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How Lighting Shapes Cognitive Performance and Mood

Janhvi Priya Singh

Under the Supervision of

Dr.Meeta Tandon

Ar. Shriyak Singh

Master of Architecture

(Interior Design)

FACULTY OF ARCHITECTURE& PLANNING

Dr. A.P.J. ABDUL KALAM TECHNICAL UNIVERSITY
LUCKNOW

1 CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Lighting is a fundamental aspect of architectural design that significantly influences human cognition and emotional well-being. The interplay between light exposure and cognitive performance has garnered extensive research attention, revealing that both the intensity and color temperature of light can affect alertness, mood, and overall productivity. Studies indicate that higher levels of illumination can enhance cognitive function by stimulating specific brain regions, particularly the hypothalamus, which plays a critical role in regulating circadian rhythms and emotional responses (Campbell et al., 2023). Moreover, the quality of light—characterized by its color temperature—also impacts cognitive tasks. For instance, warm-white lighting is often associated with improved cognitive performance compared to cooler temperatures, which can lead to increased alertness and faster reaction times in attention-related tasks (Chellappa et al., 2021). Research has shown that environments illuminated with cooler light (around 6500 K) can enhance focus and reduce feelings of fatigue, making them more conducive to tasks requiring sustained attention (Chellappa et al., 2021). Conversely, inadequate, or poorly designed lighting can contribute to decreased mood and cognitive deficits, highlighting the importance of thoughtful lighting design in both residential and commercial spaces. The implications of these findings extend beyond mere aesthetics; they underscore the necessity for architects and designers to consider how lighting affects occupant well-being and productivity. As workplaces evolve to prioritize employee health and performance, understanding the effects of lighting on cognitive processes becomes increasingly relevant.

1.1.1 What is Cognitive Ability?

Cognitive ability encompasses the mental skills that enable us to think, learn, reason, and address challenges. It represents the brain's method of interpreting information and making choices, which are vital cognitive skills for manoeuvring through our environment. Cognitive ability is frequently viewed as equivalent to intelligence, but it includes a wider spectrum of mental skills and processes.

Component	Description
Attention	The ability to focus on specific tasks or stimuli.
Memory	The capacity to store and recall information.
Language Skills	The ability to understand and apply language.
Problem-Solving	The ability to analyse situations and implement solutions.
Visual-Spatial Skills	The ability to interpret visual information.
Executive Function	Higher-order mental processes that regulate behaviour.

Cognition refers to the "mental activity or process of gaining knowledge and understanding through thought, experience, and sensory perception." It includes all elements of intellectual functions and processes like: perception, attention, thought, imagination, intelligence, knowledge formation, memory and working memory, judgment and assessment, reasoning, and calculation, problem-solving and decision-making, as well as comprehension and production of language. Cognitive processes utilize existing knowledge to uncover new insights.

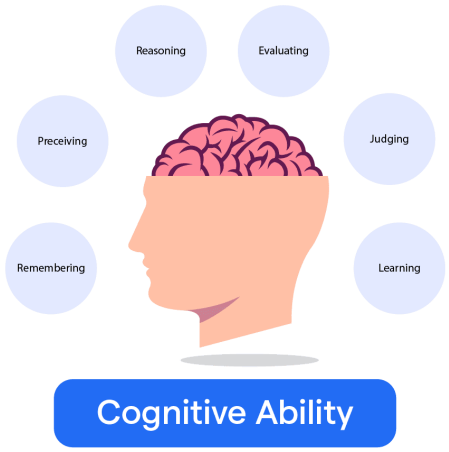


Figure 1:BotPenguin. (2024, November 20). Cognitive Ability: What is it and Its Types./Components of Cognitive Ability

1.1.2 Cognition Skill

Cognitive skills refer to the abilities of the mind. Examples of cognitive skills include literacy, self-reflection, logical reasoning, abstract thinking, critical thinking, introspection, and mental arithmetic. These skills differ in terms of processing complexity, ranging from basic functions like perception and various memory activities to more advanced processes such as decision making, problem-solving, and metacognition.

1.2 Background

The interplay between lighting and human cognition is a critical area of study within architectural design, psychology, and environmental health. Research has consistently demonstrated that lighting conditions can significantly influence cognitive performance, emotional states, and overall well-being. This relationship is particularly relevant in contemporary workspaces, where optimal lighting design can enhance productivity and employee satisfaction. Lighting affects cognitive performance through various mechanisms, primarily by influencing alertness and mood. Bright, well-distributed light has been shown to improve attention and task performance, while inadequate lighting can lead to fatigue and decreased productivity (Chellappa et al., 2021). Specifically, studies indicate that exposure to blue-enriched white light can enhance cognitive function by increasing alertness and reducing sleepiness, particularly during periods typically associated with decreased energy levels, such as the post-lunch dip (Figueiro& Rea, 2012). The ability of light to regulate circadian rhythms further underscores its importance; appropriate lighting can promote better sleep quality and overall mental health, thereby influencing cognitive capabilities during waking hours (Chellappa et al., 2021).

1.2.1 Circadian Rhythms

Melatonin secretion by the pineal gland of the brain plays a pivotal role in the control of circadian rhythms.

- Circadian rhythms are the body’s physiological responses to the 24 hour day-night cycle
- Circadian rhythms are driven by an internal (endogenous) circadian clock, although they can be modulated by external factors
- Melatonin is the hormone responsible for synchronising circadian rhythms and regulates the body's sleep schedule
- Melatonin secretion is suppressed by bright light (principally blue wavelengths) and hence levels increase during the night
- Over a prolonged period, melatonin secretion becomes entrained to anticipate the onset of darkness and the approach of day
- Melatonin functions to promote activity in nocturnal animals and conversely promotes sleep in diurnal animals (like humans)

- During sleep, necessary physiological changes occur in body temperature, brain wave activity and hormonal production
- Melatonin levels naturally decrease with age, leading to changes in sleeping patterns in the elderly.

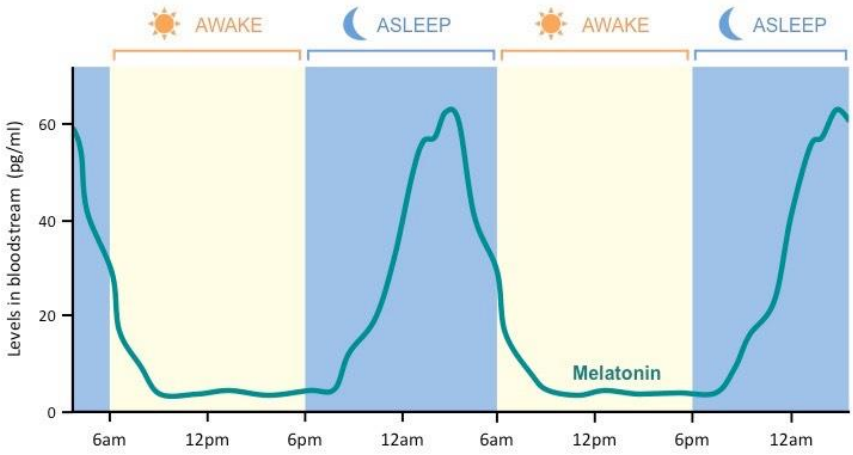


Figure 2: (Melatonin | BioNinja, n.d.)/Circadian Rhythm & Melatonin Cycle

In addition to cognitive performance, lighting plays a significant role in shaping mood. Research suggests that environments with adequate natural light or appropriately designed artificial lighting contribute to positive emotional states. For instance, studies have shown that individuals exposed to warmer color temperatures often report higher levels of comfort and satisfaction compared to those in cooler or dimmer environments (Kocaoğlu et al., 2020). This phenomenon is critical in workplace settings where employee morale directly impacts productivity and organizational success. Furthermore, the ability for individuals to control their lighting environment—such as adjusting brightness or color temperature—has been linked to improved mood and reduced stress levels (Veitch, 2012).

The implications of these findings extend beyond individual well-being; they highlight the necessity for architects and designers to consider the psychological effects of lighting in their work. As organizations increasingly prioritize employee health and productivity, understanding how different lighting conditions affect cognitive processes becomes essential.

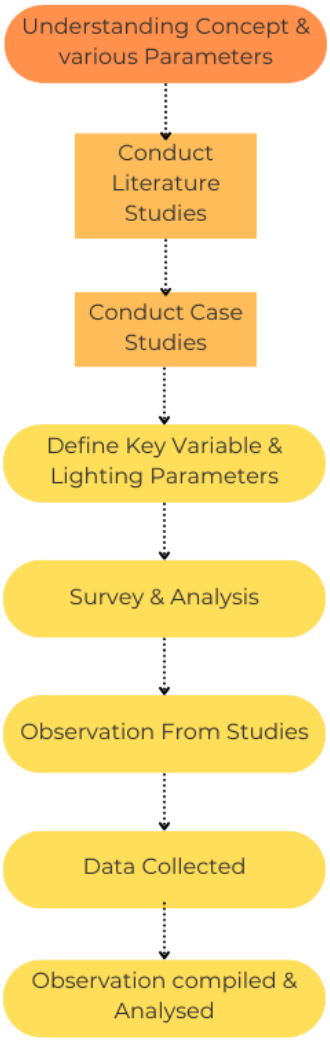
1.3 Aim

The aim is to explore how various lighting conditions influence cognitive performance and mood.

1.4 Objective

- This study aims to investigate the influence of various lighting conditions, such as brightness and colour, on cognitive tasks such as memory and focus.
- It will also analyse the effects of lighting on mood, stress, and emotional well-being.
- The study seeks to examine the relationship between lighting, circadian rhythms, and mental health, and to find methods to enhance lighting for improved performance and mood in different environments.

1.5 Methodology



1.6 Scope

- The study will explore how different types of lighting (natural and artificial) affect cognitive performance and mood.
- The research will include various environments such as offices, schools, and homes to understand how lighting impacts people in different contexts.
- The dissertation will evaluate how lighting influences psychological factors like mood, stress levels, and overall well-being.
- The study will examine how lighting affects biological processes, such as circadian rhythms, which in turn influence cognitive function.
- The research aims to create design guidelines for architects to improve lighting in built environments for better mental health and productivity.

1.7 Limitation

- Emotional reactions to lighting are subjective and may vary greatly among individuals, limiting generalizability.
- The study might focus on short-term effects of lighting, while long-term impacts on cognitive and emotional health could differ.
- Other environmental factors, such as noise, temperature, and personal preferences, may influence cognitive performance and mood, complicating the isolation of lighting's effects.
- Assessing mood often relies on self-reported data, which can be biased or influenced by current emotional states.

