Visual Rhythm in lighting design.

How light patterns create atmosphere in a museum.

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Abstract

Studies indicate that incorporating light rhythms have the potential to generate an atmosphere of curiosity to further explore a space. In lighting design, we can describe rhythm as the ‘flow of light’ as the repetition of shadow, shading and highlight patterns of an illuminated three-dimensional surface that we experience in space when we walk through it. To further investigate this topic, a survey was conducted in a computer-generated museum setting to examine how rhythmical light scenarios of both artificial and natural light can create dynamic atmospheres so that they influence the spatial exploration. For this purpose, scenarios of two categories were made by relative darkness in order to create “mystery” and brightness for ‘focal glow’. Each scenario included the incorporation of daylight conditions, encompassing both morning and evening settings. The experiment revealed a preference for the "mystery" scenarios and the evening conditions of both “mystery” and the “focal glow” scenarios. Nonetheless, it is advisable to conduct similar experiments in real-life settings to attain more substantial results and minimize potential survey bias.

Keywords: light rhythm, atmosphere, spatial exploration, museum setting, daylight.
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Introduction

‘Everywhere where there is interaction between a place, a time and an expenditure of energy, there is rhythm’ (Lefebvre, 2004). Rhythm is a concept inseparably connected to everyday life. ‘Rhythm enters into the lived’ (Lefebvre, 2004, p. 77) connecting people’s simultaneous experience of space and time. Intrinsically, it is produced by repetition which includes difference, meaning the repetition does not remain static but evolves and progresses through space and time (Lefebvre, 2004). Having said that, it is plausible to say that the concept of rhythm applies to fields of art and design. Rhythm has been defined in the arts as ‘the regular, harmonious recurrence of a specific element, often a single specific entity coming from the categories of line, shape, form, color, light, shadow, and sound’ (Chan, 2012). Similarly, in lighting design we can describe rhythm as the ‘flow of light’ as the repetition of shadow, shading and highlight patterns of an illuminated three-dimensional surface that we experience in space when we walk through it (Cuttle, 2003, pp. 72-73). Applying light-shadow patterns in space captures people’s attention in the pattern and, eventually, into the space and compels them to investigate its meaning. This meaning, when connected to the use of space, it is possible to create a narrative and, therefore, an atmosphere of curiosity that intrigues the further exploration of the space.

Based on rhythm’s ability to form atmospheres in an interior space with the help of lighting design, a literature review has been carried out in order to explore how rhythm is implemented in daylighting and lighting design. Moreover, a survey was conducted in a computer-generated museum setting to examine how rhythmic light scenarios of both artificial and natural light can create dynamic atmospheres so that they influence the spatial exploration. The ultimate purpose of this study is to gain knowledge on how we can promote mental health and well-being through rhythm-atmospheres (UN Sustainable Goal 3- Good health and Well-being) and, subsequently, how to affect economic growth by increasing the number of visitors in case of a cultural space such as the one in the case study (UN Sustainable Goal 8- Decent work and Economic growth).
Background

Rhythm of light is experienced in a space mostly when walking through it. Cuttle points out that the flow of light has to do with the shadow and highlight patterns that compliments the form of the illuminated objects as seen when you walk past them. Taking a step further, when this notion of flow of light is applied in a wider spatial context, then we can talk about what Merete Madsen described as light zones (Madsen, 2007). Light zones are the hypothetical spheres of lights surrounded by relative darkness or else darkness zones (Madsen, 2007). The sequence of daylight and artificial light zones as well as dark zones expose the flow of light when walking through them. Therefore, they are important for spatial perception and even the spatial atmosphere.

Researchers have investigated how the composition of different light zones affect the feeling of a space. Most notably the researches of Ulrika Wänström Lindh (Lindh, Understanding the Space: How Distribution of Light Influences Spatiality, 2013) and Katja Bülow (Bülow, 2013). However, while Wänström Lindh’s investigations focuses on how the light distribution influences spaciousness and enclosure of an interior space or sense of security outdoors (Lindh, Distribution of light and atmosphere in an urban environment, 2013), Katja Bülow introduces the example of Westfriedhof U-bahnstation (Bülow, 2013). In spite of the fact that Bülow refers to feelings of safety, she illustrates how light rhythms of both daylight and artificial light can influence

Figure 1 Westfriedhof U-bahnstation in Munich, lighting design by Ingo Maurer, 1998.
people’s navigation through a space. She explains that this rhythmic interplay of a gradient colors in the lampshades has the ability to guide people through the space.

