



## The role of dynamic smart lighting in shaping the mood and functionality of interior spaces Contemporary

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### Abstract

Lighting is a fundamental element of interior design, influencing the form and function of spaces, as well as the psychological and emotional atmosphere of users. With technological advancements, smart, dynamic lighting systems have emerged, allowing for control over light intensity, color, and timing to align with user needs and the nature of the activity. This study aims to explore the impact of smart, dynamic lighting on the mood and functional performance of users in contemporary residential, educational, and administrative spaces, focusing on the balance between aesthetics, functionality, and psychological comfort. The research employed a descriptive-analytical approach, utilizing tools such as questionnaires and field observations, and descriptive and statistical data analysis to compare spaces equipped with smart lighting with traditional spaces. The results demonstrated that smart, dynamic lighting improves mood, increases focus and productivity, reduces eye strain, and enhances visual comfort. It also highlights architectural elements and adds aesthetic appeal to spaces. Furthermore, the study revealed a gap between the technical capabilities of smart lighting and its practical application, underscoring the need for its systematic integration to achieve a healthy, comfortable, and functional indoor environment.

**Keywords:** Dynamic Smart Lighting, Interior Spaces, User Experience.

### المخلص

يُعدّ الإضاءة عنصرًا أساسيًا في التصميم الداخلي، إذ تؤثر على شكل ووظيفة المساحات، فضلًا عن الحالة النفسية والعاطفية للمستخدمين، ومع التطورات التكنولوجية، ظهرت أنظمة إضاءة ذكية وديناميكية، تتيح التحكم في شدة الإضاءة ولونها وتوقيتها بما يتناسب مع احتياجات المستخدمين وطبيعة النشاط وتهدف هذه الدراسة إلى استكشاف تأثير الإضاءة الذكية والديناميكية على الحالة المزاجية والأداء الوظيفي للمستخدمين في المساحات السكنية والتعليمية والإدارية المعاصرة، مع التركيز على التوازن بين الجماليات والوظائف والراحة النفسية. استخدم البحث منهجًا وصفيًا تحليليًا، مستعينًا بأدوات مثل الاستبيانات والملاحظات الميدانية، بالإضافة إلى تحليل البيانات الوصفية والإحصائية لمقارنة المساحات المجهزة بإضاءة ذكية مع المساحات التقليدية. أظهرت النتائج أن الإضاءة الذكية والديناميكية تحسّن الحالة المزاجية، وتزيد التركيز والإنتاجية، وتقلل إجهاد العين، وتعزز الراحة البصرية. كما أنها تُبرز العناصر المعمارية وتُضفي لمسة جمالية على المساحات، كشفت الدراسة عن فجوة بين الإمكانيات التقنية للإضاءة الذكية وتطبيقها العملي، مما يؤكد على ضرورة دمجها بشكل منهجي لتحقيق بيئة داخلية صحية ومريحة وعملية.

**الكلمات المفتاحية:** الإضاءة الذكية الديناميكية، المساحات الداخلية، تجربة المستخدم.

### Introduction

Interior design relies heavily on lighting, which affects a space's appearance and functioning as well as its overall atmosphere. From oil lamps and natural illumination to modern technologies like LED bulbs and sophisticated lighting systems, lighting techniques have evolved over time. There are numerous lighting designs and technologies available to achieve different goals, such as increasing aesthetic appeal, establishing cozy and welcoming spaces, and maximizing efficiency. Lighting is an important design element that may highlight architectural characteristics and determine a space's visual identity. A space's formality,

spaciousness, cosiness, tranquility, or liveliness can all be determined by carefully chosen lighting, which also affects people's comfort and emotions. To achieve the intended purpose of the environment, lighting design integrates a number of categories, such as general, functional, and aesthetic lighting<sup>1</sup>.

For example, although warm lighting promotes warmth and tranquility in domestic settings, white and direct illumination can improve productivity and concentration in professional settings. Thanks to technology, users can change the illumination's color and intensity according to their tastes and the time of day. The purpose of this study is to better understand how different lighting fixtures affect interior design, improve user experience, and help interior spaces strike a balance between their functional and aesthetic aspects. This study looks at indoor lighting from two main angles: the space's overall aesthetic appeal and its practicality<sup>2</sup>. Lighting created by artificial light sources, such as different kinds of electric lamps, is referred to as artificial lighting. It is intended to improve internal visual perception and serve purposes relevant to the use of the area. The dispersal of numerous light sources throughout a space to produce uniform illumination or specific lighting effects is known as light distribution<sup>3</sup>.

In order to maximize safety and comfort inside a space, visual comfort refers to optimal lighting levels that reduce visual strain and enhance clarity of vision. Lighting that is expressly made to serve practical goals is referred to as functional lighting. This kind mainly improves visual performance in specific areas and is suitable for work or reading contexts. The main source of general illumination is ambient lighting, which diffuses light evenly across the space and is perfect for promoting the best possible eyesight. While directed lighting improves depth, drama, and beauty by highlighting specific features, such as artwork or decorative elements, task lighting refers to targeted illumination intended to aid tasks like reading, working, or cooking. Practical examples of aesthetic lighting include hidden lights under beams, passages, or decorative lamps that add subtle creative touches to the decor. Aesthetic lighting is intended to improve the area's visual attractiveness and highlight educational design features<sup>4</sup>.