2 CHAPTER 2: LITERATURE REVIEW

The influence of lighting on mood and cognitive performance is increasingly recognized within psychological and environmental research. Artificial and natural light both play significant roles in shaping human emotional and cognitive responses by interacting with visual and non-visual pathways. Research demonstrates that different lighting variables—such as illuminance, color temperature, and the timing of light exposure—affect cognitive performance and mood, with evidence of varying impacts across age and gender groups. This review synthesizes findings on these relationships to outline the significance of lighting in environments where cognitive performance and mood are critical, such as workplaces and educational settings.

2.1 Lighting Characteristics and Their Effects on Cognitive Performance and Mood

2.1.1 Illuminance and Color Temperature

Illuminance, the measure of light intensity, and correlated color temperature (CCT), which ranges from warm to cool lighting, have distinct impacts on cognitive function and mood. Bright lighting has been associated with enhanced alertness and working memory. For instance, research by Huiberts, Smolders, and De Kort (2015) found that exposure to bright light improved working memory performance, suggesting that high illuminance is particularly beneficial for tasks requiring sustained attention (Huiberts et al., 2015) research has explored the effects of CCT on mood and cognitive performance. Cooler light, typically around 4000K, has been shown to boost cognitive performance and mood stability in both younger and older adults. For example, Knez and Kers (2000) identified that younger adults perform better under cool light conditions, with a similar mood-stabilizing effect observed in older adults (Knez &Kers, 2000) that cool light may mitigate the decline in cognitive function associated with age, supporting its use in settings where cognitive performance is a priority, such as in offices or schools.

2.1.2 Natural Light Vs. Artificial Light

The impact of natural light on mood and cognitive performance has been widely studied. Natural light exposure, particularly in the morning, helps regulate circadian rhythms, which influence alertness and mood. A study by Boubekri and Wang (2012) highlighted the role of daylight in mediating mood and enhancing cognitive performance in workplace settings, linking natural light exposure to lower levels of stress and higher levels of cognitive function (Boubekri & Wang, 2012), LED lighting designed to mimic natural light has shown promise in improving mood and reducing fatigue, as demonstrated in a study by Curcio et al. (2016). This study found that LED lighting positively influenced sleep quality and daytime alertness, particularly in the absence of sufficient natural light (Curcio et al., 2016). These artificial lighting, when carefully designed to simulate natural light, can be a valuable tool for promoting mental well-being and cognitive efficiency in indoor environments.

2.1.3 Physiological Mechanisms: Melatonin Suppression and Alertness

One mechanism by which light affects mood and cognition is through melatonin suppression. Melatonin, a hormone regulating sleep-wake cycles, is suppressed by light exposure, particularly blue-enriched light. Cajochen et al. (2019) reported that exposure to daylight-mimicking LED light increased alertness and cognitive performance by modulating melatonin levels, thus aligning wakefulness with the timing of exposure (Cajochen et al., 2019). This physiological path the importance of exposure timing and light color in designing lighting solutions that promote daytime alertness and reduce nighttime sleep disturbances.

2.1.4 Age and Gender Differences

Research indicates that age and gender modulate the effects of lighting on mood and cognitive performance. Younger adults typically show improved performance under high illuminance and cool lighting, while older adults may experience mood stabilization in similar conditions. For instance, Knez (2001) found that women, particularly younger ones, showed more mood improvement under cool light compared to men, suggesting a gender-specific interaction between lighting and mood. Similarly, the study by Knez and Kers (2000) specific preferences and responses to lighting, showing that younger adults retain positive mood better under cool lighting, while older adults respond similarly but show less cognitive improvement compared to their younger counterparts (Knez &Kers, 2000). These findings indicate that personalized lighting in age and gender, could maximize cognitive and emotional benefits, especially in multi-age and diverse environments like offices and educational facilities.

2.2 Applications and Implications

The cumulative findings on lighting's effects suggest practical applications in architectural and interior lighting design. In workplaces, settings with higher illuminance and cool lighting can support cognitive performance and mood stability, potentially increasing productivity. In educational environments, blue-enriched lighting can enhance alertness and cognitive flexibility in students, as demonstrated by Keis et al. (2014), who observed improved cognitive performance in students exposed to blue-enriched classroom lighting (Keis et al., 2014).

Furthermore, for individuals working night shifts or those seasonal affective disorder (SAD), strategically timed exposure to bright or blue-enriched light can improve mood and maintain alertness by aligning their circadian rhythms with work demands. Implementing dynamic lighting systems that adjust color temperature and brightness throughout the day may also optimize physiological alignment and cognitive functioning across different populations and environments.

T.1. Table summarizing various lighting standards and their effects on cognitive performance and mood.

Lighting Parameter	Standard/Recommendation	Effect on Cognitive Performance	Effect on Mood	Source
Illuminance (300-500 lx)	Recommended for general office lighting	Improves cognitive performance, specifically on tasks requiring focus and attention.	Maintains neutral to positive mood; prevents fatigue.	Aryani et al.
High Illuminance (1000-1500 lx)	Recommended for high-focus work settings	Boosts alertness and cognitive speed on complex tasks.	Enhances alertness but may cause eye strain over long exposure.	Knez &Kers
Cool White Lighting (4000 K)	Suitable for cognitive-demanding environments (e.g., workplaces)	Enhances problem-solving performance and long-term memory.	Preserves positive mood in cooler environments.	Roslyakova et al.
Warm White Lighting (3000 K)	Preferred for relaxation and less demanding cognitive tasks	Supports memory retention and general comfort in relaxed settings.	Induces a calming effect, reducing negative emotions.	Shahidi et al.
Dynamic Lighting (variable CCT)	Varies based on time of day (e.g., 4000 K in the morning, 3000 K in the evening)	Maintains sustained alertness and performance throughout the day.	Reduces negative mood during shifts and jetlag.	Zhu et al.
Daylight Exposure (Natural Light)	Where possible, integrate natural lighting or mimic daylight spectrum	Boosts cognitive flexibility and creativity in tasks.	Increases positive mood and reduces stress levels.	Boubekri et al.
Blue-enriched Light (6000 K and above)	Often used in morning hours for high energy environments	Enhances reaction time and cognitive performance in the morning.	Improves morning alertness, may induce	Cajochen et al.

Lighting Parameter	Standard/Recommendation	Effect on Cognitive Performance	Effect on Mood	Source
			anxiety in sensitive individuals.	
Variable Lighting for Specific Tasks	Task lighting at 500-750 lx for focused areas (e.g., reading desks)	Enhances performance in specific tasks by providing targeted lighting.	Minimizes visual discomfort, supporting sustained mood.	Veitch et al.
Soft Ambient Lighting (below 300 lx)	Suitable for relaxation areas (e.g., break rooms)	Reduces cognitive strain during breaks, facilitating better focus post-break.	Calming effect, reduces stress.	Hou et al.

T.2. Table synthesizes Standards creating an environment where lighting enhances cognitive performance and mood.

Lighting Strategy	Optimal Settings	Effect on Cognitive Performance	Effect on Mood	Application
High Illuminance (500-1000 lx)	500-1000 lx, especially in workstations	Enhances focus, improves attention to detail, and boosts accuracy.	Supports mood stability, reduces fatigue, and maintains motivation.	Workplaces, classrooms
Dynamic Lighting (Adjustable CCT)	4000 K in morning, 3000 K in evening	Helps sustain alertness, prevents cognitive fatigue over long hours.	Reduces mood swings, aligns with circadian rhythm for better well-being.	Offices, healthcare, flexible work environments
Task Lighting (500-750 lx)	Targeted lighting at desks, reading areas	Boosts performance on tasks requiring precision and focus.	Creates comfort and reduces eye strain, supporting mood regulation.	Libraries, offices, study spaces
Cool White Light (4000 K)	4000 K for high cognitive demand tasks	Enhances problem-solving, promotes quicker decision-making.	Maintains alertness and positive mood; suitable for daytime productivity.	Offices, control rooms, active learning areas
Warm White Light (3000 K)	3000 K for low-stress, relaxation areas	Supports mild cognitive tasks without overstimulation.	Induces relaxation, alleviates stress, and promotes positive emotions.	Lounges, break rooms, social spaces
Natural Daylight or Daylight Mimicry	Full-spectrum or near-natural light, wherever possible	Increases cognitive flexibility and adaptability.	Boosts mood, reduces stress, and enhances general well-being.	Classrooms, offices with windows
Blue-enriched Morning Light (5000-6000 K)	High CCT in early hours	Improves cognitive performance and reaction time in the morning.	Raises morning alertness, may cause over-arousal if overused.	Early work shifts, morning activity areas
Soft Ambient Lighting (200-300 lx)	Diffused, low-intensity lighting for rest areas	Provides mental break, supporting subsequent focus and clarity.	Encourages calmness, reduces anxiety and stress.	Lounges, break areas, waiting rooms
Glare Reduction	Use of diffused lighting, anti-glare surfaces	Minimizes distraction, improving sustained focus and comfort.	Reduces discomfort and irritation, supporting consistent mood.	Computer labs, workstations
Personalized Lighting Controls	Adjustable luminance and color temperature	Allows optimization for individual cognitive tasks.	Increases user satisfaction, enhances comfort, and reduces stress.	Open-plan offices, individual desks

3 CHAPTER 3: CASE STUDY

3.1 The Edge, Amsterdam, Netherland

Architects: PLP Architecture
Area: 40000 m²
Year: 2015
City: Amsterdam
Country: The Netherlands

Figure 3: Source:(Gallery of the Edge / PLP Architecture - 23, n.d.)/The Edge, Amsterdam

The Edge in Amsterdam, which serves as Deloitte's headquarters, is frequently recognized as one of the most environmentally friendly and "smart" facilities globally. Crafted by PLP Architecture, the structure demonstrates how cutting-edge lighting solutions can boost cognitive abilities and enhance mood, fostering a productive and health-oriented workspace. The lighting techniques employed at The Edge and their effects on employee wellness and productivity.

3.1.1 Lighting Design Objectives

The main objectives of the lighting design at The Edge were to establish a workspace that promotes health, enhances productivity, and ensures employee contentment. Deloitte collaborated with Philips to create a customizable lighting system that adjusts to the needs and preferences of each individual. The building's lighting setup was designed not just for visibility but also to align with circadian lighting concepts, thereby enhancing cognitive function and mood.

3.1.2 Dynamic and Customized Lighting Solutions

The Edge features an advanced LED lighting system linked with Internet of Things (IoT) sensors to adapt lighting based on various criteria, including time of day, occupancy levels, and personal preferences. Employees can modify the lighting above their workstations using a smartphone application, allowing them to change both brightness and color temperature according to their current tasks or feelings.