In the field of architecture, while the space is static, it has the ability to display changes and movement, which is inherent in rhythm, through natural light. Light enters the space, completely transforming it, creating atmospheres by changing people’s mood, forming captivating light and shadow patterns and revealing texture. Atmospheres that change through the course of a day or even a year and connect the interior space with the flowing energy and rhythm of life. During the 1960s and 1970s, the ephemeral quality of light was reintroduced and valued in contemporary architecture (Plummer, 2009). The attention was directed towards animating the building by using a series of images created by daylight that fluctuate in emotional intensity. Connecting, that way, space with time as an unbreakable bond, important to spatial perception. Experiencing the transitory light has also an effect on time perception or what Bergson calls duration (Plummer, 2009, p. 20). Duration refers to the experienced, subjective perception of time that differs from the ‘clock time’. The reason behind it, is that memory enables us to have a perception of time by remembering past events, regarding to daylight into space, and combining multiple moments into a single experience. When fleeting events cause by daylight are observed closely, they reveal a "temporal perspective" (Plummer, 2009, p. 20). These phenomena can stretch out time, going beyond the present moment by offering clues about their outcome and conclusion, while also resonating with a recent past from which they originated. Thus, creating a sense of anticipation for what is about to happen. Anticipation is a pre-existing curiosity for an impending event that is strongly linked with excitement and the desire to explore.
This study, as it was mentioned before, focuses on the perceived atmosphere of a place, but it is important to distinguish between mood and atmosphere. The concept of atmosphere in an environment is distinct from mood as it represents a relatively stable emotional evaluation (Vogels, 2008). While mood refers to a temporary emotional state or feeling, atmosphere is a subjective perception of the environment that relates to its anticipated effect on mood. Thus, in order to create a lively atmosphere in a museum setting and to intrigue someone’s curiosity to explore the space, you need to spark his interest and grab his attention. There are two main methods to accomplish this, which are by adding brightness to a space or by creating a feeling of relative darkness. People are instinctively drawn to the light. Richard Kelly introduced the term ‘focal glow’ (Kelly, 1952) to describe the intrinsic, attention-grabbing quality of light. Focal glow is associated with how bright highlights on objects or surfaces possess a strong allure that captures someone’s attention (Kelly, 1952). On the other hand, a sense of mystery in terms of low visibility because of lower light levels also increases the desire to explore a space (Stamps, 2004). Despite that, visual attraction can be attributed to high contrast as well (Michel, 1996, p. 64). When it comes to lighting, contrast refers to the difference in brightness between a well-lit area and its dimly lit surroundings, and vice versa. Color is another visual element that has the ability to seize people's attention. The use of vibrant colors in a singular element can attract the viewer's attention, particularly in a less saturated and darker environment (Michel, 1996, p. 65). The most significant aspect of visual attraction is caused by ‘strong patterns’ (Michel, 1996, p. 65). Regardless of whether they are naturally occurring organic patterns or man-made repetitive visual units, both have the ability to command focal attention due to their dominant presence. These are the important factors in this case that can contribute to fostering a sense of curiosity within a particular environment and enhance people’s motivation to discover and investigate it.
Thesis framework

Main research question:

1. In what way rhythmical light scenarios of focal glow and mystery, with natural and artificial light, evoke differences in atmosphere perception of curiosity in a museum?

Secondary research questions:

1. Does the atmosphere of curiosity is enhanced with the implementation of natural light or not?
2. Do the rhythmical light scenarios that comply with the standards are more effective than the other scenarios to create atmospheres of curiosity?
3. Can the perception of atmosphere vary between individuals who are experts in lighting design and those who are not?

