Ain Shams Engineering Journal xxx (xxxx) xxx

Contents lists available at ScienceDirect

Ain Shams Engineering Journal

journal homepage: www.sciencedirect.com

Simulating the natural lighting for a physical and mental Well-being in residential building in Dubai, UAE

Naglaa Sami Abdelaziz Mahmoud [a], Gamal El Samanoudy [b], Chuloh Jung [c,*]

[a] Department of Interior Design, College of Architecture, Art and Design, Healthy & Sustainable Built Environment Research Center, Ajman University, United Arab Emirates
[b] Department of Interior Design, College of Architecture, Art and Design, Ajman University, United Arab Emirates
[c] Department of Architecture, College of Architecture, Art and Design, Healthy & Sustainable Built Environment Research Center, Ajman University, United Arab Emirates

ARTICLE INFO

Article history:
Received 3 February 2022
Revised 30 March 2022
Accepted 16 April 2022
Available online xxxx

Keywords:
Lighting design
Natural lighting
Interior design
Well-being
Energy efficiency

ABSTRACT

The United Arab Emirates (UAE) is well aware of energy consumption and the reduction in carbon emissions from the quantitative analysis for lighting, but well-being, does not have a well-defined characteristic. This paper aims to investigate the context, analyze the appropriate lighting in the residential interiors in UAE, and present the planning direction of interior spaces. The methodology analyses the residential interiors' functions, human well-being status, and main innovative lighting characteristics. The analysis results are as follows; First, it is essential to establish the location and space plan in the planning phase due to the nature of the interior space functions. The context of the location has significant effects. Second, it is essential to establish the required lighting fixtures and bulbs. Third, strategic lighting layouts for the multiple interior spaces in the residential project. Interior architects provide the various lists and contents for creating a healthy lighting environment and the appropriate space. This study will serve as fundamental data to enhance the housing interiors in the UAE. Additionally, it will serve future research that supplies an efficient guide for the decision-making process to prepare the design guidelines and operational plans. Accordingly, trends, innovation, and national efforts serve as the backdrop for this study, which aims to present new strategic lighting layouts (lighting scenes) standards related to light in residential spaces for a healthy life in Dubai, UAE, by presenting and simulating natural lighting diversity throughout the day to adapt with the circadian rhythm for physical and mental well-being.
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1. Introduction

Our authentic lives have engendered a growing interest in life quality and the concept of well-being related to health [1,2]. The World Health Organization's (WHO) Charter includes integrating well-being, the meaning of welfare, and happiness, which defines human health as being disease-free and living a life of complete physical, mental, and social well-being [3,4]. A life of physical health and mental serenity is referred to as well-being [5,6]. People seek to enjoy the health of their bodies and minds and a wealthy lifestyle centered on health and the environment, rather than a life seeking material values or reputations, as well-being arises from a global lifestyle [7]. Throughout society, well-being themes are applied to food, home appliances, and fashion and are rapidly spreading with the keyword of health [8]. Eco-friendly building materials help nature and people cohabit in the real estate sector, establishing eco-friendly housing as a sustainable concept [9,10]. Well-being, which has become a new way of life, needs to be reviewed apropos the light environment of residential spaces used for rest, comfort, peace, and relaxation [11,12,13]. Lighting offers a visual stimulus and a work environment in a house-residential setting so that residents can see the contents, and it is crucial for making the interior attractive and pleasant and the link to human health [14,15]. However, to date, a tremendous oversight has obliterated the significance of light. Light is alive in its fundamental role of illuminating a space, delivering an appropriate amount of brightness consistently independent of the place's purpose and function and in users' psychological and mental characteristics [16,17].

* Corresponding Author.
E-mail addresses: n.abdelaziz@ajman.ac.ae (N.S. Abdelaziz Mahmoud), g.elsamanoudy@ajman.ac.ae (G. El Samanoudy), c.jung@ajman.ac.ae (C. Jung).

Peer review under responsibility of Ain Shams University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.asej.2022.101810
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Please cite this article as: N.S. Abdelaziz Mahmoud, G. El Samanoudy and C. Jung, Simulating the natural lighting for a physical and mental Well-being in residential building in Dubai, UAE, Ain Shams Engineering Journal, https://doi.org/10.1016/j.asej.2022.101810

In the United Arab Emirates, UAE Government's 2021 objective is to be the best in the world in the Human Development Index [18,19] and the happiest of all nations for the residents to feel a sense of belonging [20]. In 2016. His Highness Sheikh Mohammed bin Rashid Al Maktoum, the Vice-President and Prime Minister of UAE and Ruler of Dubai announced the new National Programme for Happiness and Well-being, which sets government policies, programs, and services that can promote virtues of a positive lifestyle in the community and a plan for the development of a happiness index to measure people's satisfaction [21].