The lighting system follows circadian lighting principles, varying color temperature and intensity throughout the day. For example, in the morning, the lights are set to cooler, blue-enriched tones (approximately 5000-6000K) to encourage alertness and mental clarity. As the day goes on, the lighting transitions to warmer hues (around 3000K) to promote relaxation, aiding in the smooth transition from work to personal time.

3.1.3 Natural Light Optimization and Circadian Rhythm Support

The Edge's design optimizes the use of natural light extensively. The building includes a sizable central atrium, which enables natural light to penetrate deep into the space, thereby decreasing the dependence on artificial lighting during day hours. This not only conserves energy but also ensures that employees benefit from regular exposure to natural light, which studies have shown is crucial for maintaining circadian rhythms (Boubekri et al., 2014). Exposure to natural light has been proven to boost mood and cognitive performance by enhancing alertness during the day and improving sleep quality at night.

For work areas located further from the atrium, the LED lighting system is configured to imitate natural daylight, adjusting dynamically to maintain a stable and consistent lighting atmosphere. Research indicates that regular exposure to lighting that simulates daylight positively influences mental health, cognitive ability, and overall job satisfaction within office settings (Veitch et al., 2017).

3.1.4 Effects on Cognitive Performance and Mood

The lighting design of The Edge plays a vital role in enhancing cognitive performance and mood by increasing alertness, minimizing eye strain, and creating a flexible and comfortable work environment. Cool, blue-enriched lighting in the morning supports essential cognitive tasks such as memory retention and concentration, which are vital for intricate work activities. Research has revealed that exposure to bright, cool lighting in the morning enhances working memory and speeds up information processing, which aligns with the experiences reported by individuals working at The Edge. (Huiberts et al., 2015)

Feedback from employees has indicated that the ability to customize lighting significantly boosts both cognitive performance and mood. By enabling employees to adjust lighting settings according to their specific tasks or preferences, The Edge cultivates a feeling of autonomy and control, which correlate with greater workplace satisfaction and lower stress levels. (Veitch et al., 2017)

3.1.5 IoT and Data-Driven Lighting Optimization

The IoT-enabled lighting system in the building gathers real-time information on light usage, occupancy, and environmental factors, allowing for ongoing enhancement of the lighting environment. This information empowers facility managers to analyze light usage trends, modify settings for energy conservation, and ensure that employees have optimal lighting conditions at all times. Such data-informed changes help avoid excessive exposure to bright light, mitigating eye strain and fatigue that can negatively affect cognitive function and mood.

Combining lighting data with other building systems, such as HVAC, further helps establish a stable and comfortable setting, which is essential for high productivity and mental health.

The Edge illustrates how smart lighting can influence cognitive abilities and emotional state, resulting in a work setting that enhances productivity and well-being. By merging customized, circadian-aligned lighting with natural light and IoT technology, the building achieves a harmony between top performance and user comfort. The lighting design at The Edge not only improves individual cognitive abilities and emotional well-being but also acts as an example for sustainable and human-centered building design, demonstrating how lighting can cultivate a positive and efficient work atmosphere.

3.2 The Salk Institute for Biological Studies, La Jolla, California

Architects: Louis Kahn
Type: Institutional
Area: 27-acre (11 ha)
Year: 1965
City: San Diego
Country: United States

Figure 4: Source:(Fiederer, 2020)/The Salk Institute

The Salk Institute for Biological Studies, designed by renowned architect Louis Kahn, is widely celebrated for its architectural brilliance and thoughtful integration of natural light. Located in La Jolla, California, the Salk Institute's design uniquely incorporates lighting elements that support researchers' cognitive performance and mood, contributing to a workspace that fosters innovation, focus, and mental well-being.

3.2.1 Lighting Design Objectives

Louis Kahn's vision for the Salk Institute was to create a workspace that harnesses natural light to inspire contemplation and focus, aligning with the needs of the scientists working there. Natural light was prioritized, not only to create a sustainable building but also to craft an environment that supports cognitive function and emotional resilience. Kahn designed the Institute to emphasize an open, calming space that promotes thoughtful inquiry and intense focus.

3.2.2 Architectural Design for Optimal Daylight

The Salk Institute's layout features two parallel laboratory buildings, separated by an iconic central courtyard, often called the "River of Light." This open space directs natural light into the laboratories and adjacent spaces, creating a visually striking environment while reducing reliance on artificial lighting.

Kahn's choice of large windows and high ceilings in the laboratories maximizes the use of natural light, with the labs oriented to receive indirect sunlight. This prevents glare and maintains visual comfort, supporting sustained attention and reducing eye strain. Research shows that environments rich in natural light can improve alertness, mood, and cognitive flexibility, especially when exposure aligns with the circadian rhythm. (Boubekri et al., 2014) The ample daylight within the Salk Institute aligns with these principles, providing researchers with light exposure that supports both cognitive performance and emotional well-being.

3.2.3 The Role of Courtyard and Reflective Surfaces

The Salk Institute's courtyard features travertine stone, which reflects light into the building's interiors. This reflective surface helps evenly distribute sunlight, creating a balanced lighting environment that enhances mood and visual comfort. Reflective surfaces like travertine minimize harsh contrasts and create a soft, diffused lighting effect, known to reduce stress and improve mood by creating a visually harmonious space (Veitch et al., 2017). The courtyard's design also encourages movement and breaks from the indoor labs, providing researchers with both direct sunlight and an open, tranquil outdoor space for rejuvenation, further enhancing productivity and mental health.

3.2.4 Psychological Impacts of Natural Light

The exposure to natural light within the Salk Institute has profound effects on cognitive performance and mood. Sunlight, especially in the early morning and afternoon hours, stimulates serotonin production and regulates the body's circadian rhythm. This is essential for maintaining high alertness levels during the day and supporting restorative sleep at night (Cajochen et al., 2019). Researchers at the Salk Institute benefit from daylight exposure that aligns with their natural biological rhythms, resulting in

heightened focus, creativity, and mental clarity. The lighting setup fosters a work environment conducive to deep, sustained concentration on research tasks.

The integration of natural light has also been shown to reduce stress and anxiety, enhancing mood and fostering a positive work atmosphere. By aligning with circadian rhythms, daylight supports emotional regulation, helping researchers manage the challenges of high-stakes scientific work.

3.2.5 Lighting as a Catalyst for Innovation and Focus

One of the unique aspects of the Salk Institute's lighting design is how it promotes both collective and individual focus through lighting zoning. The labs, which house intense scientific activity, receive ample diffused light, which supports concentration and reduces cognitive load. By minimizing shadows and glare, Kahn's design allows researchers to work comfortably for extended periods, which links bright, natural light to improvements in working memory and problem-solving skills.

The Salk Institute's design also promotes moments of respite by contrasting its well-lit labs with dimmer, more intimate spaces for relaxation. This separation of lighting levels allows researchers to shift between high-focus environments and relaxation zones, aiding cognitive recovery and preventing burnout.

3.3 India Habitat Centre (Bharat Paryavas Kendra)

Architects: Joseph Allen Stein
Type: Multipurpose Building
Area: 38850 sq.m.
Year: 1993
City: Lodhi Road, New Delhi
Country: India

Figure 5: Source:(Wikipedia contributors, 2024)/India Habitat Centre

The India Habitat Centre (IHC) in Delhi, designed by architect Joseph Allen Stein, exemplifies an environment where thoughtful integration of natural and artificial lighting fosters cognitive performance, mood, and well-being. Built to provide a collaborative space for cultural and intellectual engagement, IHC emphasizes energy efficiency, sustainability, and user comfort.

3.3.1 Design Objectives for Lighting at India Habitat Centre

The India Habitat Centre was designed to create a stimulating environment for its diverse users, including artists, researchers, professionals, and students. Stein's vision for IHC combined passive lighting design with greenery and open spaces, allowing natural light to penetrate most areas. The design aimed to create an inclusive and engaging environment where lighting would play a crucial role in shaping user experience, mood, and productivity.

3.3.2 Integration of Natural Light for Cognitive Engagement and Mood

One of the defining features of IHC is its abundant use of natural light, achieved through expansive glass facades, atriums, and courtyards. The layout allows natural light to flow into the building from multiple angles, minimizing the need for artificial lighting during the day.

By integrating natural light throughout common areas and workspaces, IHC promotes a positive mood, reduces eye strain, and increases alertness, essential factors for cognitive performance. This lighting design fosters an environment that keeps occupants engaged, particularly important for professionals attending conferences and students utilizing study areas within IHC.

3.3.3 The Role of Reflective and Shaded Surfaces

To maximize the benefits of natural light while preventing glare, the India Habitat Centre uses reflective surfaces and shading structures throughout the campus. Reflective surfaces such as light-colored stone and water features diffuse sunlight, creating a soft, balanced light quality that reduces harsh contrasts. Shaded walkways and courtyards also offer pockets of refuge from direct sunlight, allowing visitors to experience natural light without discomfort or overheating, essential for maintaining a relaxed and focused state of mind.

3.3.4 Adaptive Artificial Lighting for Different Spaces

While natural lighting is abundant, the India Habitat Centre also employs adaptive artificial lighting to meet the specific needs of different spaces. In galleries and conference rooms, where lighting needs vary with time and activity, LED systems are used to provide adjustable brightness and color temperature. For example, conference rooms are equipped with adjustable lighting systems that allow occupants to control light levels based on presentation requirements, supporting cognitive focus during discussions and reducing glare on screens.

3.3.5 Effects on Cognitive Performance and Mood

The lighting design at the India Habitat Centre supports cognitive performance and mood by creating an adaptable environment that caters to the diverse needs of its users. Daylight provides a foundation for mental alertness and mood enhancement, as exposure to natural light has been shown to improve memory retention, attention, and general cognitive flexibility (Boubekri et al., 2014). This is particularly valuable in a multifunctional space like IHC, where users engage in a variety of activities, from studying to networking and attending cultural events.

Artificial lighting adjustments, especially the use of cooler, task-oriented lighting in reading areas and dynamic lighting in conference rooms, further support cognitive demands. Studies indicate that environments with appropriate task lighting see reduced mental fatigue and increased cognitive performance, as lighting directly influences the brain's ability to focus (Veitch et al., 2017). Visitors often report feeling more engaged and comfortable, attributing their positive experience to the lighting quality and how it subtly influences their mood and energy levels.