The main objective of this master's thesis is to test the hypothesis that the desire for spatial exploration can be enhanced by creating an environment of curiosity through the implementation of a rhythmical lighting design in a museum. To test this hypothesis, the study will conduct an experiment utilizing two categories of rhythmical light scenarios. These scenarios consist of light zones that are designed based mostly in regards to light intensity. Specifically, made by relative darkness in order to create mystery and bright light zones for ‘focal glow’. We will refer to the first group of light scenarios as “focal glow scenarios” and the second group as “mystery scenarios.” In addition to that, the design of scenarios is implemented using both artificial and natural light sources. Despite these two categories, the scenarios are also implemented with high contrast and strong patterns to further enhance the attraction. Vibrant colors as visual attractors are going to be excluded from the experiment.
Methods

Experiment Set up

Space

For the needs of this study, an exhibition space of a museum is used to design virtual rhythmical light scenarios. According to Merete Madsen, it is essential to move through the light zones to experience their sequential nature. Museums are in fact experienced sequentially by walking through them, which makes them a suitable space for this study. The chosen space is appropriate because it offers the advantage of having access to both natural and artificial light sources. Liljevalchs+ is an art gallery and an extension of Liljevalchs art museum that was completed in 2021. During this study, the current
exhibition featured Jockum Nordström’s “No paper, no coins” collection. The selected location is primarily an art gallery that mainly showcases contemporary art. The use of this space for showcasing contemporary art eliminates the need to comply with strict light standards required to preserve artworks.

**Light scenarios**

The survey consists of four computer-generated light scenarios using softwares such as Dialux evo 11 and Adobe Photoshop 2022. The scenarios are classified into two categories: “focal glow” and “mystery”, each consisting of two scenarios. The lighting design of the scenarios consists of light zones that focus on the walls with the paintings and the floor area, specifically there is the light zones of the periphery of the floor area and the central one. Light scenarios are light installations that possess the ability to exist and be appreciated independently, separate from any exhibition. For the purposes of this study, the exhibits consist of "empty" paintings characterized by non-vibrant colors intentionally chosen to minimize any visual attraction towards them.

In the “focal glow” category, there are two scenarios both demonstrating a progressive rhythm of a gradient lighting design on the walls, going from relatively dark light zones to brighter ones. In the floor area, the periphery mirrors the gradient effect on the walls, while intentionally dimming the central area compared to the periphery. By employing this approach, the focus will be directed towards the periphery where the exhibition is located. The difference between the two scenarios the amount of daylight entering the space. One scenario takes place at noon, specifically at 12:00 pm, while the other scenario occurs in the evening at 16:30 pm in the Swedish time zone in clear sky, in the middle of February of 2023. The timing of the scenarios aligns with the exhibition hours, which span from 11:00 to 17:00 pm.
Similarly, the "mystery" category presents two scenarios that illustrate a gradient light effect, transitioning from bright light zones to darker ones on the paintings. The periphery of the floor area features the same gradient light effect as the paintings. The central floor area exhibits an asymmetrical rhythm of a light and shadow pattern created by the branches of a tree. This pattern adheres to what creates visual attraction, as it constitutes a strong, organic pattern with high contrast. In addition to these elements, this scenario features focused lighting limited to the square frames of the paintings. However, there is a similarity with the “focal glow” scenario in the daylight of the space as the scenarios take place within the same time frame.
To address questions regarding lighting standards, certain scenarios will intentionally exceed from the standards of luminance and uniformity (Appendix-Survey). The scenarios employed for that reason are the evening scenario of the “focal glow” scenario as well as the mystery, evening one. None of the scenarios meet the criteria for luminance and uniformity according to the standards; however, there are some scenarios that come close to meeting those standards. In Sweden, exhibition spaces are required to have a luminance level of 300 lux, as well as a uniformity rate of 0.4 (12464-1:2021, 2021).

Computer-generated visuals have been shown to yield results in atmospheric experiments that are similar to those obtained through in situ experiments. However, when compared to in situ experiments, they have limitations in accurately assessing the chromaticity of the atmosphere (Stokkermans, Heynderickx, de Kort, & Vogels, 2018, p. 170). In addition, it is important to ensure that the colors of the paintings in the exhibition spaces are not altered and remain true to their original hues. As a result of the limitations, colors are not taken into account when evaluating virtual environments. Thus, the experiment involves luminaires that are set to a neutral color temperature, specifically 3500 K.
Light scenarios are also depicted from various perspectives. The intention behind depicting the act of walking through is to emphasize its intrinsic connection to the concept of rhythm in lighting design, as we have previously discussed. The perspectives were chosen to simulate the experience of walking through the exhibition.

**Questionnaire**

The questionnaire employs the paired comparison method (Appendix - Survey). The questionnaire consists of a three-set of questions that compare morning scenarios of "focal glow" and "mystery," followed by a similar comparison of evening scenarios within the same categories. The next step involves comparing the different daylight conditions for each category. The order of the scenarios was consistent across all participants.