Along with UAE's national strategy, The Emirates Authority for Standardization and Metrology (ESMA) had introduced the indoor lighting standard not only for helping reduce energy consumption but ensuring a reduction in carbon emissions [22]. These new lighting scenes standards save 668 M AED annually (approximately 452 M AED in the residential sector), removing 940,000 tons of carbon emissions [23,24]. The UAE government is well aware of energy consumption and the reduction in carbon emissions in the quantitative analysis for lighting, although the lighting for well-being is not well defined for psychological and mental health [25]. Analogously, current trends, technology, and national efforts are the background of this study that attempts to present new strategic lighting layouts (lighting scenes) standards related to light in residential spaces. The paper aims for a healthy life by presenting and simulating to the users the natural lighting diversity all over the day to cope with the circadian rhythm for physical and mental well-being in Dubai, UAE, by using innovative artificial lamps.

2. Materials and methods

Illuminance is the light flux per unit area incident on a specific space, expressed in lux units [26]. A person's brightness in everyday life varies significantly from 0.2 lx of moonlight to 100,000 lx of midday sunlight [27]. Therefore, illuminance is the basis of lighting design for the characteristics of space and human behavior and is an essential factor for realizing healthy lighting. In addition, Table 1 shows the standard of illuminance required for various works in our daily life.

Table 1
Recommended Light Levels (Illuminance).

Activities	Illumination (lux)
Public areas with dark surroundings	20–50
Simple orientation for short visits	50–100
Areas with traffic; corridors - stairways, escalators, and travellators - lifts - storage spaces	100
Working areas where visual tasks are only occasionally performed	100–150
Warehouses, homes, theatres, archives, loading bays	150
Coffee break room, technical facilities, ball-mill areas, pulp plants, waiting rooms	200
Easy office work	250
Classrooms	300
Standard office work, PC work, study library, groceries, showrooms, laboratories, kitchens	500
Supermarkets, mechanical workshops, office landscapes	750
Standard drawing work, detailed mechanical workshops, operation theatres	1000
Detailed drawing work, very detailed mechanical works, electronic workshops, testing	1500–2000
Performance of visual tasks of low contrast and minimal size for prolonged periods	2000–5000
Performance of very prolonged and exacting visual tasks	5000–10,000
Performance of exceptional visual tasks of shallow contrast and small size	10,000–20,000

The lighting layout determines the light source, the amount of light, the light quality, the light color, and economic efficiency are different, all of which are essential determinants of lighting design [28]. A light source's color temperature defines whether the light looks warm white, neutral white, or cool white. The light source becomes warm, neutral, or cool as the temperature rises [29]. The term "temperature" relates to the amount of light—the heated metal flames to red at first, then yellow, white, and finally blue. The "black body curve," which describes the various light color temperatures in degrees kelvin, is the trajectory of this temperature rise (K°) [30]. If the color temperature does not precisely match the chromaticity of a blackbody, a color temperature having a similar value is displayed. The (Color Temperature) and (Correlated Color Temperature) are used to refer to each other [31]. Colors vary slightly from person to person, but a bright neutral daylight color temperature generally creates a lively atmosphere for the entire space [32]. The warm color temperature, such as incandescent lights associated with the sky at sunset, creates a sense of stability and a calm atmosphere [33]. Table 2 shows the color temperature according to the change of the sun. The change in the sun's color temperature over time is the most natural flow of light for humans, and it can be an essential element of healthy lighting concerning human biorhythms [34]. It is crucial to prevent Seasonal Affective Disorder (SAD), a health condition that occurs in places where the natural light is absent for months [35].

The components of Daylight are sunlight and skylight. The preeminent natural factor influencing the illuminance of an indoor space is the skylight resulting from sun-ray scattered by water vapor and dust when directly passing through the atmosphere [36,37]. The disadvantage of direct sunlight as a light source is the heat and the glare; therefore, designers avoid using it [38]. However, the human eye readily adapts to natural lighting for a long time, considering it the best qualitative light source [39]. Therefore, for quantitative daylight analysis, it is necessary to grasp the amount of daylight change by day timing and time of the year, where the building location is concerning and affects indoor space and human health [40,41].

Asian/Arab black eyes are more sensitive to subtle shades than blue or grey eyes [42]. Color stimulates the brain through sight and the sense of skin, and the use of these colors is essential to leading a joyful life [43]. Depending on the color temperature of Daylight affect the inhabitant by various psychological effects such as vitality, passion, dynamism, comfort, stability, and rest [44]. Among the lighting layouts, the psychological effect of color temperature is often intentionally and consciously observed, and it is an emotional means of creating a space for comfort [45,46]. Table 3 below shows the psychological effects according to the change of Daylight and can be a fundamental concept of environmental lighting concerning health.

2.1. Circadian rhythm

There is a definitive relationship between light brightness and circadian rhythm [47]. Light is the most critical stimulant to

Table 2
Color temperature (°Kelvin) of the sunlight by time.

Natural lighting source	Color temperature in °Kelvin
Clear Sky	10.000°K
Foggy Sky	9.500°K
Cloudy Sky	7.000°K
Daylight with Clear Sky (sun overhead)	5.500°K
Sunrise/Sunset 2 h before/after	4.000°K
Sunrise/Sunset 1 h before/after	3.500°K
Sunrise/Sunset	2.500°K

Table 3
Psychology effects according to natural lighting timing.