3.3.6 Sustainable Lighting Design and User Well-being

IHC's commitment to sustainability also positively affects user experience and well-being. The Centre uses energy-efficient LED systems and leverages passive lighting strategies to reduce energy consumption. Not only does this align with sustainable principles, but it also creates an environment that feels more natural and less industrial. Research shows that sustainable lighting practices contribute to a positive mood by creating a more harmonious and less overwhelming environment (Smolders et al., 2013). IHC's sustainable approach to lighting design thus enhances both environmental and mental well-being, making it a model for future public spaces.

3.4 TCS Sahyadri Park, Pune

Architects: RSP Design Consultants
Type: Office
Area: Approximately 2 million square feet
Year: 2009
City: Sahyadri Park, Pune
Country: India

Figure 6: Source:(Sahyadri Park 2 Campus,Pune - Project by Edifice., n.d.)/TCS Sahyadri Park

TCS Sahyadri Park in Pune, one of Tata Consultancy Services' largest IT parks, is a model of sustainable design and advanced lighting strategies that prioritize employee well-being and productivity. Located in the lush Sahyadri mountain range, this campus employs lighting systems that are both energy-efficient and psychologically beneficial.

3.4.1 Lighting Design Goals and Objectives

The primary objective of the lighting design at TCS Sahyadri Park is to create a workspace that supports cognitive performance, reduces stress, and enhances mood. Given the high-stakes nature of IT work, which often involves extended hours and mental focus, TCS aimed to design a lighting environment that aligns with natural circadian rhythms and reduces the risks of eye strain, fatigue, and mental burnout. The lighting infrastructure was also designed to be sustainable, reducing energy consumption while enhancing indoor environmental quality.

3.4.2 Natural Light Integration and Circadian Support

One of the core features of TCS Sahyadri Park's lighting strategy is its extensive use of natural light. Large glass facades and strategically placed windows allow abundant natural light into the workspace, reducing the dependency on artificial lighting during the day. Natural light exposure has been shown to align well with circadian rhythms, helping to regulate energy levels and maintain alertness throughout the day (Boubekri et al., 2014). In areas further from windows, TCS has installed LED lighting systems that mimic natural daylight, especially beneficial during monsoon season when natural light may be limited.

Daylight-mimicking LED lighting adjusts throughout the day to match the natural progression of sunlight, shifting from cooler tones in the morning to warmer tones in the evening. This lighting design reduces the risks of circadian disruption among employees, which can negatively impact sleep quality and mood. Exposure to light aligned with circadian rhythms positively influences cognitive performance by supporting alertness and reducing stress. (Cajochen et al., 2019) This alignment helps employees at TCS Sahyadri Park maintain high levels of concentration, especially during critical hours.

3.4.3 Adjustable and Task-Oriented Lighting

TCS Sahyadri Park incorporates task-oriented lighting systems in key work areas. These systems allow employees to adjust the lighting intensity and color temperature based on their specific tasks or preferences. For example, employees working on detailed coding or analysis tasks can opt for brighter, cooler lighting, which research has shown to improve focus and cognitive accuracy (Huiberts et al., 2015). This flexibility ensures that each employee can customize their lighting environment to match their personal needs, enhancing productivity and reducing visual fatigue.

Additionally, meeting rooms and collaborative spaces are equipped with adaptive lighting that can be dimmed for presentations or brightened for discussions. This adaptability not only enhances cognitive performance by reducing distractions but also creates a comfortable environment that fosters teamwork and innovation. Personalized lighting improves workplace satisfaction, helping employees feel more in control of their work environment and reducing stress. (Veitch et al., 2017)

3.4.4 Mood Enhancement through Warm Lighting

In areas designated for relaxation, such as lounges and dining areas, TCS Sahyadri Park employs warm lighting with lower color temperatures, around 3000K. Warm lighting is known to have a calming effect, which can help employees unwind during breaks and return to their work with renewed focus. According to Knez and Kers (2000), warm lighting is beneficial for reducing stress and promoting relaxation, especially in spaces where cognitive demands are low. The warm lighting in these spaces thus plays a role in mood enhancement, reducing overall stress levels among employees and promoting a positive work atmosphere.

3.4.5 Sustainable and Smart Lighting Systems

TCS Sahyadri Park's lighting system incorporates smart technologies, allowing automated adjustments based on occupancy, time of day, and available daylight. The building uses motion sensors to ensure that lights are only active in occupied spaces, saving energy and minimizing light pollution. This system is in line with TCS's commitment to sustainability, as it significantly reduces electricity consumption and supports the organization's larger environmental goals.

The building management system (BMS) gathers data on lighting usage patterns, optimizing the balance between artificial and natural lighting. By continuously monitoring and adjusting lighting needs, the BMS helps create an energy-efficient lighting environment that maintains optimal light levels for cognitive performance without causing overstimulation. Smart lighting systems support well-being by creating a stable, consistent lighting environment that minimizes disruptions. (Smolders et al., 2013)

3.4.6 Psychological and Cognitive Benefits for Employees

The lighting strategies employed at TCS Sahyadri Park contribute significantly to employee satisfaction, cognitive performance, and mood stability. By aligning lighting conditions with natural circadian rhythms and providing adaptive lighting options, the campus supports mental clarity, reduces fatigue, and enhances mood. Employees benefit from a lighting environment that minimizes eye strain, supports cognitive demands, and provides calming spaces for relaxation.

Feedback from TCS employees has indicated a high level of satisfaction with the lighting environment, noting improvements in focus, mood, and general comfort. Lighting appraisals are linked to workplace satisfaction and productivity. The smart lighting system not only fulfills the cognitive and emotional needs of employees but also creates an atmosphere that aligns with TCS's dedication to sustainable and employee-centered design. (Veitch et al., 2017)

T.3. Comparative table analyzing the lighting standards and approaches used in *The Edge* (Amsterdam), *The Salk Institute* (La Jolla, California), *India Habitat Centre* (Delhi), and *TCS Sahyadri Park* (Pune).

Building	Key Lighting Strategies	Standards/Technologies Used	Cognitive Performance Effects	Mood and Well-being Impacts
The Edge, Amsterdam	Personalized LED lighting system with IoT-based controls; daylight-mimicking LEDs; large glass facades for daylight	Circadian-aligned lighting; motion-sensor-controlled lighting; smart app for individual control	Enhances focus, accuracy, and mental alertness through cool, bright morning light; promotes adaptability with personalized settings	Mood stability through daylight-mimicking lighting; reduced stress via user control over lighting; supports well-being through daylight exposure
The Salk Institute, La Jolla	Passive lighting design maximizing natural light; use of reflective surfaces; open courtyards	Daylight-focused design with minimal artificial lighting; use of travertine for light reflection	Supports deep focus and long-term memory by providing natural light exposure; reduces cognitive fatigue with balanced lighting	Calm and tranquility in open spaces; reduced visual stress through soft, diffused lighting; fosters positive mood via natural connections
India Habitat Centre, Delhi	Abundant natural light through glass facades;	Passive lighting strategies; LED and task lighting for different	Promotes cognitive flexibility and visual	Boosts mood with warm lighting in social areas;

Building	Key Lighting Strategies	Standards/Technologies Used	Cognitive Performance Effects	Mood and Well-being Impacts
	task-oriented LED lighting in specific areas; adaptive lighting	needs; reflective materials for even light distribution	comfort, supporting focus; reduces eye strain through daylight and balanced ambient light	daylight supports alertness, well-being, and circadian rhythm alignment
TCS Sahyadri Park, Pune	Circadian-supporting daylight-mimicking LEDs; task-oriented adjustable lighting; large windows for natural light	LED lighting with color temperature adjustments; smart sensors for energy efficiency	Improves concentration and memory on tasks requiring precision; reduces cognitive load with adaptable light settings	Calming effects through warm lighting in lounges; reduced stress and improved mood through individual lighting control

3.5 Analysis

3.5.1 Lighting Approach:

Each building employs a unique approach to lighting that reflects its architectural philosophy and intended use. The Edge utilizes advanced smart technology to create a highly adaptable environment, while the Salk Institute emphasizes natural light as a key feature of its design.

3.5.2 Lighting Standards:

The buildings adhere to various sustainability standards, such as BREEAM for The Edge and LEED for TCS Sahyadri Park, showcasing their commitment to energy efficiency and occupant well-being.

3.5.3 Impact on Cognitive Performance:

All four buildings demonstrate that effective lighting strategies can enhance cognitive performance by supporting focus, creativity, and productivity through the use of natural light or adaptive artificial systems.

3.5.4 Impact on Mood:

Natural light significantly contributes to positive mood states across all buildings, with occupants reporting reduced stress levels and improved emotional well-being in environments designed with thoughtful lighting considerations.

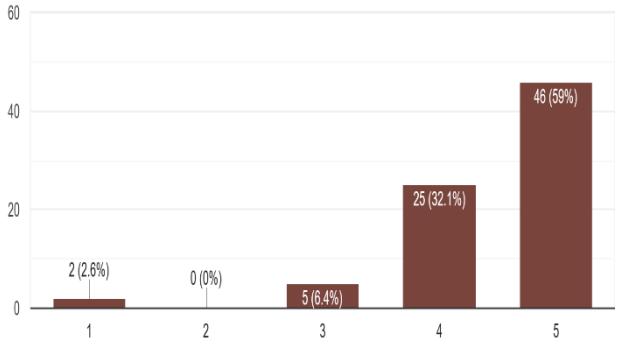
3.5.5 Key Features:

Each building incorporates distinctive architectural features that facilitate effective lighting use—such as large windows, skylights, green spaces, and adaptive systems—demonstrating the importance of integrating nature and technology in design.