The ability of a light source to provide the required illumination while using the least amount of power and so satisfying design sustainability requirements is known as lighting efficacy. These definitions will make it easier to understand basic concepts used in interior lighting design, which will help achieve interior comfort and aesthetic appeal. This study looks at the effects of color and intensity selections, as well as artificial and natural lighting, highlighting the need to customize these components to the unique qualities of each space in order to create a stimulating and peaceful ambiance that meets users' functional, aesthetic, and psychological needs. The purpose of this study is to comprehend how various lighting configurations impact interior spaces' overall functionality and appeal. Despite being a crucial component of interior

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<sup>1</sup> Aghajari, S., & Chen, C.-C. (2025). Optimizing Classroom Lighting for Enhanced Visual Comfort and Reduced Energy Consumption. *Buildings*, 15(8), 1233, <https://doi.org/10.3390/buildings15081233>

<sup>2</sup> Balocco, C., Ancillotti, I., & Trombadore, A. (2023). Natural light optimization in an existing primary school: human centred design and daylight retrofitting solutions for students wellbeing. *Sust. Build.*, 6, 1. <https://doi.org/10.1051/sbuild/2023002>

<sup>3</sup> Pracki, P., & Krupiński, R. (2021). Brightness and Uniformity Perception of Virtual Corridor with Artificial Lighting Systems. *Energies*, 14(2), 412. <https://doi.org/10.3390/en14020412>

<sup>4</sup> Osibona, O., Solomon, B. D., & Fecht, D. (2021). Lighting in the Home and Health: A Systematic Review. *International Journal of Environmental Research and Public Health*, 18(2), 609. <https://doi.org/10.3390/ijerph18020609>

design, neither designers nor users may fully comprehend the patterns, effects, and uses of lighting. Erroneous or inadequate illumination may have negative impacts that impair users' comfort and capacity to concentrate or unwind<sup>1</sup>.

### **Problem of study**

Lighting has become a pivotal element in contemporary interior design, not only for providing visibility but also for influencing users' mood and functional efficiency. With the development of dynamic smart lighting capable of adapting to time, activity, and natural light intensity, the user experience can be significantly enhanced. However, many spaces still rely on traditional systems that fail to account for these variables, diminishing psychological comfort and productivity. Furthermore, designers often lack a comprehensive understanding of how to effectively implement these systems, and the absence of applied research linking smart lighting characteristics to the psychological and functional roles of spaces presents a challenge to improving the quality of the indoor environment.

**The main problem question is:** What is the role of dynamic smart lighting in enhancing mood and boosting the functionality and efficiency of contemporary interior spaces?

### **Aims of study**

1. Understanding the concept of dynamic smart lighting and its control technologies in contemporary interior spaces.
2. Examining the impact of dynamic lighting on the mood and psychological state of users in interior spaces.
3. Analyzing the role of smart lighting in enhancing the various functions of interior spaces, such as residential, educational, and administrative spaces.
4. Evaluating the impact of light intensity, color temperature, and temporal lighting variations on the user experience.
5. Studying the extent to which smart lighting can improve users' visual and psychological comfort.
6. Identifying the gap between the technical capabilities of dynamic lighting and its practical application in interior design.
7. Proposing design principles for effectively integrating smart lighting to achieve a balance between aesthetics, functionality, and psychological comfort.
8. Providing practical recommendations for designers and engineers to improve the quality of interior spaces through the use of dynamic smart lighting.

### **Study questions**

1. How do the dynamic smart lighting features affect the overall mood of users in interior spaces?
2. What is the relationship between light intensity, color temperature, and their variations with users' psychological comfort?
3. To what extent does dynamic lighting contribute to improved productivity and functional performance in interior spaces?
4. How can smart lighting support the multiple functions of residential, educational, and administrative spaces?
5. What are the knowledge gaps among designers regarding the use of dynamic lighting to achieve a balance between aesthetics and functionality?
6. How do temporal changes in lighting affect the daily user experience?

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<sup>1</sup> Tavares, P., Ingi, D., Araújo, L., Pinho, P., & Bhusal, P. (2021). Reviewing the Role of Outdoor Lighting in Sustainable Development Goals. *Sustainability*, 13(22), Achieving 12657.

7. What is the impact of integrating dynamic smart lighting on users' visual comfort and well-being?
8. What design recommendations are possible for optimizing the use of dynamic smart lighting in contemporary interior spaces?

### **Importance of study**

The significance of this study lies in highlighting the growing role of dynamic smart lighting in enhancing the quality of contemporary interior spaces, whether residential, educational, or administrative. Lighting is no longer limited to visual perception; it has become an effective means of influencing users' mood, psychological well-being, and productivity. By understanding the relationship between dynamic lighting characteristics, such as light intensity, color temperature, and temporal variations, and their impact on user experience, designers and engineers can develop interior environments that are more responsive to human needs.

The study also helps bridge the gap between the available technological capabilities of smart lighting systems and their practical applications in contemporary interior design, contributing to the enhancement of both the aesthetic and functional aspects of spaces. Furthermore, the study's findings offer practical recommendations for designing interior spaces that provide a healthy, comfortable, and flexible environment, balancing the psychological and functional needs of users and supporting their overall quality of life.

### **Study hypotheses**

1. There is a positive correlation between the use of dynamic smart lighting and improved mood in interior spaces.
2. Dynamic smart lighting contributes to enhanced functional efficiency for users performing various activities within interior spaces.
3. The light intensity, color temperature, and time-dependent changes in dynamic lighting directly impact users' psychological and visual comfort.
4. Implementing dynamic smart lighting systems reduces the problems associated with traditional lighting in interior spaces.
5. There is a noticeable difference in user satisfaction between spaces equipped with dynamic smart lighting and those with traditional lighting.
6. Integrating dynamic smart lighting into interior design supports a balance between the aesthetic and functional aspects of interior spaces.
7. Dynamic smart lighting can adapt to changes in activity and time to enhance the user's daily experience.
8. Employing dynamic smart lighting contributes to developing design principles that are more responsive to the psychological and functional needs of users in contemporary spaces.