Natural light time	Psychological effects
Sunrise	People become active at the beginning of a new day through light radiation gives vitality, physiologically and psychologically.
Sunset	People become calm and comfortable in the evening's orangy light and tend to do gentle activities.
Night	People's movements also change quietly.

change the circadian rhythm [48]. Circadian System refers to the internal body clock, which collectively refers to the three regular rhythms of body, emotion, and intelligence [49]. The circadian system regulates physiological rhythms such as human body temperature, sleep pattern, hormone secretion, and blood pressure [50]. A melatonin hormone made during sleep plays a vital role in regulating biological rhythms so that the body's overall function is in harmony [51]. Melatonin decreases when exposed to light in the morning, rises from around the evening, and increases gradually to the night; it reaches its peak at 2:00 am to 3:00 am, and when dawn approaches, the amount of secretion decreases sharply, maintaining a low level from morning [52]. As such, melatonin is reduced by light, so it is meaningful to secrete appropriate melatonin through step-by-step brightness control before waking up or going to sleep [53]. Therefore, the human retina's light plays a vital role in seeing objects and matching the human body's rhythm to the 24-hour cycle [54]. Fig. 1 shows the hormones and body cycles related to light, where the illumination control can adjust the biological rhythm to suit the human body's characteristics and life patterns.

2.2. Vision and lighting

There is a close correlation between light brightness and circadian rhythm [55]. The human eye can see a wide range of brightness during the day, from tens of thousands of luxe to less than 1 lx at nighttime [56]. Bright and dark adaptation are two types of responses linked to light luminosity. Generally, it takes about 30 min to change from bright adaptation to dark adaptation, and on the contrary, bright adaptation when coming out from a dark place to a bright one is concise, about 200 ms [57]. However, age affects visual perception; the older, the more the eye cells' sensitivity to feel and respond to light decreases, and the sensitivity of the abstract body and rod to respond to the quantitative change of light decreases with age [58]. As a result, the time required for dark adaptation increases, and at the same time, the adaptability to variation decreases, making it difficult to see an object in a dark place. In a residential environment, measures for the difference in brightness between the background and the subject or lighting are necessary, so a lighting layout that can adjust the illuminance and color temperature according to age should be considered in a residential space as the functionality of these spaces.

2.3. Psychology and lighting

The human brain emits different brain waves depending on the state of the body or the state of mind, and through these brain waves, it is possible to grasp the state of the brain [59]. Because light detects color not only by the eyes but also by the skin, the muscles are also tense by the light [60]. People generally respond faster than usual when they receive bright or red light, and the response when they receive dark or green light is rather delayed [61]. Therefore, interior architects must do a lighting study in terms of brightness and hue, as these factors have a significant impact on the physical and psychological of the users. Color always exists and has much influence on our lives. Color selection occurs based on scientific psychology, physiology, lighting, and aesthetics [62]. As culture develops, using color's psychological and physiological effects becomes more decisive [63]. Humans have various psychological reactions in space according to the direction of lighting. The projecting role of light is for visual activities, but the range of light is broad enough to affect environmental factors. Even in the same space, it is possible to create a space that changes in various ways according to the usage of light [64]. Lighting has a visual effect of reducing or expanding a given interior and acts as an element that affects the expression or size of the room or the height of the ceiling [65].

2.4. Review of new light sources

2.4.1. UV-A LED lamps

The photocatalytic reaction refers to the irradiation of ultraviolet light using wavelengths of 300–400 nm emission similar to the sunlight or fluorescent lamps onto the surface of an object coated with titanium oxide (TiO_2), and the light is absorbed on the surface by the photocatalytic action of TiO_2 [66]. The photocatalytic reaction can be an environmentally friendly technology because it is the same as the principle of photosynthesis in plants [67]. Photocatalytic lamps apply UV-A contained in light to the surface of luminaires or lamps to decompose organic substances that cause contamination by generating oxygen generated by photocatalytic material absorbing UV-A contained in light [68]. The active oxygen generates the intense oxidizing action, and all organic matter

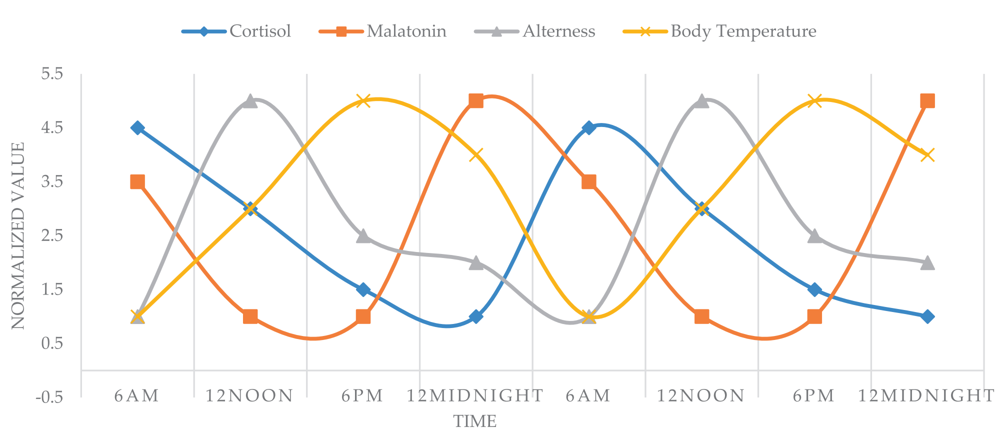

Fig. 1. Hormones related to light and circadian rhythm.