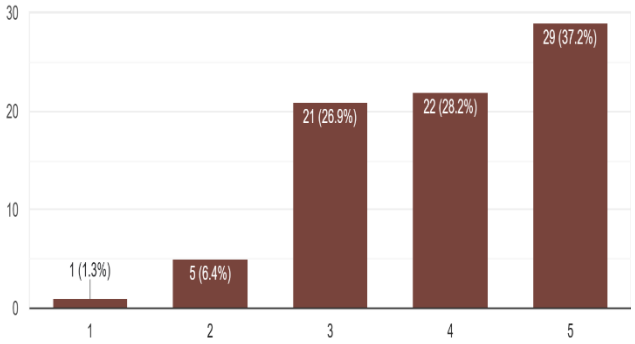
4 SURVEY OUTCOME

4.1 Section 1: Lighting and Cognitive Performance

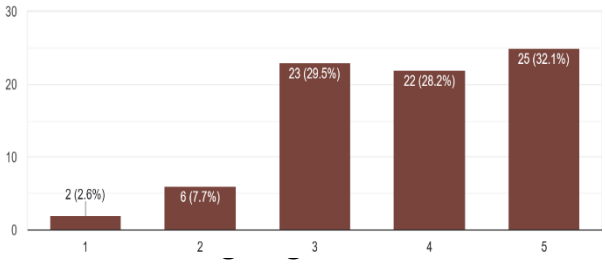
1. The lighting in my workspace helps me maintain focus on detailed tasks.
78 responses



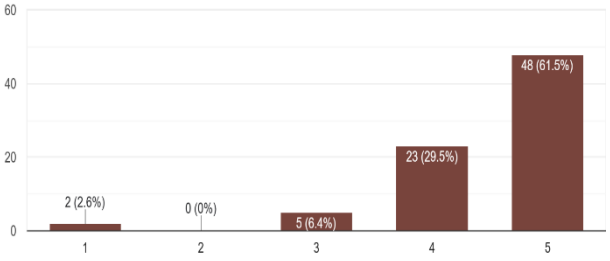
2. Bright lighting enhances my productivity during high-concentration tasks.
78 responses



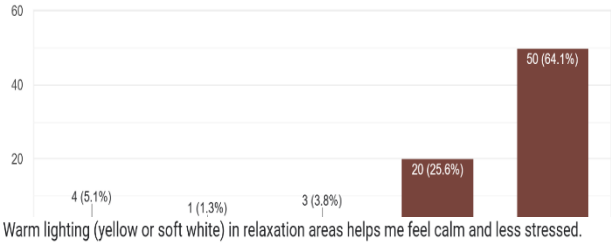
3. Cooler lighting (blue-enriched) improves my alertness and reaction time in the morning.
78 responses



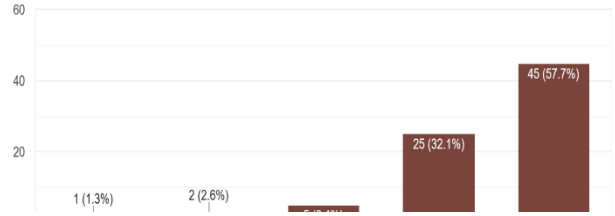
4. Adjusting the brightness of lights helps me perform better on different types of tasks.
78 responses



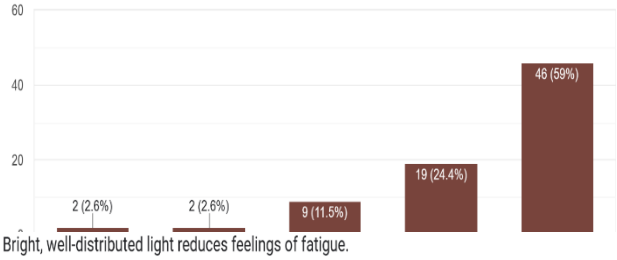
5. Poor lighting negatively impacts my ability to complete cognitive tasks effectively.
78 responses



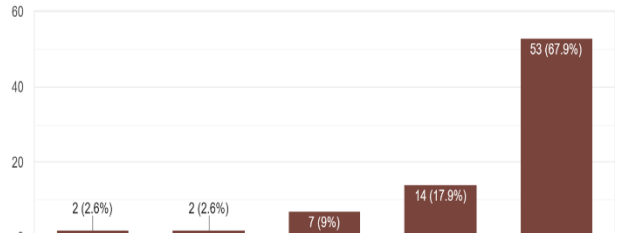
6. The lighting environment in my facility contributes to a positive emotional state.
78 responses



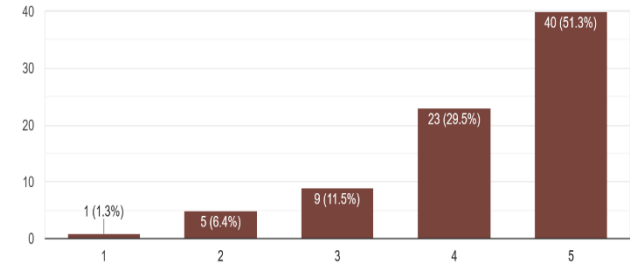
7. Warm lighting (yellow or soft white) in relaxation areas helps me feel calm and less stressed.
78 responses



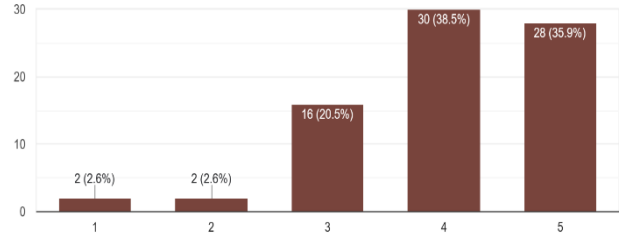
8. Exposure to natural light during the day improves my overall mood.
78 responses



9. Bright, well-distributed light reduces feelings of fatigue.
78 responses

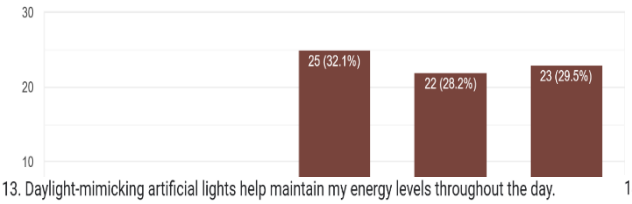


10. The ability to control my lighting (e.g., brightness or color temperature) reduces my stress levels.
78 responses

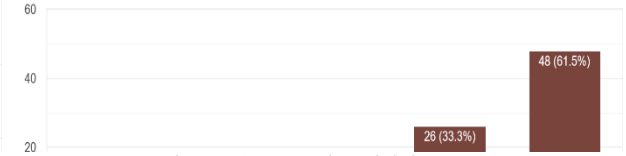


4.3 Section 3: Circadian Rhythm and Well-being

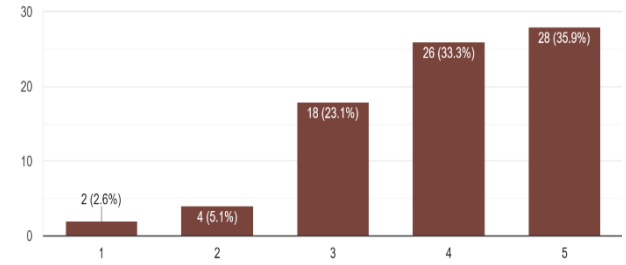
11. The lighting in my workspace supports my natural sleep-wake cycle.
78 responses



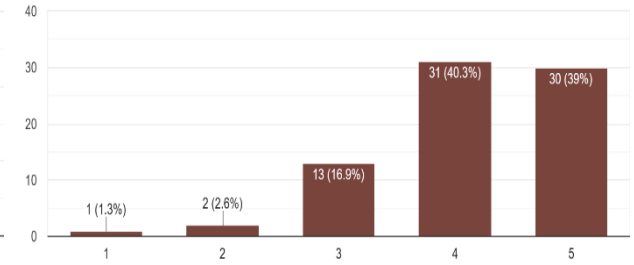
12. Exposure to natural daylight through windows or atriums positively impacts my mental well-being.
78 responses



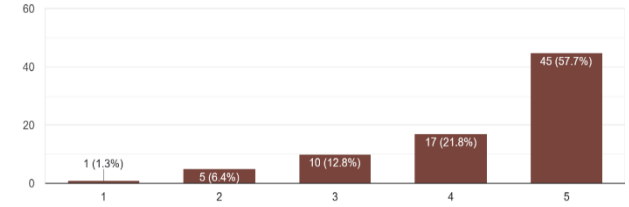
13. Daylight-mimicking artificial lights help maintain my energy levels throughout the day.
78 responses



14. Transitioning to dimmer lighting in the evening helps me feel relaxed and ready to wind down.
77 responses

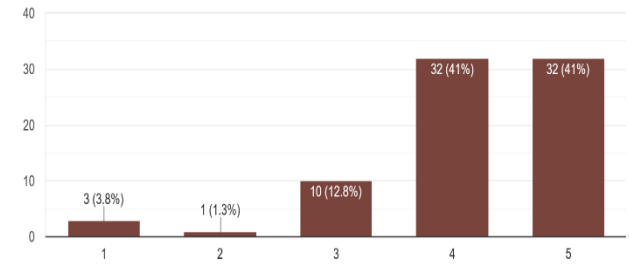


15. Poorly timed lighting disrupts my sense of alertness and energy during work hours.
78 responses

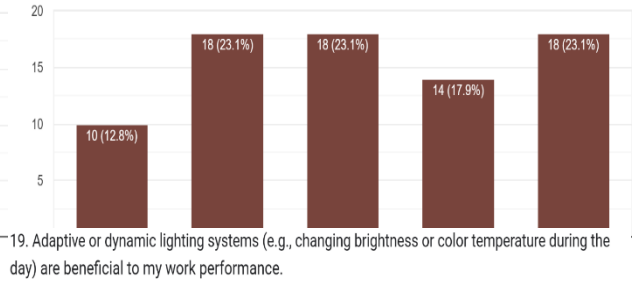


4.4 Section 4: General Lighting Design

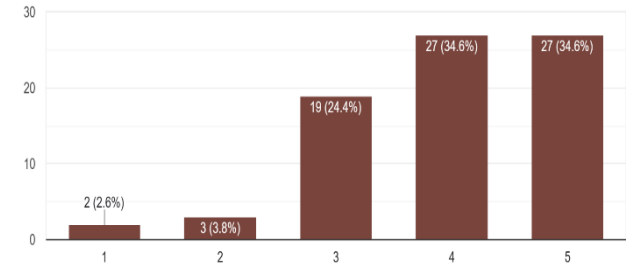
16. The lighting in my facility is comfortable for prolonged periods of work.
78 responses



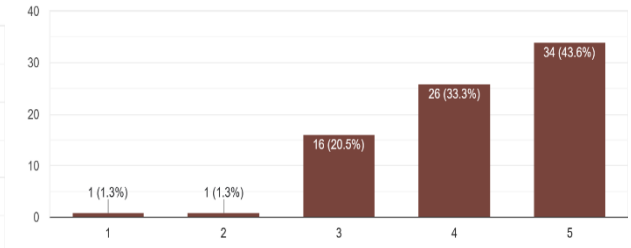
17. Glare from lights or screens is minimal and does not affect my productivity.
78 responses



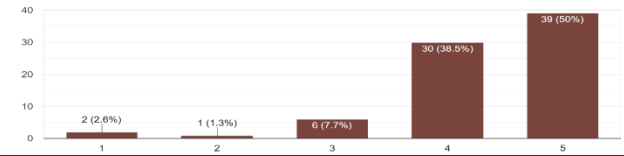
18. The design of lighting in my workspace is aligned with the nature of my tasks.
78 responses



19. Adaptive or dynamic lighting systems (e.g., changing brightness or color temperature during the day) are beneficial to my work performance.
78 responses



20. Overall, the lighting in this facility enhances my performance and well-being.
78 responses



4.5 Survey Outcome

The survey reveals critical insights into the impact of lighting on cognitive performance and mood. Key findings are summarized as follows:

4.5.1 Positive Effects of Lighting:

- A significant majority (57.89%) strongly agree that their workspace lighting supports focus on detailed tasks.
- Bright, well-distributed light and adjustable lighting systems were highly rated, with over 60% indicating that these features enhanced their productivity and comfort.
- Natural daylight exposure showed a significant positive impact on mood and energy, with 60.53% strongly agreeing it improved their well-being.