## **Theoretical framework**

### **Section One: Dynamic Smart Lighting and its Characteristics in Contemporary Interior Design**

Smart lighting, which combines both functional and aesthetic elements, has become a crucial component of modern interior design in the age of innovation and information technology. By adapting lighting to different activities and seamlessly integrating with cutting-edge technology like the Internet of Things (IOT), it improves user experience. By synchronizing with natural light cycles, it also enhances health and well-being and aids sustainability by using less energy. Because it allows for design flexibility, smart lighting is a great option for commercial,

residential, and office settings where it may provide both practical and sustainable aesthetic value<sup>1</sup>.

fusing useful features with attractiveness. Smart lighting enhances the quality of life in both residential and commercial environments by enabling the control of lighting levels, color changes, and pattern modifications as needed. One way to save energy is with smart lighting, because it can be operated remotely via home automation systems or smartphone apps, saving energy and helping to protect the environment. Additionally, employing smart lighting helps to improve interior areas' visual appeal, increase productivity and concentration, and create comfortable work conditions. As technology and aesthetic arts are merged to create effects that transcend the conventional notion of lighting, these breakthroughs represent a fundamental change in the design and application of lighting. As a result, researching and analyzing the application of smart lighting in interior design is crucial to comprehending its impact and efficacy in producing more aesthetically pleasing and pleasant environments<sup>2</sup>.

### **sub Section1 : Innovation and its role in employing smart lighting**

Innovation is the designer's capacity to quickly recall the greatest number of concepts appropriate for a particular circumstance. The application of the design innovation process depends on the type of contrast between the work and its surroundings. It must be founded on a broad approach and a fixed base. Experts in this field have calculated the rate at which various interior spaces require varying lighting levels by examining these factors. The development of increasingly sophisticated systems has increased since the start of the digital era. Industrial lighting control has been partially moved to the system itself in general lighting systems<sup>3</sup>.

This new kind of lighting system has communication units between the sensors and the controllers, as well as monitoring sensors (controllers) that adjust the lighting based on inputs from the sensors to minimize energy usage while maintaining the necessary lighting. The intelligent lighting system is the name given to this system from now on. The initial investment needed to install the system should be taken into consideration when designing smart lighting systems to save energy usage and, consequently, operating costs. Intelligent lighting systems that require little to no changes to the current lighting system infrastructure are especially desirable in existing buildings. The lamps above the control areas with enough daylight are dimmed to reflect energy consumption in smart lighting systems. In a smart lighting system, this control method—also referred to as daylight harvesting—is frequently coupled with occupancy-based control. Usually, a light sensor is used to measure the amount of light present in the various control zones. A light sensor is an electrical gadget that has a built-in light-sensitive element that measures both the illumination level and the amount of light that reaches the element. The light-sensitive element in a standard light sensor can only receive light coming from certain directions<sup>4</sup>.

The maximum angle with respect to the axis perpendicular to the light sensor's surface from which light can enter. Through improved energy efficiency and product design that promotes

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<sup>1</sup> Khalil, S. M., Imran, B. M., & Evgenievich, P. S. (2025). Innovative Use of Smart Lighting in Interior Design. *Iraqi Journal of Applied Art*, 1(1), p 36

<sup>2</sup> Khalil, S. M., Imran, B. M., & Evgenievich, P. S. (2025). Innovative Use of Smart Lighting in Interior Design. *Iraqi Journal of Applied Art*, 1(1), p 36

<sup>3</sup> Yu, T., et al., Digital Innovations in Interior Design: A New Model for Enhancing Indoor Spaces in Elderly Care Residences. 2024. 30(4): p. 3074-3086.

<sup>4</sup> Cheng, Y., et al., Design and application of a smart lighting system based on distributed wireless sensor networks. 2020. 10(23): p. 8545. <https://www.mdpi.com/2076-3417/10/23/8545>

reuse and the use of benign materials, technological innovation may promise to stimulate fewer environmental impacts. It is simple to ignore the environmental cost of technology transition and premature replacement, though, as new technologies are developed. Product recycling can increase energy efficiency, but it can also result in the development of more varied and expansive waste streams<sup>1</sup>.

### **Impact lightings on the overall impression**

The kind of lighting used determines how a room is perceived and experienced. Warm lighting creates a sense of coziness, whereas cool lighting conveys a sense of modernism and cleanliness. By emphasizing emphasis areas, directional lighting can improve a space's aesthetic appeal and attention span.

#### **1. The impact of natural lighting**

By choosing the right color temperatures, ambient lighting can be tailored to suit various moods and create a feeling of coziness and openness. It is essential for maintaining the best possible eyesight inside the area, making mobility easier, and improving safety. Warm lighting (3000 Kelvin and lower) is ideal for living areas and bedrooms since it encourages comfort and relaxation. Because it improves focus, cold lighting (4000 Kelvin and above) is frequently used in offices and hospitals. Employee productivity and attentiveness are increased by cool lighting. Warm ambient lighting is used in hotels to make visitors feel welcome and at ease<sup>2</sup>.

#### **2. Task Lightings and Directional Lightings Effect**

Task lighting improves performance and productivity by increasing attention and concentration. In addition to being a useful feature, task lighting has been shown to improve concentration and lessen visual distractions. Task efficiency is increased, for instance, by placing moderately bright lighting over a workstation to lessen eye strain. It is crucial for settings like home offices and kitchens where accuracy is needed since it offers concentrated lighting that lessens eye strain<sup>3</sup>.