attached or contacted is wholly incinerated and decomposed, leaving only CO_2 or H_2O [69]. The effect of the photocatalyst UV-A LED lamp has an antifouling function that maintains the light flux by decomposing oil components attached to the lamp surface and suppressing the brightness decrease due to contamination [70]. Deodorizing provides a comfortable living space by removing odors such as cigarette scents from everyday living spaces, ammonia from toilets, and cooking odors from the kitchen [71].

2.4.2. Anion LED lamps

Anion LED lamps neutralize and remove dust floating in the air. Attaching the negative ion function to the luminaire can save electricity consumption due to carelessness by operating only when a person is active [72]. The available anion LED lamps to range from 9 W to 55 W, and with an efficiency of 95 lm/w, they can save energy and create a bright indoor environment [73]. Air purification is one of the benefits of an anion lamp, which purifies, precipitates, and removes ions created by numerous dangerous pollutants; dust removal function to decompose and reduce Escherichia coli and MRSA bacteria in contact with the lamp, blood and cells purification, and sterilization [74]. It affects the human body, such as the activation of the body, increasing resistance, and regulating the autonomic nervous system.

A purifying anion LED lamp is a transparent light bulb made of glass that passes ultraviolet rays and sterilizes water or air, bypassing the wavelength from mercury discharge [75]. Exposure to this light is harmful, so appropriate safety measures are necessary. A healthy home environment should use such a neuter light, sterilize germs, and switch on independently from the automated ventilation system after using the toilet, causing no harm to the human body [76].

When the light emitted from the heating element is dispersed into the spectrum, infrared rays are outside the end of the red spectrum [77]. Among these spectra, the shortest wavelength is near-infrared, and infrared rays generally have a more decisive thermal action than visible or ultraviolet rays [78]. As an effect of the infrared lamp, it is easy to install in a variety of uses and a wide range of ways by preventing glare by a special coating and has a fast-thermal response that reaches the use temperature within seconds after lighting due to the conversion of 92% of the energy consumed to infrared; it has high energy efficiency. Furthermore, since the lamp function by heat, there is low heat loss attributable to air, and since light penetrates deep within, it has good drying benefits. Above all, the air only transmits light to an object (the human body) without heating; it may improve health by enhancing the restorative effect [73]. Table 4 below compares traditional standard fluorescent lamps used in residential interiors and a new generation of technological lamps.

Unlike traditional incandescent or gaseous light sources, LEDs are small semiconductor devices that convert electrical energy into separate light colors. LED has a long life, high efficiency, low heat generation, and low light source, so it can slim down or create numerous luminaires. As the current price of LED is gradually decreasing, if LED is applied appropriately for purposes such in residential spaces, it is an auxiliary lighting device for safety and movement guidance when moving at night by approaching health with the concept of human safety and psychological stability.

2.5. Methods

The study looks at how the UAE's current house lighting layout may be used to create new lighting scenes in a residential project that are both healthful and environmentally friendly. The illuminance measurements of each interior area calculate the illuminance averages for each expected function. The comparative evaluation of the lighting environment with the international illuminance standards is decisive for improving the lighting environment.

Along with keeping the well-being trend acknowledged as a new lifestyle throughout society, the paper explores light's nature in residential spaces. The analysis of the effects of the light environment on human biorhythms and visuality with further exploration of the physiological and psychological factors, in addition to the investigation of the relationship between the living space and a healthy lighting environment, enabled the paper to propose a new lighting layout (lighting scenes) for a healthy and eco-friendly environment, using 3Dmax and DIALux programs on a rendering proposal for an apartment in Dubai, UAE.

The proposed lighting scenes, associated with the proposed interior design, will give the future users of the apartment an idea about the importance of having a flexible lighting layout for their well-being. The proposed lighting scenes will give the appropriate image of the proper lighting level and lighting color temperature for the expected functionalities in each room/interior. The proposed lighting scenes will provide a practical decision-making framework for developing design standards and operational strategies in Dubai, UAE.

3. Results

The theoretical review and analysis of new lighting sources led to the following new lighting proposal developed for each interior space by finding the relationship between the residential space requirements and the light strategy for the interior environment. The proposals consider simulating the natural lighting levels and colors that improve the users' biorhythms and visualities by the artificial lighting sources. The proposals are for one apartment for a typical family that needs to be composed of a Master Bedroom, Children's Room, Living Area, Bathroom, and Miscellaneous Space, using the recommended light level and the color temperature that follows the circadian rhythms.