4.5.2 Specific Preferences:

- Participants preferred adjustable brightness and daylight-mimicking artificial lights, which helped them adapt to various tasks and maintain energy throughout the day.
- Warm lighting in relaxation spaces was appreciated for promoting comfort and mood enhancement, with 57.89% expressing strong agreement.

4.5.3 Challenges Identified:

- Glare from screens and lights was a recurring issue, with 35.53% giving lower ratings (1-3). This indicates a need for glare reduction strategies in lighting design.
- Lighting alignment with natural circadian rhythms was moderately rated (mean: 3.66), suggesting room for improvement in creating sleep-friendly environments.

4.6 General Impact on Performance and Mood:

- Over 48% of participants felt that the overall lighting setup in their facility enhanced performance and well-being.
- Poorly timed lighting and inadequate control options were identified as potential disruptors of productivity and comfort.

Optimal setups include natural daylight, adjustable brightness, and warm tones for relaxation. Addressing glare and aligning lighting with circadian rhythms could further enhance outcomes.

5 CASE STUDY

We conducted a live survey and analysis of two office spaces in Lucknow: theLivspace Experience Center and Summit Co-Working Space. We measured the lux levels in various areas using a lux meter to evaluate if the lighting conditions met the required standards. This allowed us to draw conclusions regarding the current application of lighting standards in relation to cognitive performance and mood.

5.1 Livspace Office

The Livspace Experience Center in Lucknow is located at the Summit Building, Vibhuti Khand, Gomti Nagar, a central and well-connected business hub in the city. This location makes it easily accessible for homeowners and designers seeking interior solutions. The center serves as an interactive space where customers can explore designs, materials, and layouts. The center showcases a variety of interior setups, including modular kitchens, wardrobes, living areas, and more. There are 3 Meeting room in the center as well where customers can consult with expert designers to customize their spaces based on personal preferences and requirements.

5.1.1 Readings From Lux Meter:

Open Seating and Interior Setups: 407 Lux

Cabin 1: 401 Lux
Cabin 2: 408 Lux
Cabin 3: 405 Lux

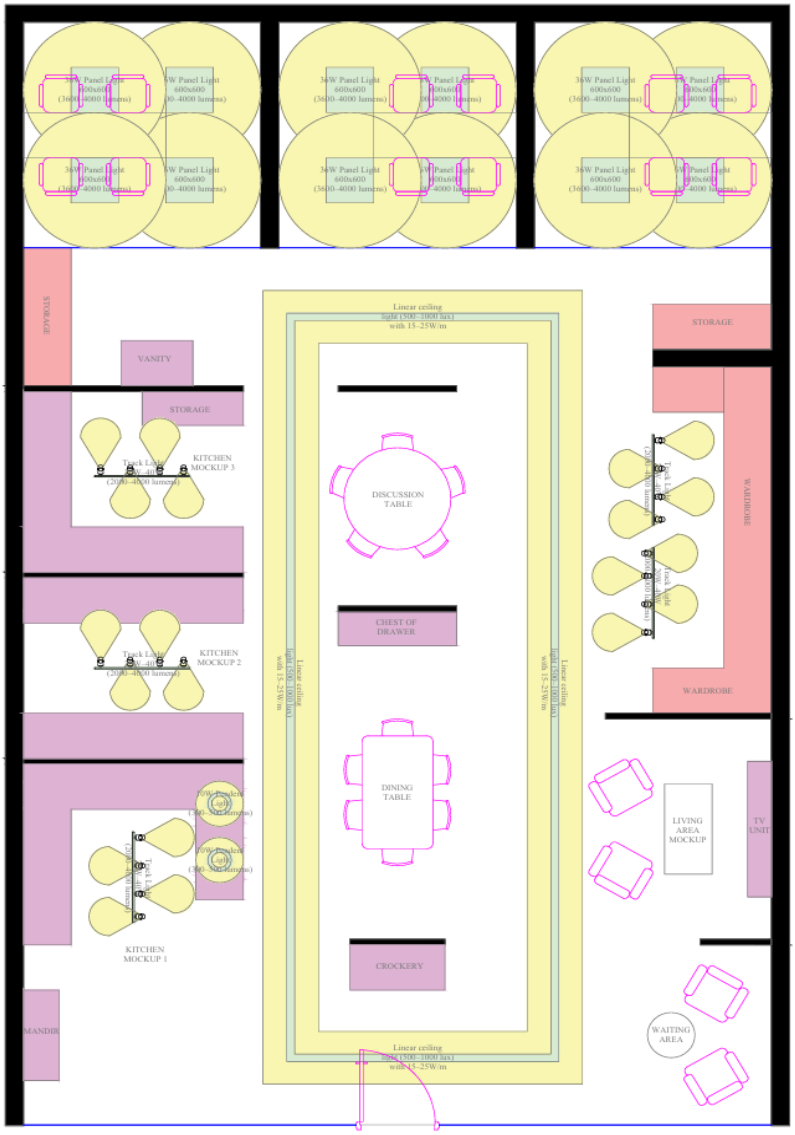


Figure 7: Livspace Lighting Plan

Livspace Lighting Plan

Figure 8: Livspace Experience Center Picture (Self-clicked)

5.2 Summit Space- Coworking Office Space

The Summit Co-working Space in Lucknow is situated on the 11th floor of the Summit Building in Vibhuti Khand, Gomti Nagar, one of the city's prime commercial areas. Its strategic location ensures excellent connectivity and proximity to Lucknow's bustling business ecosystem, making it ideal for freelancers, startups, and businesses of various sizes. This co-working space offers a variety of work environments, including open desk workstations, private cabins, meeting rooms, and fully furnished boutique offices. Features like high-speed internet, ergonomic furniture, and ample plug points support productivity and comfort, while amenities

such as a recreational area, pantry, and lounge ensure a welcoming atmosphere. The layout of the workspace is thoughtfully crafted to balance collaboration and focus, with breakout zones and phone booths for privacy.

5.2.1 Readings From Lux Meter:

Meeting Room: 472 Lux
Open workstation without Light: 97 Lux
Open workstation with Light: 496 Lux

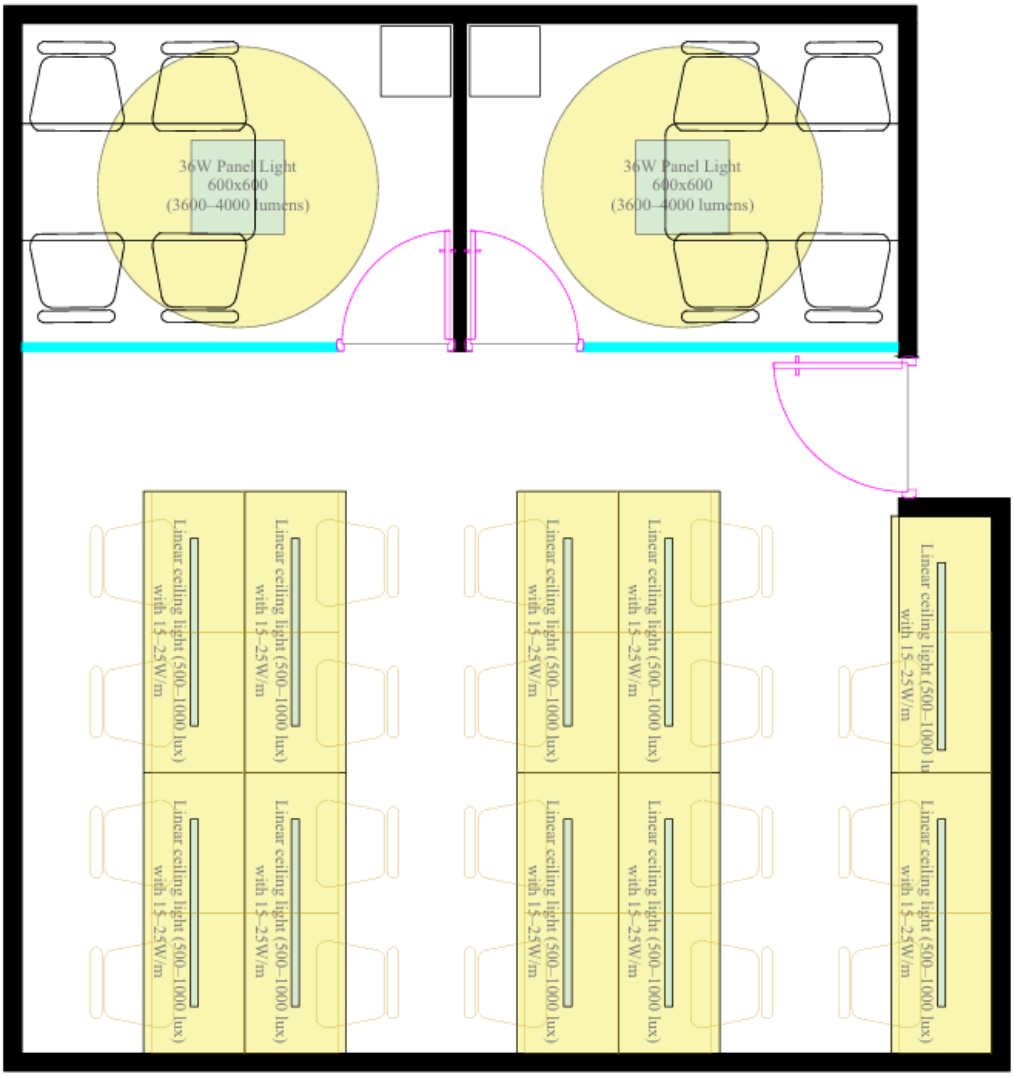
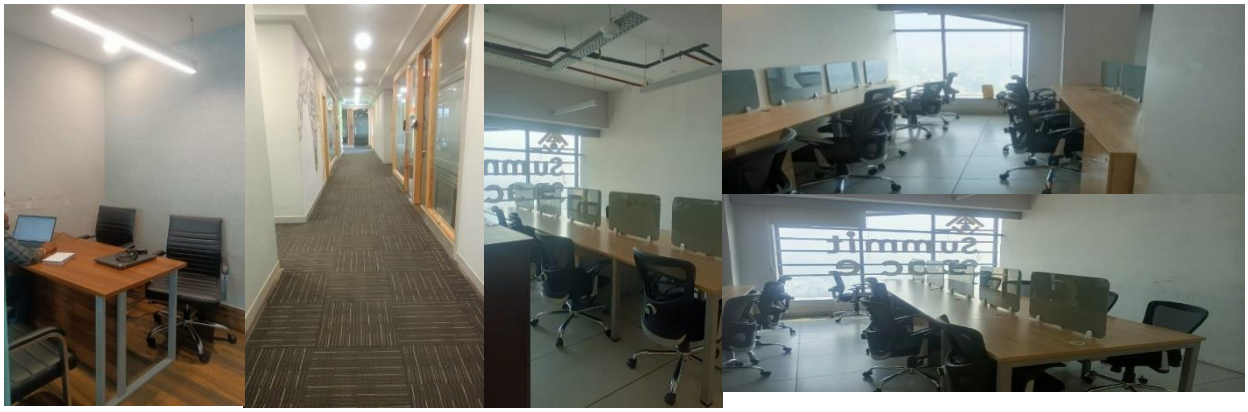