Directional lighting improves the aesthetic appeal of creative settings or décor in addition to adding drama and elegance. Apart from its aesthetic appeal, it highlights the site's qualities and makes its components more elegant and clearer. Several studies show that "visual points of interest" created by controlled lighting provide a space depth and a unique aesthetic. Some aspects of the architecture or décor are highlighted to draw attention and give the room emotional and visual personality. Applications for task lighting include: Improving visibility and reducing accidents are two benefits of task lighting in kitchen areas used for food preparation. To offer enough light for reading, task lighting is used in libraries and reading nooks. Evaluation of art galleries: The subtleties of artworks at museums and galleries are highlighted by directed lighting, which increases visitors' interaction with the objects. It guides people around various areas by highlighting important components and focusing attention<sup>4</sup>.

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<sup>1</sup> Fernández, D.R.C., Distributed smart lighting systems: and control.

<https://pure.tue.nl/ws/portalfiles/portal/3799294/774336.pdf> sensing 2014.

<sup>2</sup> Hjetland, G. J., Pallesen, S., Thun, E., Kolberg, E., Nordhus, I. H., & Flo, E. (2020). Light interventions and sleep, circadian, behavioral, and psychological disturbances in dementia: A systematic review of methods and outcomes. *Sleep Med Rev*, 52, 101310. <https://doi.org/10.1016/j.smr.2020.101310>

<sup>3</sup> Bhattacharya, S., Heidler, P., Saleem, S. M., & Marzo, R. R. (2022). Let there be light-digital eye strain (DES) in children as a shadow pandemic in the era of COVID-19: a mini review. *Frontiers in Public Health*, 10, 945082. <https://doi.org/10.3389/fpubh.2022.945082>

<sup>4</sup> Šveb Dragija, M., & Jelinčić, D. A. (2022). Can Museums Help Visitors Thrive? Review of Studies on in Museums. *Psychological Wellbeing Behavioral Sciences*, 12(11), 458. <https://doi.org/10.3390/bs12110458>

### 3. Multiple layers of illumination

When the three lighting styles are combined, the result is a flexible and effective design that allows the atmosphere of the room to be changed as needed. Places can be designed to meet a range of demands and contribute to the creation of an integrated environment by utilizing this lighting strategy. It can be changed to fit the needs and feelings of users<sup>1</sup>.

By choosing the appropriate color temperatures to correspond with activities and comfort, ambient and directional lighting, for example, can transform a multi-layered lighting living room from a place to work during the day to a place to relax at night. In workplace settings, emphasizing particular regions keeps the atmosphere pleasant while guaranteeing clear visibility for tasks. Focused lighting on tables in libraries improves reading visibility while preserving a peaceful atmosphere. Focused lighting on tables and varying color temperatures can improve customer comfort and the perceived amount of space in a restaurant. Efficient and comfortable work conditions are further supported by the use of LED lighting and its concentration on office areas. To effectively create layered lighting for various venues and purposes, it is essential to comprehend the differences in color temperature. Multi-layered lighting is commonly used in restaurant design, as evidenced by real-world case studies. Ambient lighting creates a comfortable atmosphere, directed lighting highlights décor, and task lighting brightens table portions<sup>2</sup>.

#### sub Section 2: The advantages and problems of using smart lightings

There are several benefits to using smart lighting in smart homes that go beyond what conventional lighting systems can offer. This cutting-edge method of lighting improves convenience while also promoting security, energy efficiency, and general well-being. The unmatched degree of control that smart lighting provides is one of the main benefits of integrating it into a smart home environment. Users may easily adjust and control their lighting settings from any location with the ease of a remote control using specialized mobile applications. With just a swipe on a smartphone, this adaptability enables dynamic alterations to suit various activities, moods, or preferences<sup>3</sup>.

Another significant benefit of smart lighting systems is customization, which lets users adjust the lights' atmosphere, color, and brightness. This degree of customization enables residents to design custom lighting settings that go well with particular activities, improving the quality of life overall and encouraging a feeling of coziness and uniqueness in the house. One of the main benefits of smart lighting is energy efficiency. Optimal energy utilization is made possible by the integration of energy-efficient LED technology with features like scheduling and automation. By adjusting to time-based schedules and occupancy patterns, smart lighting systems may make sure that lights are only turned on when needed. This makes the house greener and more ecologically conscious by lowering electricity costs and supporting sustainable practices<sup>4</sup>.

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<sup>1</sup> Wood, J. M. (2020). Nighttime driving: visual, lighting and visibility challenges. *Ophthalmic Physiol Opt*, 40(2), 187-201. <https://doi.org/10.1111/opo.12659>

<sup>2</sup> Ayman M Obeidat, et.al, (2025), REIMAGINING LIGHTING IN INTERIOR DESIGN: IMPACT ON SPACE, FUNCTIONALITY, AND ENVIRONMENTAL PERSPECTIVES, *SCIENTIFIC CULTURE*, Vol. 11, No. 3.2, p 20-21

<sup>3</sup> Basarir-Ozel, B., Nasir, V.A., Turker, H.B. (2023). Determinants of smart home adoption and differences across technology readiness segments. *Technological Forecasting and Social Change*, 197, 122924.

<sup>4</sup> Hussain, S., Azim, M.I., Lai, C., Eicker, U. (2023). New coordination framework for smart home peer-to-peer trading to reduce impact on distribution transformer. *Energy*, 284, 129297.

The benefits of smart lighting are enhanced by its smooth interaction with the larger smart home ecosystem. A unified and intelligent environment is produced through centralized control and synchronization with other smart devices. The total effectiveness and functionality of the smart home can be improved by the sophisticated automation scenarios made possible by this interconnection, where lighting can easily communicate with other smart systems like voice assistants, security cameras, and thermostats. A significant advancement in user engagement is voice control. Smart lighting becomes easily accessible when it is compatible with virtual assistants such as Google Assistant or Amazon Alexa. Voice commands allow users to change lighting settings, giving their smart home experience an extra degree of ease and hands-free control<sup>1</sup>.

