The boundaries between light and color in architecture: the different lighting solution

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ABSTRACT

Light and color are innate characteristics in architecture. Hardly an environment, a building, or a monument can be devoided of light and color. The reason is simple. Even if humans holistically perceive what surrounds them, sight is generally the first sense activated in the discrimination of the environment.

Lighting technology and colorimetry are inextricably connected. The visible spectrum and our sensibility to different radiations, allow us to perceive colors and experience space. This assumption also implies that its indeed possible to achieve significant changes in a space, with the sole use of light and color.

The relationship between light and color is well known from a photometric and colorimetric point of view; however, the relationship between these two actors has different meanings in the symbolic and interpretative sphere. This article aims to explore these aspects. The color is not an intrinsic physical property of the objects; the lighting designer must be aware that changing the technology or the propriety of light sources directly affects the chromatic aspect of an object and as such perceptions of architecture and symbolism of its color.

This article wants to demonstrate that seeing architecture, means interpreting a context through its colors and shapes.

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1. Introduction

Light invites us to enter a space, highlights details, and fascinates us. Light plays a crucial role in our ability to see and appreciate past and present architecture. Light is one of the most critical factors in architecture and color is one of its properties. Together, they shape our perception of the built environment and play a critical role in interacting with architectural spaces.

Lighting and its colors have not only functional features but also add emotional value to architecture by helping to create an experience for those who inhabit the space. Architecture achieves its goal through natural and artificial lighting by showing off its shapes, textures, and details.

Color is another important element in architecture that influences our emotional and psychological response to space (Radwan and Helwan University, 2015). Architects use color strategically to evoke certain moods, create visual harmony or contrast, and express the intended character of a building. From the exterior façade to the interior finishes, the choice of color can influence the perception of a building and highlight or downplay certain architectural features.

Light and color work in harmony to determine the character, mood, and visual impact of architecture. They allow us to appreciate the interplay of form, space, and materials and contribute to understanding architectural concepts, intentions, and narratives. Without light and color, our architectural experience would be severely limited, as they provide the necessary visual cues and stimuli that enrich our perception and create meaningful connections between us and the built environment.

2. Lighting strategies: aspects and approaches

To achieve a harmonious balance between lighting and architecture, it is essential to consider the three basic elements of architectural lighting: Aesthetics, Functionality, and Efficiency (Lam, 1977).

In aesthetics, designers examine the emotional impact of light in architecture. Aesthetic considerations refer to how lighting enhances the visual appeal and ambiance of a space. This can be achieved by highlighting architectural features, emphasizing textures and materials, providing focal points, and creating a desired atmosphere. The goal is to create a visually appealing environment that complements the architectural design and evokes the desired emotional response.

The second fundamental aspect is the function of light. Regardless of the aesthetic aspect of the designed light, the light always has a very specific purpose, which is to allow the process of vision. Functionality refers to the practical aspects of lighting in architecture, meeting the specific requirements of the space and its users.

Today, the aspect of efficiency is fundamental. Creating a fantastic lighting project is an accomplishment in itself, but it is even more impressive when the project is also extremely energy efficient. Efficiency focuses on optimizing energy consumption and minimizing environmental impact without compromising the aesthetic and functional aspects of lighting.

Balancing aesthetics, function, and efficiency in architectural lighting requires a thoughtful and holistic approach. This includes collaboration between architects, interior designers, and lighting designers to ensure that lighting design enhances architectural intent, provides necessary functionality, and promotes energy-efficient practices.

Lighting design is a relatively young profession introduced by Richard Kelly in the second half of 1950, using the title "architectural lighting consultant" (Petty, 2014). Before the Second World War, it was common to use light according to the theory of the quantitative approach: since electric light was finally available, it was common to produce large amounts of light without thinking about the people or any aesthetic effect. It is only after the Second World War that people begin to think not only about lighting but about how to illuminate, that is, studying the right amount of light that allows a proper vision of the surroundings. This theory is called a qualitative approach (Ganslandt and Hofmann, 1992).

The figure of the contemporary lighting designer, more complex than the profession described by Richard Kelly, is defined by the energy crisis of the 1970s with the oil embargo and the resulting high energy costs. If before the energy crisis, the general rule of lighting designers was "more light, better vision," after the energy crisis the mantra changed to "the right amount of light in the right place at the right time." (Neumann *et al*, 2010). Most light must now reach its destination with as little waste as possible to achieve the highest efficiency (Skarżyński and Żagan, 2022). Aesthetics, function, and efficiency are thus the three characteristics that the lighting designer must consider when looking at a project as a unity of light and color.