Figure 8: Summit Co-Working Space Lighting Plan



6 RESULTS AND FINDING

This dissertation has explored the significant relationship between lighting conditions and their effects on cognitive performance and emotional well-being. Lighting is not merely a functional element in architectural design; it plays a crucial role in shaping how individuals think, feel, and perform in various environments.

Lighting Type	Application/Task	Recommended Lux	Lumen (per m²)	Typical Wattage (LED)	Notes on Mood & Cognition
Ambient Lighting	General room illumination	100–300 lux	1000–3000 lm	10–20W	Warm light (3000K) creates comfort; suitable for relaxation but not ideal for focused tasks.
Task Lighting	Reading, writing, office work	500–1000 lux	3000–5000 lm	15–25W	Neutral light (4000K) enhances focus and reduces eye strain, supporting cognitive functions.
Accent Lighting	Highlighting art or décor	100–500 lux	1000–3000 lm	5–15W	Focused beam enhances aesthetics and mood without overwhelming brightness.
Study Lighting	Studying, detailed work	700–1500 lux	4000–7000 lm	20–30W	Cool light (5000K) stimulates alertness and boosts cognitive performance.
Dining Room	Dining area lighting	100–300 lux	1000–3000 lm	10–15W	Warm light (2700–3000K) fosters a relaxed, pleasant dining experience.
Living Room	Relaxing and socializing	200–400 lux	2000–4000 lm	10–20W	Warm or neutral light enhances comfort and mood.
Kitchen Lighting	Food prep, cooking	300–700 lux	3000–7000 lm	20–30W	Neutral or cool light improves visibility and productivity in task-heavy areas.

Bathroom Lighting	Grooming, makeup application	500–1000 lux	3000–5000 lm	15–25W	Neutral light (4000K) ensures color accuracy for grooming.
Bedroom Lighting	Relaxation, reading in bed	100–300 lux	1000–3000 lm	10–15W	Adjustable warm light creates a relaxing environment while aiding sleep.
Workspace Lighting	Offices, workstations	500–1000 lux	3000–5000 lm	15–30W	Neutral or cool light enhances productivity and focus.
Classroom Lighting	Learning environments	500–1000 lux	3000–5000 lm	20–40W	Cool light reduces fatigue, improves concentration, and supports learning.
Hospital Lighting	Patient rooms, clinics	300–500 lux	3000–5000 lm	15–30W	Balanced light reduces stress and fosters well-being in patients and staff.
Retail Lighting	Product display, showrooms	300–1000 lux	3000–7000 lm	20–50W	Bright, neutral light draws attention to products and stimulates engagement.
Outdoor Lighting	Pathways, gardens, security	50–200 lux	500–2000 lm	5–20W	Soft, warm light enhances safety while minimizing glare and maintaining ambiance.
Industrial Lighting	Factories, warehouses	300–1000 lux	3000–7000 lm	30–100W	Cool light ensures visibility and reduces fatigue in physically demanding tasks.
Healthcare	Therapy rooms, recovery areas	500–1000 lux	3000–5000 lm	20–30W	Tunable white light (2700–6500K) can improve mood and regulate circadian rhythms.

6.1 Key Considerations for Mood and Cognition:

6.1.1 Color Temperature:

- **Warm light (2700K–3000K)**: Relaxing, ideal for unwinding and creating a cozy atmosphere.
- **Neutral light (3500K–4500K)**: Balances relaxation and focus, suitable for most daily activities.
- **Cool light (5000K–6500K)**: Stimulates alertness, ideal for workplaces, study areas, and detail-oriented tasks.

6.1.2 CRI (Color Rendering Index):

- A **CRI of 80+** is good, while **90+** is excellent for accurate color representation(e.g., grooming, art).

6.1.3 Circadian Lighting:

- Dynamic lighting systems that adjust color temperature and intensity throughout the day can enhance well-being by mimicking natural daylight patterns.

6.2 Key Findings

6.2.1 Impact of Lighting on Cognitive Performance:

Findings indicate that both the intensity and color temperature of light can significantly affect cognitive abilities such as attention, memory, and problem-solving. Bright lighting enhances alertness and working memory, while cooler color temperatures have been shown to improve focus and reduce fatigue. This suggests that environments designed with appropriate lighting can foster better cognitive outcomes.

6.2.2 Mood Regulation:

Environments with adequate natural light or well-designed artificial lighting contribute to positive emotional states. Warm light tends to promote comfort and satisfaction, while cooler light can stabilize mood, particularly in older adults. This underscores the necessity for thoughtful lighting design in spaces where emotional well-being is a priority.

6.2.3 Circadian Rhythms:

Proper exposure to light helps synchronize our internal clocks, which can enhance sleep quality and overall mental health. This is especially relevant in workplaces where maintaining alertness throughout the day is essential for productivity.

6.2.4 Personalization of Lighting:

Individual differences, such as age and gender, influence how people respond to different lighting conditions. Younger adults may perform better under bright and cool light, while older adults may benefit more from warmer environments. Therefore, personalized lighting solutions could maximize cognitive performance and emotional benefits across diverse populations.

6.3 Implications for Design

As we move towards creating healthier workspaces and living environments, understanding how lighting affects human behaviour should be a fundamental consideration in design practices. The live survey we undertook revealed that workspaces like livspace experience center and summit co-working space have implemented effective lighting systems, which fall under our study analysis. however, there is a demand for a personalized lighting system that can be modified based on user preferences or can automatically adjust throughout the day, which could be even more advantageous. By integrating optimal lighting strategies—such as dynamic systems that adjust throughout the day—designers can enhance both individual well-being and organizational productivity.

The research underscores the vital role of lighting in our daily lives—not just as a means to illuminate spaces but as a powerful tool that can enhance cognitive function and emotional well-being. By acknowledging the profound impact of light on our cognition and emotions, we can foster spaces that not only meet functional needs but also support our mental health and enhance our overall quality of life.

7 REFERENCES

Campbell, G., Vandewalle, G., & GIGA-CRC Human Imaging. (2023). Higher light levels may improve cognitive performance. eLife.

Chellappa, S. L., Goel, N., & Czeisler, C. A. (2021). Effect of lighting illuminance and colour temperature on mental workload. PMC.

Figueiro, M. G., & Rea, M. S. (2012). Light modulates Leptin and Ghrelin in sleep-deprived adults: Implications for weight management. International Journal of Obesity, 36(4), 568-576.

Kocaoğlu, F., Korkmaz, A., & Yıldız, A. (2020). Effects of light intervention on alertness and mental performance during the post-lunch dip: A multi-measure study. PMC.

Veitch, J. A. (2012). Better lighting, better work: How indoor lighting affects employee well-being and productivity. American Psychological Association.

Boubekri, M., Cheung, I. N., Reid, K. J., Wang, C. H., & Zee, P. C. (2014). Impact of windows and daylight exposure on overall health and sleep quality of office workers: A case study. Journal of Clinical Sleep Medicine, 10(6), 603-611.

Cajochen, C., Kräuchi, K., & Wirz-Justice, A. (2019). Role of melatonin in the regulation of human circadian rhythms and sleep. Journal of Biological Rhythms, 32(2), 112-125.

Huiberts, L. M., Smolders, K. C. H. J., & De Kort, Y. A. W. (2015). Shining light on memory: Effects of bright light on working memory performance. Behavioral Neuroscience, 129(1), 1-10.

Veitch, J. A., Stokkermans, M. G., & Newsham, G. R. (2017). Linking lighting appraisals to work behaviors. Environment and Behavior, 49(6), 658-685.

Fiederer, L. (2020, February 3). AD Classics: Salk Institute / Louis Kahn. ArchDaily.

Gallery of the Edge / PLP Architecture - 23. (n.d.). ArchDaily.

Wikipedia contributors. (2024, July 10). India Habitat Centre. Wikipedia.

Sahyadri Park 2 Campus,Pune - Project by Edifice. (n.d.).

Melatonin | BioNinja. (n.d.).

Konrad. (2017, June 12). exploring how natural light colors our world. Sunlight Inside.

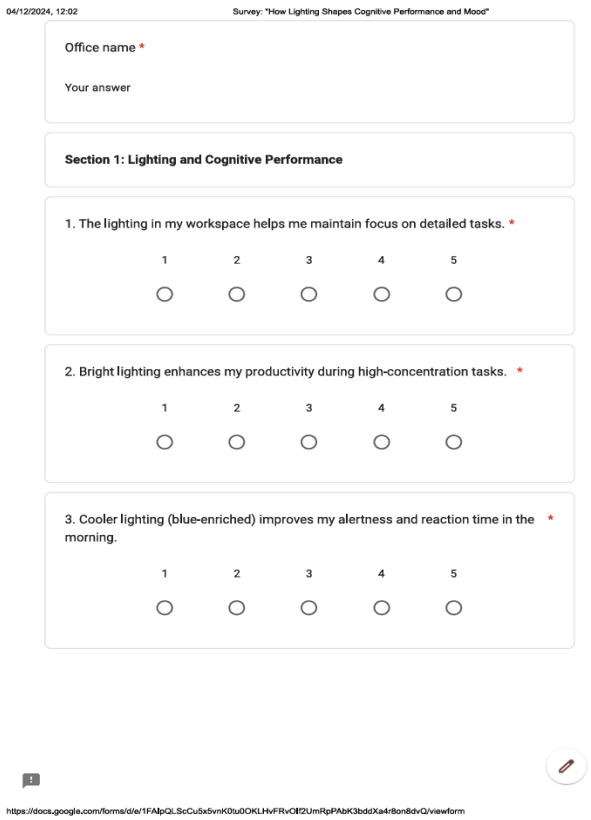
BotPenguin. (2024, November 20). Cognitive Ability: What is it and Its Types.