The survey begins with demographic questions pertaining to participants' age and their level of experience in the field of lighting design. Following that, it presents three sets of questions for each comparison concerning the participants’ perception of atmosphere, their preferences regarding which space motivates them to explore it further, and the specific elements that contribute to that motivation. The questions for spatial exploration employ a seven-rating Likert scale ranging from "very much" to "moderately," concluding with "slightly" for each space and including a “neutral” rating as well. As for the perception of atmosphere of curiosity, the questions encompass a range of excitement levels, from very exciting to moderately exciting, and finally, slightly exciting as well as neutral. The word “exciting” is a term which can be found in Vogels research about atmosphere metrics (Vogels, 2008). The question about the preferred elements is a multiple choice one and the elements are: the ceiling, the periphery of the floor area, the center of the floor area and the walls with the paintings.

**Participants**

The participants possess a diverse range of experience in lighting design as well as individuals without expertise in the field. The aim is to investigate whether individuals without specialized knowledge in the area of lighting design are capable of perceiving the atmosphere, or whether it goes unnoticed by them. In this manner, we can ascertain the relevance of the topic to the practice of lighting design. More specifically, 17 people
participate with no experience in lighting design and 20 experts in lighting design, 37 in total. The experienced ones consist of 2 professional lighting designers, 14 lighting designer students and 4 professionals in other area with lighting design studies. The survey excludes 5 people who answered: “Professional in other area without lighting design studies”, as there was an ambiguity in the term.

The age range for the survey has been confined approximately to 20-50 years as this particular group provides certain advantages with regard to their visual acuity and viewer’s perspective. Compared to children, individuals in this age group have a similar height and their visual acuity has not yet declined.
Results

The survey was carried out utilizing the Google Forms format in an online setting and the results processed and visualized in Excel. The survey did not take into account the cultural background and the gender of the participants. The age group of 25 to 34 constituted the largest portion (67.5%) of the participants. The remaining participants were distributed across the age groups of 18 to 24 (21.6%), 35 to 44 (8.1%), and one participant fell within the 45 to 54 age category. The study benefitted from a substantial proportion of participants falling within the age range of 18-34, which enhanced the study's perspective and visual acuity considerations.

Comparison of focal glow and mystery scenario in the morning

In the morning comparison of the scenarios, individuals without lighting design expertise favored the "mystery" scenario (n=9) over the "focal glow" (n=6) when comparing the two. However, the majority of them rated the "mystery" scenario as moderately (n=4) and slightly (n=4) exciting, despite the greater number of individuals selecting it over the “focal glow” scenario. Regarding spatial exploration, individuals without lighting design experience also preferred the "mystery" scenario (n=12), although the assessment indicated a reduced likelihood of exploring the space. Likewise, individuals with expertise in lighting design preferred the "mystery" scenario (n=13), finding the atmosphere moderately exciting (n=9) and expressing a moderate preference (n=9) for further exploration of the space. The participants, both experts and non-experts, were primarily drawn to explore the space due to the central area of the

Figure 10 Evaluation of atmosphere perception of focal glow (left) and mystery (right) scenarios at 12:00 on 14 of February 2023 for experts and non-experts
“mystery” scenario, specifically the captivating pattern of tree branches on the floor (Appendix-Results).

Comparison of focal glow and mystery scenario in the evening

The results in the comparison of the "focal glow" and "mystery" scenarios in the evening show the preference for the evening "mystery" scenario that matches the preference observed in the morning. Non-experts in lighting design perceive the "mystery" scenario (n=12) as moderately exciting and have a moderate motivation (n=12) to walk through the space. In the same manner, the "mystery" scenario received mostly moderate evaluations from experts (n=13) in terms of both atmosphere perception and spatial exploration. In the evening scenarios, the center of the floor area and the walls with paintings of the “mystery” scenario stood out for non-experts. Individuals with experience in lighting design selected both the center and the periphery of the floor area in the "mystery" scenario. At the same time, considerable preference was given to the walls with paintings in the "focal glow" scenario (Appendix-Results).
Comparison of daylight conditions

Comparison of “focal glow” scenario in the morning and in the evening

The comparison of daylight conditions for the "focal glow" scenario in the morning and in the evening yielded interesting results. In the evening scenario of "focal glow," the majority of non-experts (n=13) assessed the atmosphere as moderately exciting. Similarly, most of participants (n=13) expressed a moderate motivation to explore the space. On the other hand, experts provided similar responses regarding their perception of the atmosphere and their engagement in spatial exploration. A significant number of experts (n=15) responded with moderate to high levels of excitement regarding the atmosphere in the evening scenario of "focal glow". The same scenario was
predominantly perceived as moderately engaging for spatial exploration (n=16), with slight variations observed for responses indicating slightly and very much engagement.