3. Light in Architecture

In architecture, there is usually a concern about the balance between light and shadow, but this is always linked to the crucial and interconnected relationship

between light and color. Light is the source that reveals and interacts with colors, allowing the perception and experience of the full range of hues in a space.

In the context of historic architecture, light helps reveal the intricate details, textures, and shapes of buildings. Many architectural structures from the past were designed with a deep understanding of daylight and its interaction with space, strategically using natural light through the openings to create dramatic effects and highlight certain structural elements. The play of light and shadow in Gothic cathedrals, for example, highlights the beauty of their intricate stained glass windows and sculptural details (Górczewska, 2011).

Light is also a fundamental design aspect in contemporary architecture. Today, various techniques are used to manipulate and control natural and artificial light to create specific atmospheres, evoke emotions, and highlight architectural features.

Overall, it is crucial to understand the interplay of natural light, artificial lighting, and color as essential components in shaping the character and experience of architectural designs, where these elements work synergistically to support the functionality, aesthetics, and desired user experience of the space.

Architecture and light have always been interdependent concepts. Le Corbusier believed in the transformative power of light in architecture and considered light an essential element that shapes space and materials. Le Corbusier states, "Architecture is the learned game, correct and magnificent, of forms assembled in the light " adding "Our eyes are made to see forms in light" (Le Corbusier, 2013; Plummer and Corbusier, 2013). This relationship between light and architecture inevitably takes place in space.

Le Corbusier's use of natural light inspired Bruno Zevi's approach to light, but he differed from others in that he viewed light as a fundamental material for architectural design. Zevi believed that light could be used to create spaces that were emotionally charged and that it could be used to shape the form and character of a building. If other architects focused on functional lighting, Zevi believed that lighting could shape the unique identity of a place by focusing on the emotional and esthetic aspects of light in architecture. When asked what constituted the atmosphere in architecture, Zevi replied, "There's no doubt about it, the light in the space." (Cirillo, 2001)

It was Sigfried Giedion emphasized how closely light is linked to the definition and perception of space, writing, "Light gives the feeling of space. Darkness dissolves space. Light and space are inseparable. When light is turned off, the emotional content of space disappears

and becomes impossible to grasp. When it is dark, there is no difference between the emotional evaluation of space and that of a well-designed interior" (Giedion, 1982). Giedion's words perfectly explain the task of the lighting designer, a very important figure for some architects of our time.

Zaha Hadid, often described as the grand dame of contemporary architecture, considered artificial and natural lighting an integral part of her architectural vision. She often collaborated with lighting designers to develop customized lighting solutions that complemented the complex geometries and fluid forms of her buildings (Sebastian *et al.*, 2018). For Hadid, lighting was an essential tool to show and interpret the forms and textures of her architecture.

4. The perception of light and color

Color is imperceptible without light. The viewer is strongly stimulated by color, a phenomenon that results from the interplay between the molecular composition of an object, specific wavelengths of light, and the neurological structure of an organism. Without any of these elements, there would be no color perception. Color, then, is not an inherent property of an object, but rather an event that results from the intertwining of these factors (Bryant, 2011). The proprieties of the material that composes the object, the position, and the physical condition of the viewer are all crucial factors, as is the role that light plays in all perceptions. In addition, color is fundamental in representing architectural elements, their concealment, and their impact.

In general, architecture can be considered a set of inseparable qualities: space, movement, textures, objects, details, and surfaces flooded with light and colors. In both an interior and exterior environment, we experience color and light as the result of perceptual and emotional adaptation.

Arne Valberg states a fundamental difference between physical stimulus quantities, photometric, colorimetric, or otherwise, and the subjective qualities that are perceived (Valberg, 2005). Spatial perceptual situations are very complex. As we move through space, our perception and experience of the spatial totality are affected sequentially and simultaneously by adaptation to different lighting and then also by the interaction of the light with color. Perception and experience thus result from our interaction with the environment, which cannot be calculated only photometrically, as is often done.

Color and light in architecture have not only a functional sense, but also an emotional sense, as they influence our

experiences, feelings, and our physiological well-being, and are thus relational qualities that arise from human participation and action in space. If the designer aims to consider light and color more connectedly, the field is vaster than simple good lighting practice.

While it is true that light and color are commonly perceived through the human visual system, it is equally true that the perceived sensations are full of meaning (Little, 2014). Because they are sensory experiences, the perception of light and color can be understood differently, from the rational view to the purely subjective view of 'liking or disliking' to culturally influenced meanings.