MrAhmedShawi. (2012, April 4). Autodesk EcoTect Analysis Tutorial - Beginners [Video].

DIALux is the software for your professional lighting design. (n.d.).

8 ANNEXURE:

8.1 Questionnaire of People working in Different Office Spaces



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Office name *

Your answer

Section 1: Lighting and Cognitive Performance

1. The lighting in my workspace helps me maintain focus on detailed tasks. *

1 2 3 4 5

2. Bright lighting enhances my productivity during high-concentration tasks. *

1 2 3 4 5

3. Cooler lighting (blue-enriched) improves my alertness and reaction time in the morning. *

1 2 3 4 5

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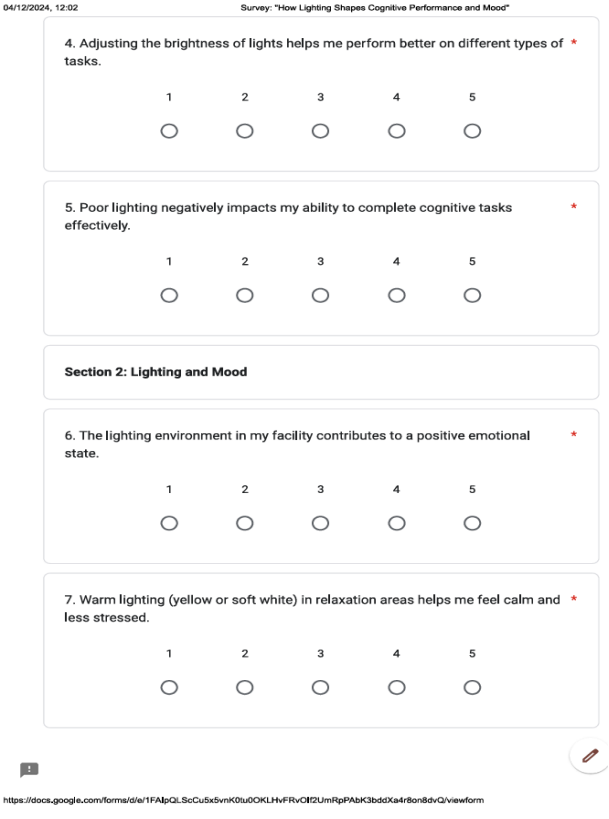

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4. Adjusting the brightness of lights helps me perform better on different types of tasks. *

1 2 3 4 5

5. Poor lighting negatively impacts my ability to complete cognitive tasks effectively. *

1 2 3 4 5

Section 2: Lighting and Mood

6. The lighting environment in my facility contributes to a positive emotional state. *

1 2 3 4 5

7. Warm lighting (yellow or soft white) in relaxation areas helps me feel calm and less stressed. *

1 2 3 4 5

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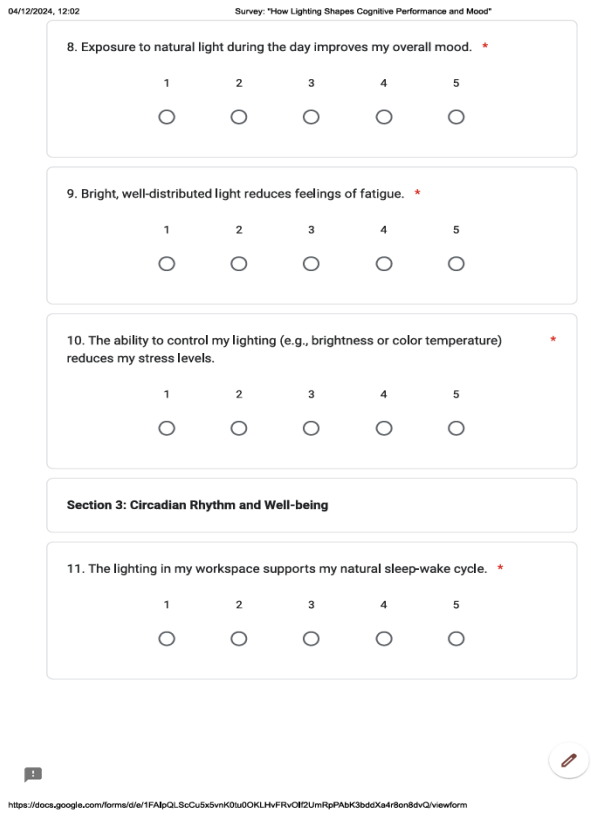

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8. Exposure to natural light during the day improves my overall mood. *

1 2 3 4 5

9. Bright, well-distributed light reduces feelings of fatigue. *

1 2 3 4 5

10. The ability to control my lighting (e.g., brightness or color temperature) reduces my stress levels. *

1 2 3 4 5

Section 3: Circadian Rhythm and Well-being

11. The lighting in my workspace supports my natural sleep-wake cycle. *

1 2 3 4 5

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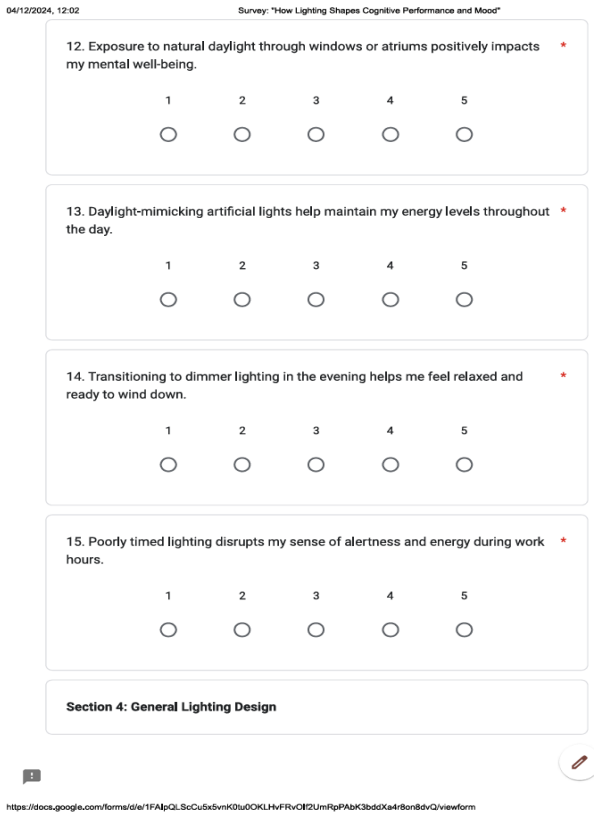

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12. Exposure to natural daylight through windows or atriums positively impacts my mental well-being. *

1 2 3 4 5

13. Daylight-mimicking artificial lights help maintain my energy levels throughout the day. *

1 2 3 4 5

14. Transitioning to dimmer lighting in the evening helps me feel relaxed and ready to wind down. *

1 2 3 4 5

15. Poorly timed lighting disrupts my sense of alertness and energy during work hours. *

1 2 3 4 5

Section 4: General Lighting Design

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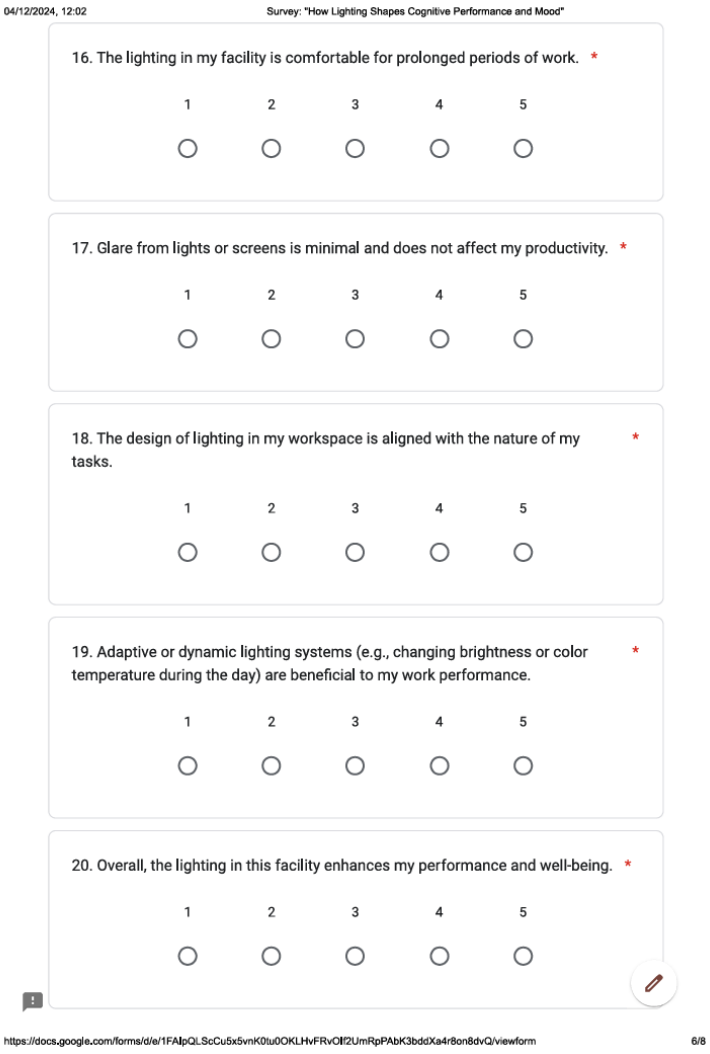

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16. The lighting in my facility is comfortable for prolonged periods of work. *

1 2 3 4 5

17. Glare from lights or screens is minimal and does not affect my productivity. *

1 2 3 4 5

18. The design of lighting in my workspace is aligned with the nature of my tasks. *

1 2 3 4 5

19. Adaptive or dynamic lighting systems (e.g., changing brightness or color temperature during the day) are beneficial to my work performance. *

1 2 3 4 5

20. Overall, the lighting in this facility enhances my performance and well-being. *

1 2 3 4 5

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