Comparison of “mystery” scenario in the morning and in the evening

In the "mystery" scenario, individuals without experience in lighting design favored the evening scenario. Specifically, while the majority chose the evening scenario in the "mystery" scenario, the atmosphere was perceived as slightly exciting. Similar findings were observed for spatial exploration, with both slight and moderate levels of engagement reported in walking through the space.

The results are nearly consistent among individuals with expertise in lighting design. Although the evening "mystery" scenario received the highest number of responses, it
was mainly perceived as slightly exciting. Identically, their selection of the same scenario indicates a moderate inclination for further exploration within the space.

**Results for all participants**

For all participants, the evening "mystery" scenario received the highest number of responses (n= 25) concerning the perception of atmosphere, with moderate excitement ratings. At the same time, the scenario that elicits the highest motivation among participants to walk through the space is the "mystery" scenario in the morning (n=25), with also a moderate level of motivation. There is a moderate correlation between excitement and the motivation to navigate through a space. On the other hand, the morning and evening "focal glow" scenarios were perceived the same (n=12), with approximately half the number of responses compared to the evening "mystery"
scenarios. Regarding the exploration of the space, the evening “focal glow” scenarios was favored (n=12) making the morning “focal glow” scenario (n=10) the least motivating to navigate through.

Regarding the comparison of daylight conditions, the evening "mystery” scenario garnered the highest number of responses (n=29) in terms of atmosphere perception and as far as the inclination to explore the space, participants chose the evening “focal glow” scenario (n=29). In general, the evening scenarios prevailed against the morning ones. The least selected scenario when it comes to atmosphere and space navigation in regards to daylight conditions is the morning “mystery” scenario.

In the morning comparison between the “focal glow” and “mystery” scenarios, the element that had the greatest impact on walking through the exhibition was the center of the floor area in the “mystery” scenario. All participants regarded the walls with the paintings as the most captivating element in the morning focal glow scenario. When comparing the same scenarios in the evening, the center of the floor area of the “mystery” scenario emerged as the most visually prominent. At the same time, in the evening “focal glow” scenario, the walls with paintings garnered the most attention from participants.

Figure 17 In the morning comparison, the most prominent element is the center of the floor area of the mystery scenario (left) and for the focal glow scenario (right) is the wall area.

Figure 18 In the evening comparison, the most prominent element is the center of the floor area of the mystery scenario (left) and for the focal glow scenario (right) is the wall area.
Discussion

The results demonstrated the expected preference of the participants. Both experts and non-experts in lighting design express a preference for the “mystery” scenarios. The preference for the evening “mystery” scenario in atmospheric perception, along with the preference for the center of the floor area, suggests that a strong, asymmetrical pattern serves as the most effective rhythmic element for capturing people's attention. Nevertheless, there is a concern regarding whether the pattern will divert attention away from the exhibition. A possible solution to address this issue could involve utilizing similar patterns with lower contrast. This is evident in the morning “mystery” scenario, which has lower contrast and is the most preferred scenario when it comes to spatial exploration. The preference of the evening “mystery” scenario with 0,12 uniformity aligns with findings from previous research indicating that high lively responses were attributed to medium levels of uniformity (Stokkermans, Vogels, de Kort, & Heynderickx, 2018). In the same study, the bright and uniform scenarios were assessed as “highly detached spaces” (Stokkermans, Vogels, de Kort, & Heynderickx, 2018).

This study's findings are in line with that observation, as the morning, “focal glow” scenario, which stands out as the most uniformly lit, is considered the least motivating to navigate through.

The presence of daylight under clear sky conditions did not noticeably improve the sense of curiosity or have a significant impact on the experience of traversing through the space. The reason why is that the both evening scenarios of “focal glow” and “mystery” are most preferred than the morning scenarios, especially the morning “focal glow” one. The morning scenarios are the ones that are uniform and brightly lit up and like the aforementioned study (Stokkermans, Vogels, de Kort, & Heynderickx, 2018), these cases lead to detached sense of atmosphere. These findings contradict the claim of researchers that daylight in museums should be included in exhibition design (Schielke, 2020, p. 8). However, in case of a real-life experiment of rhythmical scenarios and daylight conditions, the results might be different as the participants of this study can actually experience the passage of time through the changes of daylight.