With this variety of actions, there are different experience levels with light and color. They range from experiences based on perception (formal aspects of color and light), to direct experiences with the surrounding world (expressions of color and light), to indirect experiences (conventional meanings of color and light) rooted in culture and history, such as traditions, customs, trends, art, and so on (Klarén *et al.*, 2013).

Rudolf Arnheim analyzes the creation process of artistic perception and talks about form, space, movement, and even color and light, as fundamental aspects for visual understanding. He writes, "If we had wanted to begin with the first causes of visual perception, a discussion of light should have preceded all others, for without light the eyes cannot perceive form, color, space, or movement" adding "But light is more than just the physical cause of what we see. It also remains psychologically one of the most fundamental and powerful human experiences" (Arnheim, 1997).

5. Light and color in the lighting project

Color is not a physical property inherent in what we see; thus the proprieties of light play a fundamental role in lighting design. Color and light are described within specific Spectral Power Distributions, therefore, without light, color cannot exist, but often this fundamental matter is not considered. Not considering that light and color in architecture are two different but inseparable aspects of the same issue, generally, different paths are followed. In lighting research, it mostly aimed to solve aspects of visibility and comfort, while in the field of color, attempts have been made to solve the needs of design, style, and fashion. Today, however, in particular through psychophysics, which is the subfield of psychology that studies the relationships between physical stimuli and sensory systems, it has been possible to define some fundamental aspects of color and light, underlining their ability to contribute to human well-being.

In the process of lighting design, it is necessary to clearly understand how the space is experienced by users, both for the creative process and for the critical distance. Very often designers tend to improve an object's appearance or interpret a place's mood when in reality the aim should be to promote the psycho-physiological well-being of individuals.

Designing color and light implies that insiders have a solid understanding of the conditions that govern visual perception (Klarén, 2013). Light and color condition us through the visual system, through non-visual paths, and also by affecting the circadian system. The Spectral Power Distribution of light and our non-linear sensibility to colors can significantly alter our experience of space. Concerning colored lights, it is typical for individuals to think of vivid and saturated colors (Labrecque and Milne, 2012). Rich and saturated colors are only a small portion of what today's artificial lighting technology has made available to us. Even white light could by now be defined as colored light given the range of white tones available to illuminate our environments. We are constantly flooded with color from both our natural and manmade surroundings. Colored artificial light, however, does not share the same eminence as daylight. For many, the colored lighting, fixed or dynamic, should be designed only for theatre, art installations, or special events, and not used to illuminate our architecture for the everyday. Colored lighting schemes in architecture have received mixed reactions from the public as it is difficult to relate to or understand the message intended by the designers.

Lighting designers are well aware of how colors and materials can appear differently under these lighting conditions, but they harness this knowledge to modify and enhance the perception of space, as well as to visually communicate with people. With dynamic colored lighting, a space can seem larger or smaller, darker or brighter than it really is, not only using the balance of light and darkness as a focus of the design but also through color. For instance, when a room is bathed in monochromatic light, the surfaces and textures seem to blend together, allowing to stand out new contrasting focal points. On a larger scale, many monuments and cities are being designed with color-changing lighting.

6. The different lighting solutions in an urban environment

The perception of a city is strongly connected to its lighting creating iconic landmarks that can improve the "wayfinder" concept (Lynch, 2008). Lighting with its color and shapes enhances the visibility and usability of urban spaces transmitting messages and communicating with people as a perfect marketing tool (Schielke, 2015).

Fig. 1. White light for the façade of Lit Brothers, Philadelphia, USA. Ph. © Jeffrey Totaro, Color Kinetics
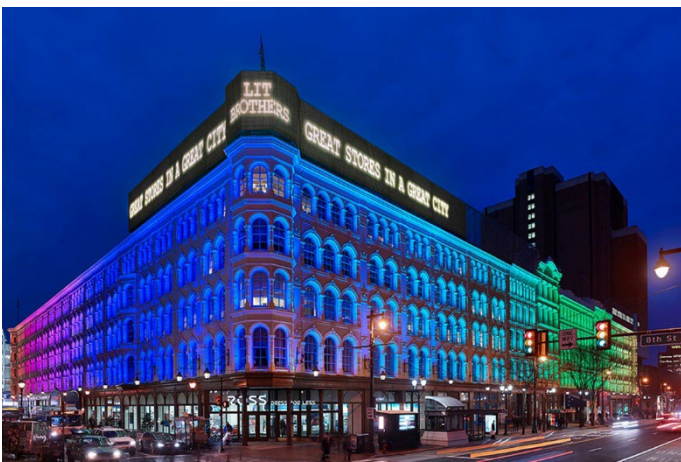