Table 4
Comparison of properties between traditional lamps and new lamps.

Category	Traditional Lamp	New Lamps	
	Standard Fluorescent Lamp	Photocatalytic UV-A-LED Lamp	Anion LED Lamp
Color Temperature	Low to Optimal [2700–6500°K]	Warm and Daylight [3000°K and 6000°K]	Full Spectrum [2700–7500°K]
CRI - Color Rendering Index	Low to Average [52 –65]	Optimal [85]	Optimal [90–97]
Glare	High	Low	Low
Vision	Decreasing Vision	Protecting Vision (Acquired the highest FIRST 'A' for indoor lighting standards)	Improve overall health
Function	Only Lighting	Lighting + Antifouling, deodorant, antibacterial effects	Lighting + purification, and sterilization

3.1. Master bedroom

The master bedroom is a private space that strongly requires privacy and should be comfortable for relaxation, stability, and stress relief. Currently, most bedrooms are standard in their interior layout, with one lighting fixture at the center. Such lighting fixtures position has a high luminance per illumination area, providing local illuminance rather than overall lighting, leading to extensive glare and visual impairment. Moreover, it is impossible to adjust the illuminance according to its purpose, as it gives a general ambient-focal lighting layer.

Considering the above issues, the lighting layout of the master bedroom should not have glare with soft light output, and it is necessary to produce suitable layers and levels for human's biological rhythm. The biorhythm lighting equipment considers human body rhythm through sequential changes in illumination and color temperature from before going to bed to waking up. The light source is the warm white (3000°K) of the T5 straight tube fluorescent lamp, the latest high-efficiency light source with a tunable controller, by applying daylight color (6500°K) to adjust the illuminance level and color temperature through dimming. Table 5 below is a layout for lighting production step by step to match the human body rhythm by calculating the illuminance and color temperature with data from actual field measurements for the application of the biorhythm lighting equipment through tunable and dimming control. Fig. 2 shows a step-by-step simulation of the change in illuminance and color temperature when applying the biorhythm artificial lighting to the master bedroom.

3.2. Children's room

It is necessary to design lighting for a child's room at eye level. Since lighting dramatically affects a child's vision, it is ideal for brightening the object without directly irritating the eyes. The core strategy should consider safety, function, and growth. The new lighting layout for the children's room is to improve the brightness control and uniformity system and resolve through separate arrangements by planning a slim-type direct lamp composed of T5 straight fluorescent lamps, with a tunable controller and semi-direct luminaires. In addition, the layout should consider the children's changeable needs and growth, tracking the lighting devices that can serve as support. According to the user's activity, such criteria enable directing the pattern and provide an appropriate illuminance suitable for the space. Table 6 shows the lighting layout for the children's room, and Fig. 3 shows the simulation according to the layout.

3.3. Living room

The living room is the representative area in residential housing for a family, and it is a multifunctional place where family members conduct most of their activities. Since the living room is larger than the other areas, uniformity is low, resulting in a significant contrast in illumination inside the space. Therefore, the living room needs a flexible lighting system, such for rest, conversation, reading, and watching TV. Since the Dubai Municipality illumination standard requests, the usage of the T5 straight fluorescent lamps for living rooms, accordingly, a tunable and dimmable control system will solve the problems of existing living rooms to enable illumination control and color temperature control according to purpose, use, and season. Such controllability enables various lighting scenes by applying the appropriate switch; the direct / semi-recessed luminaires will divide and arrange to improve uniformity. In addition, cove lighting or cornice lighting can be applied to the first side of the living room to secure work illumination and complement the lighting production layout suitable for the purpose. Cove or cornice lighting can be more practical than wall-mounted luminaires that are not appropriate, while cove lighting can create a soothing and calm atmosphere throughout the room to make the interior space look wider for the multifunctionality expected. Table 7 below is a lighting layout for lighting the living room showing stage development to fit the human body rhythm by calculating illuminance and color temperature from actual field measurements using lighting equipment via tunable and dimming control. Fig. 4 shows simulation scenes according to the living room layout.

3.4. Kitchen & dining area

The dining area is a central space for modern people's health and lifestyle. However, in most apartments and houses, the location of the dining table is fixed, and the fact that the layout of the dining table is not flexible as desired is also the most dissatisfying reflex for the residents. The color rendering index of the light source affects the food's appearance enormously. Therefore, after evaluating food consumption and health, the significant activities

Table 5
Lighting layout for master bedroom layout with biorhythm illumination.