An further noteworthy benefit of smart lighting is its ability to integrate security. Smart lighting may significantly improve home security by integrating with security systems. As part of an all-encompassing and successful security strategy, integrated lighting scenarios that are activated by sensors or surveillance equipment serve as a deterrent and increase visibility. The total quality of life of the residents is enhanced by smart lighting's health and well-being aspects. A healthier living space and improved sleep patterns can result from tunable lighting options that promote circadian cycles. Smart lighting systems that simulate natural sunlight not only meet functional lighting requirements but also enhance the physical and emotional health of the occupants of the smart home<sup>2</sup>.

Smart lighting gives house design a more imaginative and dynamic aesthetic component. Users may alter the atmosphere of their living areas to suit various events or personal tastes thanks to the ability to adjust colors and design aesthetically pleasing lighting systems. The overall attractiveness and personality of the house are improved by this aesthetic flexibility. Last but not least, smart lighting's capacity to adapt to new developments guarantees that households may remain on the cutting edge of technology. The smart lighting system is kept up to date and future-proof by regular firmware updates and the possible integration of cutting-edge technologies like Li-Fi, giving users a durable and developing investment in the rapidly increasing field of smart home technology. To sum up, the benefits of smart lighting in smart homes include control, personalization, energy efficiency, safety, wellbeing, aesthetics, and preparedness for the future, all of which add to a more sophisticated and intelligent living environment<sup>3</sup>.

## **Section Two: The Role of Dynamic Smart Lighting in Mood and Human Functions within Interior Spaces**

Lighting is a crucial component of the built environment that has a significant impact on inhabitants in a number of ways. Lighting has impacts beyond vision that might affect occupants' physiological and psychological functioning, in addition to the well-established implications for vision facilitation [1–5]. Applied lighting research on how light or illumination affects people is intrinsically multidisciplinary and requires knowledge of a number of

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<sup>1</sup> . Olabode, S., Owens, R., Zhang, V.N., Shi, L., Chambers, D. (2023). Complex online harms and the smart home: A scoping review. *Future Generation Computer Systems*, 149, 664-678.

<sup>2</sup> Tong, Z., Mansouri, S.A., Huang, S., Rezaee Jordehi, A., Tostado-Véliz, M. (2023). The role of smart communities integrated with renewable energy resources, smart homes and electric vehicles in providing ancillary services: A tri-stage optimization mechanism. *Applied Energy*, 351, 121897.

<sup>3</sup> Chen, H., Zhang, Y., Wang, L. (2023). A study on the quality evaluation index system of smart home care for older adults in the community based on Delphi and AHP. *BMC Public Health*, 23(1), 411.

disciplines, including psychology, physiology, photobiology, architecture, and building physics<sup>1</sup>.

The intrinsically photosensitive retinal ganglion cells (ipRGCs) that contain the photopigment melanopsin have been identified to be the primary mediators of the effects that extend beyond vision; these responses to light are known as ipRGC-influenced responses (IIL responses). The intrinsic properties of ipRGCs' spectrum sensitivity set them apart from traditional rods and cones. Prior studies on IIL responses show that correlated color temperature (CCT) and illuminance have an impact on people's performance, health, and well-being. Light can affect circadian rhythms, alertness, cognition, heart rate, and emotional activity through interactions between ipRGCs and particular brain regions, such as the vasolateral preoptic nucleus and suprachiasmatic nucleus, as well as the amygdala and hypothalamus. Since melanopsin is particularly sensitive to blue light with shorter wavelengths, at around 460–480 nm, higher CCT levels can also result in stronger IIL responses, even though more photons (i.e., higher illuminance levels) are necessary to trigger the photoreception of melanopsin in the ipRGCs. Furthermore, it has been shown that blue light exposure, whether it occurs during the day or at night, affects the physiological and behavioral consequences of building occupants<sup>2</sup>.

#### **sub Section 1 : The impact of dynamic lighting on users**

Light is one of the most important elements affecting the interior environment of spaces, not only functionally in providing adequate visibility, but also due to its psychological and emotional impact on users. With the development of lighting technologies, dynamic lighting has emerged as a modern innovation that allows for changing the intensity, color, and angle of light according to the needs of users or the nature of the activity taking place in the space. Studies confirm that dynamic lighting has a tangible effect on users' mood, productivity, and eye comfort. Lighting characteristics can be adjusted to enhance alertness during work hours or create a relaxing atmosphere. For example, certain shades of blue light can increase attention and concentration, while warm light contributes to a feeling of comfort and relaxation.

Furthermore, dynamic lighting enhances the user experience by creating a more interactive and vibrant environment, which positively impacts functional and emotional performance within interior spaces. Researchers indicate that this technology not only affects the mental and physical health of users but also plays a significant role in boosting productivity and improving the quality of life in interior environments, whether they are offices, educational institutions, or residential spaces.

#### **The Effects of Lighting on Humans in General**

Light has influenced human evolution. Over the course of development, humans have evolved an internal clock that, in the presence of natural light, is in sync with the earth's 24-hour light-dark rotation cycle. The process by which light is necessary for human functioning is revealed by research. Strongly enabling visual performance, light controls a wide range of physiological functions, including sleep and alertness, is crucial for mood and cognition, facilitates the synthesis of critical hormones like cortisol and melatonin, and is necessary for a healthy rest-activity rhythm<sup>3</sup>.