The results also indicate a lack of significant difference in responses between experts and non-experts in lighting design. The consensus means that they share the same views and understand the design in a similar way. This indicates that the design successfully
communicates its purpose and appeals to a wider audience. It shows that the design is effective, impactful, and achieves its intended goals.

Typically, in exhibition design, spaces are uniformly and bright lit like "white cubes" (Schielke, 2020, p. 11). The findings of this study, which favor evening scenarios over morning ones, support the notion that the objective approach of uniformly lighting and exhibiting artwork can be perceived as less exciting (Schielke, 2020). Museums face a particular challenge when presenting numerous exhibits, as the abundance of visual stimulation in the environment can lead to observer fatigue. This is attributed to the mental effort required for processing and perceiving the objects on display (Schielke, 2020). The implementation of rhythmic lighting design can play a role in addressing and mitigating this issue. Rhythmic lighting design has the potential to enhance not only the individual rooms but also the overall exhibition experience. For instance, when rooms with an exhilarating rhythmic lighting design follow less captivating ones, it can introduce a layer of rhythmic lighting design that adds to the overall rhythm and evokes fluctuations in people's mood, creating a dynamic interplay between the environment and their emotions. By doing so, we can enhance well-being and attract more attendees to an exhibition, addressing the UN goals for sustainability.

Exhibition spaces in Sweden are required to adhere to lighting standards that mandate a uniformity level of 0.4 and luminance of 300 lux. Contrarily, the evening "mystery" scenario, considered the most exciting among all others, exhibits a uniformity level of 0.12 and luminance of 82 lux, which deviates from the mandated standard. The deviation from the standards is further amplified as the uniformity and luminance calculations exclude the light and shadow pattern present in the center of the floor area. It is worth considering challenging the lighting standards to incorporate rhythmical scenarios that align with people's perceptual preferences.
Limitations and future studies

The study encountered limitations related to various aspects of the procedure. A notable limitation of the study pertained to potential bias introduced by the sequential presentation of visual design scenarios in the survey. The scenarios that were presented second in the questionnaire were the ones preferred by the participants. When comparing the morning scenarios first, followed by the evening scenarios, the responses indicated a preference for the evening scenarios. Upon closer observation, it becomes apparent that there may be a bias present due to the treatment of the initial morning scenarios as a reference point when comparing them to the subsequent evening scenarios.

Another constraint lies in the restricted availability of information regarding the construction of Liljevalchs+ and its associated details. The inclusion of this information would have enhanced the relevance and applicability of the study's findings to Liljevalchs+.

Furthermore, it is important to acknowledge that the study is limited by the absence of the participants' actual experience of the space and physically walking through it. Allowing participants to explore the space from their own perspective would likely lead to a different experience, providing a better understanding of their motivation to explore the space and the extent of that motivation. Another limitation of the study is the absence of physical paintings displayed on the walls. In an experiment conducted in a real exhibition space, the presence of paintings with their unique visual rhythm would have the potential to impact participants' perception of atmosphere and inclination for spatial exploration. The same principle applies to the architectural design of the museum and exhibition space. As for the exhibition, there could be a concern that the presence of the light installation might distract or shift attention away from the main focus of the exhibition. However, this is feasible as the installation could be light art itself and it depends on the curators and artists which one, the exhibition or the light art, need to be more prominent.

Regarding future research, it should incorporate in situ experiments with real-life scenarios to further investigate the topic of visual rhythm in lighting design. Furthermore, it is necessary to conduct research on rhythmic lighting design that integrates dynamic colors, vibrant hues, and gradient saturation variations. It is, also,
possible to identify exhibitions featuring exhibits characterized by a monotonous visual rhythm for example a photography exhibition with black and white portraits. In such cases, it becomes feasible to introduce rhythmic lighting scenarios that can alter the atmosphere, evoking curiosity without detracting attention from the exhibition itself. Research in rhythm in lighting design can also explore the application of rhythmic dynamic lighting in diverse settings and spaces that are experienced in a sequential manner such as parks or shopping malls.
Conclusions