Phase	Time/activities	Lighting scenes
1	30 min before waking up	**1.1. 30 min before** At sunrise, the color temperature of the sun is (3.000°K), illuminance (5 lx) - The Scene (100%) **1.2. 15 min before** Sunrise for 1 h, the color temperature (3.500°K), illuminance (30 lx) The Scene (3.000 K 85% + 6.500°K 15% (about 3.525°K) **1.3. After 30 min** Maintained for 10 min with a color temperature of (4.000°K), illuminance (60 lx) The Scene for 2 h at sunrise (3.000°K 70% + 6.500°K 30% (about 4.050°K))
2	Morning-Afternoon (automatic after Phase 1)	**2. All Day** On a bright day, the color temperature of the sun is 5.500°K, illuminance 150 lx (3.000°K 25% + 6.500°K 75% (about 5.625°K))
3	After 6 pm	**3. 2 h before and after sunset** Color temperature 4.000°K, illuminance 300 lx (3.000°K 70% + 6.500°K 30% (about 4.050°K))
4	15 min before going to bed	**4. At sunset** The sun's color temperature changes from 3.000°K, 5 lx to 3 lx, and turns off after 15 min.
5	Various	- The dressing table used 4.500°K/300 lx Bright and non-distorted lighting production Marital conversation 3.500°k/150 lx Relaxing lighting production while looking at each other's faces Mood lighting 3.000°K/60 lx

Fig. 2. Master bedroom simulation with biorhythm lightings scenes.

Table 6
Lighting layout for children room layout with biorhythm illumination.

Phase	Activities	Lighting scenes
1	General, Conversation	**1. All Day** Color temperature 3.000°K/illuminance 150 lx
2	Reading/ Studying	**2. All Day** Color temperature 5.000°K/illuminance approximately 300 lx
3	Play	**3. All Day** Color temperature 6.500°K/illuminance approximately 150 lx

Table 7
Lighting layout for living room layout with biorhythm illumination.

Phase	Activities	Lighting scenes
1	General, Conversation	**1. All Day** Color temperature 3.000°K/illuminance 100 lx
2	Reading, Work	**2. All Day** Color temperature 5.500°K/illuminance 500 lx (Concentration)
3	TV	**3. All Day** Color temperature 4.000°K/illuminance 150 lx
4	Home Theater	**4. All Day** Color temperature 3.000°K/illuminance 30 lx
5	Guest	**5. All Day** Color temperature 4.500°K/illuminance 600 lx
6	Work With detail	**6. All Day** Color temperature 5.500°K/illuminance 700 lx

of residential space, and the psychological relationship resulting from that location, it is required to analyze the utility and possibilities of space appearance. The cooking space or the kitchen should have an appropriate color rendering index for various tools, and the photocatalytic UV-A-LED lamp reviewed above, in Section 2.4, can be applied. The lamp's color temperature should be adjustable to reach a pleasant space. Since the working light at the sink level can be installed, avoiding direct exposure of the photocatalytic LED lamp in a way to guarantees the cooking space's hygienical layout. The dining table space needs to be comfortable and lively throughout the lighting scenes. In addition, a proposed lighting strategy that considers the health of modern people by utilizing the color of light. Color temperature control is a method of manipulating the spatial render required by the space users by dividing them with switches to yellow and blue or various filters. Table 8 is a lighting layout suggestion for the kitchen. Fig. 5 shows a simulation of the kitchen and dining table lighting scenes.

3.5. Bathroom

The Bathroom should be a sanitary space that performs physiological functions, a resting space, and a space that ensures indepen-

Fig. 3. Children room simulation with biorhythm lightings scenes.

Fig. 4. Living room simulation with biorhythm lightings scenes.

Table 8
Lighting scenes for kitchen and dining room with biorhythm illumination.

Phase	Activities	Lighting Scenes
1	Illumination Control	–Photocatalytic UV-A-LED Lamp of 4.500°K / 500 lx −0%∼100% illumination control for Cooking
2	Blue series	–Photocatalytic UV-A-LED Lamp of 7000°K –Use of tunable control –Lighting for the General/Ambient setting
3	Yellow series	–Photocatalytic UV-A-LED Lamp of 3.200°K –Use of tunable control –Lighting to enhance appetite
4	Red series	–Photocatalytic UV-A-LED Lamp of 2.700°K –Use of tunable control –Lighting that appears the food deliciously

Table 9
Lighting layout for bathroom layout with biorhythm illumination.

Phase	Activities	Lighting scenes
1	Functional Lighting	–Anion LED Lamp of 4.500°K/150 lx Neutral White
2	Night Lighting	–Anion LED Lamp of 6.500°K/5 lx Dimmed Daylight

dence. Therefore, it is necessary to create a clean and comfortable indoor atmosphere considering the emotional aspect. The new layout of the Bathroom aims to create high-quality lighting by creating a spacious and cozy space in a narrow space. Therefore, an artificial window in a space without a window using wall bracket lighting equipment simulating the natural light flows. The Bathroom is spacious and relaxing and can help human psychological/-mental health. Other scenes for the Bathroom include a layout to set the sleeping time through illumination control in advance and provide lower illumination than usual so that they can effortlessly go to bed again after using the Bathroom using the previously reviewed sterilization lamps, anion LED lamp, to create a space that is comfortable and conducive to health. Table 9 below shows the lighting layout for the Bathroom, and Fig. 6 simulates the lighting scenes according to the bathroom layout.