Fig. 2. Lit Brothers facade is illuminated with dynamic colored lighting to reflect holidays, local celebrations or world events. Ph. © Jeffrey Totaro, Color Kinetics
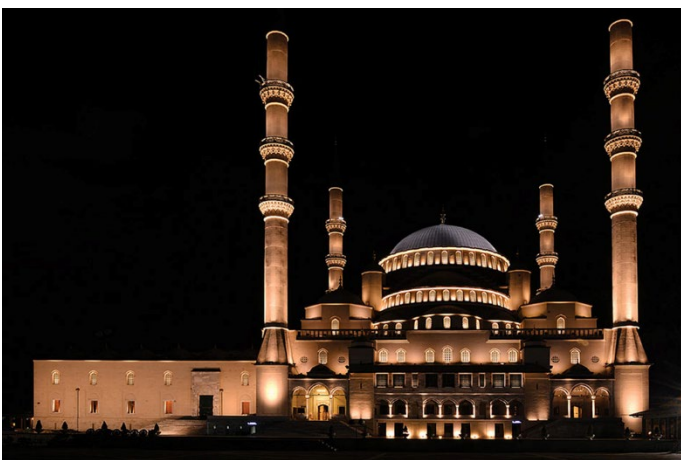

Fig. 3. The lighting of Kocatepe Mosque in Ankara, Turkey, uses tunable white technology to highlight all of the building's architectural details. different color temperatures of white light. Ph. © Istavrit Agency, Color Kinetics

With the addition of lights, projections, and video, the facades are able to evoke emotions in the viewer. Today, technology and creativity are working together and giving life to new and dynamic architectural lighting solutions that offer cities the opportunity to interact more and more with their public. This can be achieved with different lighting solutions depending on the project idea, from simple static light to advanced individual pixel-controlled solutions.

The fixed lighting of facades or monuments convey emotions in a static way, showing the architecture in a stable and immutable manner. This type of lighting can be done with white tones or color. This approach is sometimes, and erroneously looked as simple. Architectural lighting designer must first know the aim of the project. This includes determining whether the lighting should be studied to create an image of the fictitious facade or to show the architecture as it is typically seen in daylight, accentuating specific characteristics.

This type of lighting project will involve deep study of the history and architectural style of the building itself (Di Salvo, 2015).

Static lighting allows only the control of the light intensity, offering the possibility of adapting to changes in the environment and daylight conditions.

To achieve a change in the image of the facade in a subtle and non-invasive way, the optimal solution is to use tunable white lighting, technology that can adjust the color temperature by combining multiple white lighting sources. The color temperature of lighting has a significant impact on the architecture. The possible variations in color temperature from warm white to cold white can change the facade's appearance and thus convey various emotions or enhance different textures and colors.

The achievement of dramatic and more evocative effect, often implies that cities are to be illuminated with soft or saturated colors. Lighting can be programmed by changing colors only at specific times allowing the architecture to be temporarily transformed into a living object of the urban landscape. When colored light is designed in the urban landscape, however, the lighting designer must carefully consider every element that will illuminate and with which colors since it will be linked to an image and an experience that the observer will live and admire as if he was inside a painting.

Selecting a functional and easily achievable technology will be essential whichever solution is chosen.

Today technology is very advanced and with it the complexities. It is therefore crucial to choose intuitive

solutions that allow the integration of lights and interactive technologies and that give the possibility to control the entire system simply and effectively. Only in this way, will technology not become an obstacle to creativity.

Fig. 4. The facade of County Hall, London, UK, is illuminated to full height with a uniform color-changing light, making the building an iconic and eye-catching landmark on the South Bank both by night and by day. Ph. © Redshift Photography, Color Kinetics

6. Conclusions

Although colored artificial light sometimes incurs a negative reception from users, it should be seen as an exciting and powerful tool that can produce impressive results when used correctly.

The union and play between light and color, when designed with care, improve the identity of an environment by creating a new character and allowing those who live it a unique experience, sometimes managing to tell a story with a fascinating theatrical effect.

The fundamental aspects are in the choice of color, in the way it is applied, and the understanding of its effects. However, it is essential to know the basic principles that include the use of colors such as the right choice of contrasting tones to create depth or to highlight, or to understand how color can alter the appearance of textures, materials, and space. Color science must become a technical basis for lighting designers to be able to implement the right illumination with the most appropriate technology.

The question "Why color?" should be the first thing that crosses the mind of lighting designers willing to use colored light.

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The author of this piece of research declares no known conflict of interest with other people and/or organizations.

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9. Short biography of the author

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Licensing terms

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