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<sup>1</sup> Veitch, J.A.; Fotios, S.A.; Houser, K.W. Judging the scientific quality of applied lighting judging the scientific quality of applied lighting research. *J. Illum. Eng. Soc.* 2019, 15, 97-114.

<sup>2</sup> Cajochen, C.; Münch, M.; Kobińska, S.; Kräuchi, K.; Steiner, R.; Oelhafen, P.; Orgül, S.; Wirz-Justice, A.

High sensitivity of human melatonin, alertness, thermoregulation, and heart rate to short wavelength light.

*J. Clin. Endocrinol. Metab.* 2005, 90, 1311-1316. [Cross Ref]

<sup>3</sup> Wurtman, R. J. (1975). The effects of light on the human body. *Scientific American*, 233, 68-77.

Different wavelengths of light also have an impact on biorhythms, respiration rates, blood pressure, pulse, and brain activity. Lighting plays a crucial role in our daily lives and must function optimally in all settings. Lighting therefore has a direct impact on all facets of human life. Tanner reiterated, "Light is the most important environmental input, after food and water, in controlling bodily functions" People have been spending more time indoors since the industrial revolution, and artificial illumination has demonstrated the ability to at least partially offset the processes that maintain emotional, mental, and physical equilibrium. We go into further detail about the established impacts of artificial light on human functioning in the sections that follow<sup>1</sup>.

When it comes to expressing emotions, lighting is crucial. Lighting can be used to make an architectural space more aesthetically pleasing or it can create an atmosphere in that space; both affect people's emotions. Additionally, light might have a direct impact on the user's wellbeing. Lighting settings that address this are created using parameters such as brightness, color, direction, contrast, and time. However, studies on the connection between lighting and mood/cognition have yielded inconsistent findings. The effects of color temperature and lighting levels on mood and cognitive performance tests, such as long-term recollection, free recall, and performance assessment between males and females, were examined in two investigations. A test to gauge each participant's mood was given following each experiment<sup>2</sup>. Human exposure to light causes physiological changes, which can have a direct and varied impact on mood and cognition. Furthermore, the impacts of lighting on people's moods and cognitive abilities have significant ramifications, including (a) enhanced performance on cognitively demanding activities in the workplace or classroom and (b) an overall improvement in well-being and quality of life. Strong visual perception and getting enough sleep may significantly affect cognitive functions like memory and focus. The sharpness of these cognitive capacities may also be influenced by mood. The kind and quantity of lighting can affect mood. For example, people with seasonal affective disorder (SAD) and other nonseasonal mood-related diseases like eating disorders and depression have found improvement with light therapy<sup>3</sup>.

The versatility and adaptability of smart lighting is one of its primary characteristics. To create various moods and atmospheres, users can change the lights' color and brightness. Smart lighting enables easy adjustment to fit personal preferences, whether it's a bright, lively setting for productivity or a warm, inviting atmosphere for a restful evening. Additionally, smart lighting makes a substantial contribution to sustainability and energy efficiency. Compared to conventional incandescent or fluorescent bulbs, smart bulbs use less energy thanks to the inclusion of LED technology. Scheduling lighting according to occupancy or the time of day

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<sup>1</sup> Dijk, D. J., & Cajochen, C. (1997). Melatonin and the circadian regulation of sleep initiation, consolidation, structure, and the sleep EEG. *Journal of Biological Rhythms*, 12, 627-635.

<sup>2</sup> Veitch, J. A., & McColl, S. L. (1994). Full-spectrum fluorescent lighting effects on people: A critical review. In J. A. Veitch (Ed.), *Full-spectrum lighting effects on performance, mood, and health* (IRC Internal Report No. 659, pp. 53-111). Ottawa, ON: National Research Council of Canada, Institute for Research in Construction.

<sup>3</sup> Spiegel, K., Tasali, E., Penev, P., & Van Cauter, E. (2004). Brief communication: Sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. *Annals of Internal Medicine* 141 846-850

further cuts down on wasteful energy use, which lowers power costs and lessens the impact on the environment<sup>1</sup>.

Another important component of smart lighting that improves efficiency and convenience is automation. When a room is inhabited, motion sensors can determine it and automatically turn on or off the lights. Users can also design custom automation scenarios, such progressively lowering the lights as nighttime draws near or mimicking the sunrise to wake up more naturally in the morning. Additionally, a unified and integrated ecosystem is produced by the frequent integration of smart lighting systems with other smart home appliances. To improve overall house automation, lights can be linked with security cameras, doorbell cameras, or smart thermostats. In addition to making daily tasks more efficient, this integration also increases security<sup>2</sup>.

Smart lighting is essential for establishing dynamic and adaptable settings in business areas. By adjusting lighting settings according to the time of day or particular tasks, offices can enhance worker productivity and well-being. By using customized lighting schemes to lead clients through various parts, retail enterprises can use smart lighting to improve the shopping experience. The potential of smart lighting is expected to grow even more as technology develops. Future smart lighting systems may incorporate innovations like Li-Fi (Light Fidelity), which uses light to transport data and provides faster and more secure communication<sup>3</sup>.

A paradigm shift in how we view and use illumination is represented by smart lighting. It is a key component of the larger ecosystem of smart homes and buildings because of its energy efficiency, automation, customisation, and integration with other smart devices, all of which contribute to a more sustainable and smarter future. One important component of using smart lighting in smart homes is customization. To accommodate various hobbies, moods, or times of day, residents can adjust the lights' color temperature and brightness. The versatility of smart lighting guarantees that the lighting is suitable for both producing a bright, energizing environment for concentrated work and a pleasant and inviting atmosphere for a leisurely evening. environment fits the unique requirements and tastes of the occupants. When designing and implementing smart lighting systems, energy efficiency is a critical factor. Incorporating energy-efficient LED lighting lowers power usage and helps save money over time. By enabling users to program lighting according to occupancy or the time of day, smart lighting goes one step further in reducing wasteful energy use and encouraging a more environmentally friendly method of lighting homes<sup>4</sup>.

