicates emotional intent. The documented emotional effects are strongly dependent on intentional lighting decisions. Second, the most pronounced emotional effects in all three cases are produced by contrast, whether between darkness and natural light (Yad Vashem), between near-absence and abundance of light (Jewish Museum Berlin), or between the warmth of daylight galleries and the controlled intimacy of artificially lit zones (NMEC). Third, the PAD framework accurately predicts the emotional outcomes of specific lighting conditions across all three cases, confirming its validity as a design tool for museum lighting.

V. RECOMMENDATIONS

➤ *Adopt Emotionally Intentional Lighting as a Design Standard:*

Lighting should not be treated as a purely technical concern. Architects should define the emotional outcome of each gallery space before determining its lighting strategy, using frameworks such as the PAD and SVOE models as structuring tools.

➤ *Harness Port Harcourt's Solar Conditions Deliberately:*

The directional sunlight of Port Harcourt can be harnessed. Facade apertures, clerestories, and angled slots should be used to introduce controlled natural light that produces the contrast and tonal variation that trigger emotional responses.

➤ *Design Through Contrast, Not Brightness:*

The emotional tone of the Jewish Museum Berlin and Yad Vashem was not derived from high illuminance but from the intentional combination of dark and light zones. Designers should zone spaces by emotional intent, allowing transitions between low and high illuminance to carry narrative weight.

➤ *Deploy Indirect Top-Lighting to Manage Tropical Glare:*

Light baffles, angled reflectors, and diffusing surfaces should be used to soften and redirect natural light before it enters gallery spaces. This preserves the emotional quality without causing thermal discomfort.

➤ *Use Controlled Artificial Lighting in Artifact-Sensitive Zones:*

Warm artificial lighting (2,700–3,000 K), applied directionally, can produce the calm and reverence appropriate for sensitive displays, as demonstrated by the NMEC's Royal Mummies Hall.

➤ *Commission Primary Empirical Research with Nigerian Museum Visitors:*

The PAD-based predictions in this study are drawn from global literature. Post-occupancy evaluations and visitor affect studies in Port Harcourt museums are needed to establish locally grounded evidence.

VI. CONCLUSION

Lighting is a primary instrument through which museum architecture shapes emotional experience. This paper has shown, through literature review and three international case studies, that illuminance, colour temperature, and contrast produce measurable and predictable emotional outcomes in museum visitors. The Jewish Museum Berlin demonstrates that a single building can carry a visitor through the full emotional range from fear to hope through lighting variation alone. Yad Vashem demonstrates that a sustained arc from darkness to natural light can encode grief, endurance, and renewal into architecture. The NMEC shows that a museum in a high-solar environment can use both natural and artificial light to produce distinct emotional states across a single visit.

Port Harcourt possesses the climatic and cultural conditions to produce museums of comparable emotional depth. What has been lacking is a design framework that treats lighting as an experiential and narrative instrument rather than a technical one. This paper establishes the empirical and precedent basis for that framework. The next important step is primary research with Nigerian museum visitors to confirm whether PAD-predicted emotional responses to specific lighting conditions hold within the local cultural context of Port Harcourt. This would help build the locally grounded evidence base that future museum design in Port Harcourt will require.

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