The objective of this study is to investigate the concept of visual rhythm in the context of lighting design, with a particular focus on its relevance to the practice of museum lighting. As previously discussed, the experience of rhythm arises as individuals traverse through different light zones, influencing the spatial atmosphere and enhancing the exploration within a given space. Within this context, an experiment was conducted to explore various rhythmical scenarios designed to create visual allure, with the aim of captivating individuals and encouraging their engagement in walking through an exhibition space. Two distinct scenarios were implemented in the study: the "focal glow" scenario, designed to entice individuals through the use of bright and inviting illumination, and the "mystery" scenario, which aimed to capture people's attention through low visibility and a light and shadow pattern. In addition, these scenarios were implemented using natural daylight as a crucial component in the design.

The results of the experiment indicate that the "mystery" scenarios, specifically during the morning and evening periods, exhibited a greater prevalence and effectiveness compared to the "focal glow" scenarios. It demonstrates that a combination of limited visibility, contrast and a prominent, natural light and shadow pattern is favored over alternative options. Additionally, the findings indicate that scenarios characterized by "focal glow" and “mystery” are more prevalent in the evening compared to morning settings. This suggests that daylight does not play a significant role in shaping the rhythmic scenarios and the corresponding atmosphere they create.

Moreover, there is no notable distinction in the perception of atmosphere and spatial exploration between experts and non-experts in lighting design, underscoring the importance of rhythmic scenarios. Regarding lighting standards, there is a need for them to be questioned, as individuals exhibited a preference for scenarios that deviate from the prescribed uniformity and luminance proposed by the standards.

Nonetheless, it is advisable to conduct similar experiments in real-life settings to attain more substantial results and minimize potential survey bias.
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Visual rhythm in light design

This survey is part of the research project for a Master thesis at KTH, Royal Institute of Technology, in Stockholm, Sweden. The following survey wants to investigate people’s perception of atmosphere in a museum setting.

The data will be collected anonymously and exclusively utilized for the scope of the research. The survey will be conducted on a voluntary basis. The participants can leave the survey anytime. Please read carefully at the beginning of each section before answering.

What is your age?
- Under 18
- 18-24
- 25-34
- 35-44
- 45-54
- Above 54

Do you have any expertise in light design?
- None
- Professional light designer
- Lighting design student
- Professional in other area with light design studies
- Professional in other area without light design studies
When completing the survey, pretend that you’re inside the building and the pictures show what you see. Think about how you feel in the place rather than just judging the images.

### Question 1
Which space do you think is more exciting to you?

- Space 1 - Very exciting
- Space 1 - Moderately exciting
- Space 1 - Slightly exciting
- Neutral
- Space 2 - Slightly exciting
- Space 2 - Moderately exciting
- Space 2 - Very exciting

### Question 2
Which space do you prefer to explore further?

- Space 1 - Very much
- Space 1 - Moderately
- Space 1 - Slightly
- Neutral
- Space 2 - Slightly
- Space 2 - Moderately
- Space 2 - Very much

### Question 3
Which elements in the space you choose above made you want to explore it?

- The lighting
- The periphery of the four walls
- The color of the floor area
- The view with the columns
Which space do you think is more exciting to you?

Which space do you prefer to explore further?

Which elements in the space you chose above made you want to explore it?

- The ceiling
- The periphery of the floor area
- The center of the floor area
- The walls with the paintings

Which space do you think is more exciting to you?

Which space do you prefer to explore further?
Which space do you think is more exciting to you?

[Dropdown]

Which space do you prefer to explore further?

[Dropdown]
Figure 19 Calculations for mystery scenario at 12:00, the calculations’ grid is placed 0.8 m above ground covering only the illuminated area.

Figure 20 Calculations for mystery scenario at 16:30, the calculations’ grid is placed 0.8 m above ground covering only the illuminated area.

Figure 21 Calculations for focal glow scenario at 12:00, the calculations’ grid is placed 0.8 m above ground covering only the illuminated area.

Figure 22 Calculations for focal glow scenario at 16:30, the calculations’ grid is placed 0.8 m above ground covering only the illuminated area.
Appendix- Results

Figure 23 Preference in elements of the space for focal glow and mystery scenario at 12:00 on 14 of February 2023 for experts and non-experts

Figure 24 Preference in elements of the space for focal glow and mystery scenario at 16:30 on 14 of February 2023 for experts and non-experts