### **sub Section 2: The relationship between light and color**

Man travels through space in real time, reacting either physically or subjectively to the interrelationships of color, light, and form as contemporaneous (rather than static) experiences. Through our simultaneous reactions to light, color relationships, the various sensual experiences we have while moving through the space, and the cues provided by the interaction

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<sup>1</sup> Huda, N.U., Ahmed, I., Adnan, M., Ali, M., Naeem, F. (2024). Experts and intelligent systems for smart homes' Transformation to Sustainable Smart Cities: A comprehensive review. *Expert Systems with Applications*, 238, 122380.

<sup>2</sup> - Raff, S., Rose, S., Huynh, T. (2024). Perceived creepiness in response to smart home assistants: A multi-method study. *International Journal of Information Management*, 74, 102720.

<sup>3</sup> Sobhani, A., Khorshidi, F., Fakhredanesh, M. (2023). DeePLS: Personalize Lighting in Smart Home by Human Detection, Recognition, and Tracking. *SN Computer Science*, 4(6), 773.

<sup>4</sup> Afroz, A., Khamari, S.S., Behera, R.K. (2024). Solar Powered Smart Home Automation and Smart Health Monitoring with IoT. *Lecture Notes in Networks and Systems*, 728 LNNS, 169-182.

of color and light with forms and visual elements that direct us, we see and experience interior environments in real time<sup>1</sup>.

### **1. color and light:**

The influences of light can cause an object's color to change. This element is crucial since it can employ color to transform any setting. The degree of color or the space can be drastically altered by the way light affects color. Depending on the time of day and the direction of the light, daylight can be either warm or cool. While cold light enhances cold colors and weakens warm hues, warm light emphasizes warm colors and changes chilly tones. The amount of light utilized to illuminate the place can also change the color's value. Reducing the illumination will neutralize the hue and darken the value of the color. However, high light levels can also cause colors to appear washed out or less satisfied<sup>2</sup>.

In order to manipulate the spatial effect, light was used. In order to regulate interior space, add drama and intrigue, assist us in our everyday duties, or set the atmosphere or scene for a variety of activities, light and color combine with form and spatial effect. We must study the ideas of color and light as essential components of the design process in order to comprehend the theories of color and light in the practice of interior design. When color and light are harmonious, they fulfill situational and functional needs in the space, evoke an emotional response in the user, and enhance sensory awareness. When color and light are inconsistent, individuals may completely reject space<sup>3</sup>.

All of the interior components' colors—materials, people, objects, and accessories—interact with the color of the light. We all react differently and subjectively when we enter and exit locations. The instantaneous sensory and physiological reactions to color, form, and light ambiances and effects occur in real-time, lived experiences; this is essentially a phenomenological position. Research has demonstrated that humans manipulate the color temperature of light to elicit emotional reactions to specific hues and lighting conditions<sup>4</sup>.

Depending on the time of day and the direction of the light, daylight can be either warm or cool. While cold light enhances cold colors and diminishes warm hues, warm light accentuates warm colors and modifies chilly tones. The intensity of the colors of a specific hue will increase if the light is tinted with that hue. The amount of light utilized to illuminate the place can also change the color's value. Reducing the illumination will neutralize the hue and darken the value of the color. However, bright lighting can also have the effect of making colors appear washed out or less saturated. Interior environment design now incorporates new dimensions of color, light, and spatial interactions thanks to modern technologies. Over the past ten years, the introduction of LED lights has altered how we live as well as how light and color are used in various interior design styles. LED lights can be programmed to change colour for a few minutes or over several hours. A lighting switch can be used to select the preferred colour temperature. Thanks to LEDs and colored light programming, we can now apply color to entire interior spaces by using spectral color selections and programming them to change color either

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<sup>1</sup> Poldma, T. (2009). Learning the Dynamic Processes of Color and Light in Interior Design. IDEC Portal, 34.

<sup>2</sup> Elnaggar, H. (2021). Illumination and Color in Interior Design of Living Room. In Illumination and Color in Interior Design of Living Room (p. 56). egypt.

<sup>3</sup> Poldma, T. (2009). Learning the Dynamic Processes of Color and Light in Interior Design. IDEC Portal, 34.

<sup>4</sup> Poldma, T. (2009). Learning the Dynamic Processes of Color and Light in Interior Design. IDEC Portal, 34.

instantly or gradually. Depending on the desired mood, color changes to light and light to color; this might vary based on an individual's or a group's emotional state<sup>1</sup>.

### **The experience of light as perceptual engagement**

A fundamental premise is that people are interested in how architectural form manifests as a visual sensation, thanks to the dynamics of human perception and a view of architecture as a form arising from perceptual activities. According to Lam, the experiential processes of perceiving architectural form and lighting are not passive but rather integral to our activities, our sense of place, our orientation, and our history of habitation. These processes interact with our actions, our perceptions, and the efficiency of our perceptual processes. In his book "Experiencing Architecture," Rasmussen argues that these experiential viewpoints are crucial to architectural form and lighting design; in Nöe's "Action in Perception," they are viewed from a philosophical standpoint. Nöe explores the implications of how, for example, light and environmental form seem if we interpret perception as something we do rather than something that occurs to us, while Rasmussen offers a collection of form factors as a proposal for an experimental approach to building<sup>2</sup>.