3.6. Miscellaneous space

The entry hall, which defines the overall ambiance and the first visual impression of the house in a residential area, must consider the entrance's recognition and light for guests' ease. Currently, automatic door handles with functional switches are increasing, and the entrance is displayed even in low illumination. Therefore, the lighting layout using the photocatalytic UV-A-LED lamp in connection with the corridor, which is a hidden space in the residential space, will enable the flow of these spaces. Indirect lighting using a photocatalytic UV-A-LED lamp can reduce energy loss because it generates less heat and provides safety by inducing the movement line to lead the circulation from the entrance to the corridor. In addition, the lower position of a light source provides psychological tension relief and peace.

The dressing room dedicated to changing clothes and preparing for going out needs about 300 lx, and the overall lighting is 150 lx along with the typical bedroom. Since the clothing colors change substantially depending on the lamp's color rendering index, a warm daylight bulb with an average CRI of 80–90 is compulsory. In the dressing room, a space for makeup, it is essential to produce

Fig. 5. Kitchen and dining room simulation with biorhythm lightings scenes.

Fig. 6. Bathroom simulation with biorhythm lightings scenes.

bright and soft shadows by increasing the number of lighting equipment. Such a layout leads people to change their mood and find a sense of psychological stability.

4. Discussion

The proposed scenes generate the lighting levels and color in each interior space within the selected apartment. The Master Bedroom needs variable light levels for illuminating the different functions; (3.000°K/5lx) to simulate the sunset/sunrise effects strengthen the before sleeping and after waking mood to (5.500°K/300 lx) for the marital conversation, using the standard T5 fluorescent tunable lamp, which follows the study of Peña-García [26]. The Children's Room requires fewer variations due to playing and reading/studying functions, between (3.000°K/150 lx) and (6.500°K/300 lx). The specific selection of these levels enhances the kids' needs [36]. Both Master Bedroom and Children's Room will have the brightness and the variability of light to preserve the circadian cycle since they are inextricably linked [47].

The Living Room is the central area in interiors houses nowadays, and the multiple functions necessitate different lighting illumination and color. The range for the Living Room illumination starts with the Home-Theater mood (3.000°K/30 lx) and the detailing task (5.500°K/700 lx). It typically takes 30 min to go from bright to dark adaptation, but light adaptation when transitioning from a dark to a bright environment takes only 200 ms [57]. It is eventually essential to have a smart control system to support users' well-being [41]. The living room requires a versatile lighting system that can be used for relaxation, discussion, reading, and watching television. The Dubai Municipality's lighting regulation specifies that T5 straight fluorescent bulbs be used in living rooms [60]. As a result, a tunable and dimmable control system will alleviate current living room concerns by allowing lighting and color temperature customization according to purpose, usage, and season [62].

The kitchen/Dining area has multi-hygienic tasks, yet limited along the days. The cooking period requires the Photocatalytic UV-A-LED Lamp under the cooking counter. The lighting illumination mainly needs different light colors; (2.700°K-7.000°K/500 lx). The photocatalytic UV-A-LED lamp is used in the cooking environment or kitchen to provide a satisfactory color rendering index for various instruments [68]. The lamp's color temperature may be adjusted to create a relaxing environment [70]. The cooking environment can be kept clean since the working light may be put at the sink level, avoiding direct exposure to the photocatalytic UV-A-LED bulb [71].

The Bathroom has only two sceneries; the standard function needs a hygienic and clear vision. The use of the Anion LED Lamp in an indirect setting is a must [72]. The Bathroom should be roomy and soothing to benefit users' psychological and mental health [48]. Therefore, an artificial window is created in a location without a window by employing wall bracket lighting equipment to simulate natural light flows [64].

While the other areas, such as the entrance and the corridor, should have a leading aspect. The dressing area needs a specific high color rendering index between 80 and 90 CRI to simulate the natural lighting concerning the materials' colors appearance [44]. The simulation of the natural lighting, using new innovative lamps technologies, with the help of smart controllers will be the key to creating these multiples lighting scenes for healthy home interiors.

5. Conclusion

Human well-being is the responsibility of architects and interior designers. According to their professional position, they must examine many aspects of the surrounding context and the users' environmental parameters. Furthermore, the exact lighting illumination and the light color temperature play a critical influence in the interior functionality's success. Such information necessitates a thorough examination to extract the most relevant simulation for the users' advantage in terms of visions and functions to achieve the optimal desired functionality, mood, and relaxation in their living environments.

In hot countries, such as the UAE, the weather conditions produce a specific light intensity and color temperature. Such a contextual environment provides each person with individual cognition and background, permitting the interior architect to focus on a more specialized task connected to lighting simulation in their respective homes. A simulation of artificial lighting is established, and different lighting scenes are created to stimulate the circadian rhythm to increase users' overall functionality, similar to variations in natural lighting. A fixed lighting scene leads to boredom and affects the user mentality in an unwanted way. The simulation of natural illumination in the proposed residential apartment projected several sceneries relevant to the functionality and demands of each room's interior.