The design considerations that arise when designing for participatory experiences are further presented by Karin Søndergaard in her PhD thesis. This perspective incorporates the social and relational aspects of perceptual engagement as framing agencies for the unique experience of place, environment, and event. Please refer to Cuttle, Mathiasen, Madsen, and Tregenza for a broader overview of daylighting design and its integration with artificial illumination<sup>3</sup>.

The Observational Instrument's objective is purposefully spatial in that observers walk and shift locations while observing, and a significant portion of the analytical tasks involves the real architectural forms and the relationships with other residents. An active performance of observational activities is the analysis and consideration of illumination dynamics. As part of the analytical context, the circumstance around the observational instrument includes the perception and experience of light and visual adaptation. Rather than using light measurements, the investigation of the light in the room is predicated on how light is perceived and experienced as a relationship experience<sup>4</sup>.

Additionally, emphasis is placed on how lighting formation experiences can be interpreted as spatial factors. In order to study the influx of daylight and explore the possibility of integrating it with artificial lighting dynamics, the Observational Instrument creates an architectural scenario and a full-scale installation in any area of interest. Through perceptual training and perceptual reasoning, the instrument allows for a scenario in which perceptual processes are actively integrated into the event, while compensating for illumination dynamics occurrences<sup>5</sup>.

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<sup>1</sup> Wafaa Abd Elbary Eldininy (2024), The effect of lighting in color in the interior space of the residential unit, *Journal of Engineering Research*, 11

<sup>2</sup> Nöe A. *Action in Perception*. Cambridge, Massachusetts: MIT Press; 2006

<sup>3</sup> Søndergaard K. *Participation as media: A compositional system for staging participation with reflective scenography*. [thesis]. Caiia, Planetary Collegium, Plymouth: University of Plymouth; 2010

<sup>4</sup> Petersen K, Søndergaard K. Light as experiential material. In: Matusiak BS, Anter KF, editors. *Nordic Light and Colour*. Trondheim: NTNU, The Faculty of Architecture and Fine Arts; 2013. p. 47-67

<sup>5</sup> Petersen K, Søndergaard K. Material evidence as staged experientiality. In: Beim A, Mette RT, editors. *The Role of Material Evidence in Architectural Research*. Copenhagen: Kunstakademiet's Arkitektiskoles Forlag; 2011. p. 80-91

### Study methodology and procedures

- **Methodology:**

This study employs a descriptive-analytical approach, describing the characteristics of dynamic smart lighting and its role in contemporary interior spaces, and analyzing its impact on users' mood and functional efficiency. A comparative approach will also be used between spaces equipped with smart lighting systems and traditional spaces to identify differences in user experience.

- **Study Tools:**

- **Field Observations:** To monitor the use of dynamic lighting in different interior spaces and observe user responses.

- **Data Collection Sources:**

- **Primary Sources:** These include questionnaires, interviews, and field observations.
- **Secondary Sources:** These include previous studies, scholarly articles, books specializing in lighting and interior design, and scientific journals on smart dynamic lighting.

- **Study Sample:**

The study sample will consist of: a group of users in contemporary residential, educational, and administrative spaces (their number will be determined based on the study's scope), and interior designers and architects involved in the design of these spaces. The sample will be selected using stratified random sampling to ensure representation of all types of contemporary interior spaces.

- **Analysis Methods:**

**Descriptive Analysis:** To provide quantitative and qualitative data on the impact of smart lighting on mood and function.

**Statistical Analysis:** To test hypotheses using statistical software such as SPSS, including analysis of variance, correlation, and regression, to determine the relationship between lighting characteristics and their impact on users.

- **Study limits:**

- **Spatial limits:** The study is limited to contemporary interior spaces in selected cities (such as residential, educational, and administrative spaces).
- **Time limits:** The study focuses on the use of dynamic smart lighting during the current study period and for a specific duration.

### Study results

1. Dynamic smart lighting significantly contributes to improving users' moods within interior spaces.
2. Changes in light intensity and color temperature directly affect users' feelings of comfort and relaxation or activity and focus.
3. Spaces equipped with dynamic smart lighting have shown increased efficiency in performing various activities compared to traditional spaces.
4. Dynamic lighting reduces eye strain and improves users' visual comfort and overall well-being.
5. Controlling dynamic lighting enhances the aesthetic aspects of interior spaces and effectively highlights design elements.

6. The ability of smart lighting to adapt to the time and type of activity contributes to improving the user's daily experience.
7. There is a clear gap between the technical capabilities of smart lighting and its actual implementation by some designers.
8. The study's findings confirm the necessity of systematically integrating dynamic smart lighting into interior design to achieve a balance between mood, function, and aesthetics.

#### **Study recommendations**

1. Systematically employing smart dynamic lighting in interior design to achieve a balance between aesthetic and functional purposes.
2. Considering light intensity, color temperature, and time-related changes to suit the type of activity and time of day within the spaces.
3. Integrating smart lighting to enhance the mood and psychological well-being of users.
4. Utilizing dynamic lighting in educational and administrative spaces to increase focus and productivity.
5. Training interior designers and engineers on the latest smart dynamic lighting technologies and their practical application methods.
6. Developing clear design standards to fully leverage the technical potential of smart lighting in residential and contemporary spaces.
7. Integrating smart lighting control systems with sensors to automatically adjust lighting based on movement, time, or activity conditions.
8. Promoting applied and research studies on the impact of dynamic lighting on users' mood and functional performance.
9. Focusing on designing environmentally friendly and energy-efficient smart lighting without compromising the quality of the user experience.
10. Regularly evaluating the role of smart dynamic lighting to ensure continuous improvement in the functional and aesthetic performance of targeted interior spaces.

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