In the future, data from the resulting application of the lighting environment of the proposed home space will be used to examine the proposal scenes of the light environment of the residential interiors. The applications proposed in this study in the home environment should be assessed and coupled with health considerations. These data will help improve the residential environment in Dubai-UAE, fitting for the well-being era. It is necessary to validate and analyze the lighting environment of the residential space by installing a flexible lighting system promoting the users' friendliness to create the proposed light scenes. Problems should be derived and supplemented by measuring the quantitative value of lighting and surveying residents' satisfaction. Moreover, the use of tuneable and dimmable systems will promote the achievements of such a healthy lighting environment.

Author Contributions

Funding

This research received no external funding.

Institutional Review Board Statement

Data Availability Statement

New data were created or analyzed in this study. Data will be shared upon request and consideration of the authors.

CRediT authorship contribution statement

Naglaa Sami Abdelaziz Mahmoud: Writing – review & editing, Investigation, Project administration, Resources. **Gamal El Samanoudy:** Writing – original draft, Conceptualization, Methodology, Data curation. **Chuloh Jung:** Writing – review & editing, Software, Formal analysis, Validation, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

The authors would like to express their gratitude to Ajman University for APC support and Healthy and Sustainable Buildings Research Center at Ajman University for providing great research environment. The authors would like to extent their appreciation to the Interior Designer, Mr. Hisham Dandy, for sharing his interior design proposal of Dubai Apartment as well the Research Assistant, Architect, Mr. Ezzeldin El Samanoudy for his contribution in creating the lighting simulation scenes.

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Dr. Naglaa Sami Adbel Aziz Mahmoud is an Educator, Researcher, Lighting & Acoustic Consult, and Professional Interior Designer having applied projects designing, supervision, and consultancy. As an educator, fascinated by her profession, she spends her favorite time in the studio with future designers. As a researcher, she publishes yearly book chapters, articles, and papers in conference proceedings that reached, in February 2020, 2000 reads and downloads. As academic, she developed a number of reports related to the interior design department improvement, accreditation, and assessment processes. Meanwhile, Dr. Naglaa creates, establishes, and updated some courses - including the launch of the course learning outcomes for all courses - at the undergraduate and postgraduate levels. For career development, she attended the workshops held in Ajman University, and online courses, that deal with different professional and specialized aspects. Head and member of many committees; Curricula and Study Plan Committee, Department Timetable, Courses Syllabus Updating, Library' Book Selection, Accreditation, Master Degree, QS, and Assessment. Recently as the head of the department, she establishes the Lighting and Acoustical Lab for interior applications and experimentations. She was selected to be APID' Ambassador - May 2018 -(Association of Professional Interior Designers the only professional association in the MENA region) for the preparation of the biannual IFI Congress Dubai 2020 hosted by APID. Dr. Naglaa is setting the requirements for the International Accreditation for the Interior Design Program - CIDA as well as the First Master's Degree in Interior Design. Being a member of a number of professional institutions and journals editing board, she serves in evaluating, peer reviewing and judging in specialized competitions.

Dr. Gamal El Samanoudy was Professor of Interior Architecture at Minia University in Egypt and now Associate Professor at Ajman University in UAE. " He is a specialist in Museum & Exhibition Design, and having many design projects in the Arab World and France (residential and commercial). He is interested in the development of the interior design educational program through the published papers in conference proceedings. He is part of many committees such as the academic, the research, and the master committee. He creates and develops the design course syllabus in the undergraduate and postgraduate levels. Additionally, he designs and supervises several events for Ajman University, starting from the selection of the entrance's colors' schemes in J1 then in J2. He designs the exhibition stand (Sheikh Zayed Hall) of Ajman University and organizes many exhibitions in the university and different Hotels, Halls, and events, including the Registration and Reception of the New Students of the University. Prof. Gamal's students won a competition of administrative furniture, and they travel to Italy as winning prize after he designs and implements the first Exhibition stand in the Offices Exhibition in Dubai World Center. As a journal editor and academic, he evaluated several papers and articles available in his CV. In 2018, he has been selected by APID (Association of Professional Interior Designer in MENA Region) to serve in the organization of IFI Congress 2020 hosted by APID.

Dr. Chuloh Jung is an innovative, inclusive and positive faculty member with extensive experience in government-funded R/D since 2000 in the Department of Architecture, College of Architecture, Art, and Design at Ajman University. He received B. Arch. and Ph.D. from Yonsei University in Seoul, Korea. He also holds two master's degrees, namely M. Arch. and M. Des. S. from Graduate School of Design at Harvard University. He joined Ajman University in 2013. As his Ph.D. degree was about applying ubiquitous computing on residential environments, he became one of the national board members of U-City (Smart City) in Korea and head of several government-funded interdisciplinary R/D teams such as Smart Home Industrialization Center in KMU in Seoul, Korea. Now he is the director of Ajman University Innovation Center and incubates many innovative startups and keep on writing success stories within the SME ecosystem of United Arab Emirates.