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Analysing lighting spectrum design in enhancing human well-being

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ABSTRACT

Lighting design plays an essential role in interior design which it will affect human health and wellbeing physically and biologically. Therefore, this research was to analysing lighting spectrum design in enhancing human well- being. The research will be carried out in qualitative form which will study the interior of the commercial building and analysis the lighting design of it in terms of lighting spectrum and suggest the way to improve after study similar research. The problem statements in this research are limited understanding of the specific knowledge gaps related to lighting spectrum, limited access to resources and training related to lighting design, and the low comfort level of lighting spectrum design to human. This research aims to identify the inadequate or adequate of the lighting design in commercial buildings in terms of lighting spectrum, and to propose proper lighting spectrum design for commercial buildings based on the study of the selected building or interior. There was research carried out to study interior lighting design failure in residential buildings and its reasons instead of commercial building. Thus, identify the inadequate or adequate of the lighting design in commercial buildings and the way to improvement in terms of lighting spectrum will be the main part in this research. The research findings will identify the effects when public expose under inadequate or adequate interior lighting design, and the suggestions improvement for lighting design in terms of lighting spectrum that improve human wellbeing. These findings will guide the public or researchers to create better lighting design.

Introduction

Analysing lighting spectrum for an interior space is essential to enhance human well-being. Interior lighting design spectrum can influence human well- being biologically and psychologically (Pasau, Al Asy'Ary, and Sabudu 2024). In terms of biological impact of lighting, light can influence human circadian rhythms, sleep patterns, and overall health, whereas in terms of psychologically, light can affect human's mood, productivity, and emotional well-being (Davis et al. 2023). By conducting this research, a proper light spectrum will be determined and as a guideline for the professionals in industry of interior design io order to create an interior design with maximum comfort level and achieve human well- being. The lack of comprehensive understanding and accessibility to resources and training related to lighting spectrum design in Malaysia, causing the suboptimal lighting designs in Malaysia. This research will be mainly focused on improving commercial building's interior lighting design in terms of lighting spectrum, by finding out the proper lighting spectrum to enhance human well-being. The research is to determine what is the most comfort lighting spectrum to human well-being, what are the common failure lighting design in commercial buildings, and how can proper lighting spectrum

design be proposed and implemented to improve human well-being. Those finding based on the questions need to be determined in order to determine the proper lighting spectrum for an interior space that gives the users the highest comfort level, and to provide a guideline for the public to create a suitable lighting design that enhance human well-being.

Literature review

The light spectrum, also known as the electromagnetic spectrum, it is a scientific term used to describe light wavelengths (Zwinkels 2015; Sudarti and Uyun 2021). The light they can be seen by human eyesight was called visible light, in which its wavelengths were 380 to 780 nanometres (Cougnard-Gregoire et al. 2023). Light can also be recognised as an energy that comes in various wavelength, known as the light spectrum (Araújo et al. 2022).

Wavelength for 7 colours (Lindsay Jankovic 2018):

- Violet - smallest wavelength, 380-450 nanometers, Highest frequency.
- Indigo - 420 - 440 nm
- Blue - 450 - 495 nm
- Green - 495 - 570 nm
- Yellow - 570 - 590 nm
- Orange - 590 - 620 nm
- Red - biggest wavelength, 620 - 750 nanometers. Lowest frequency

In 2023, A study of the emotional impact of interior lighting colour in rural bed and breakfast space design had been carried out to determine the emotional pleasing for an individual when the individual exposed under different lighting colour in rural bed and breakfast space (Wei et al. 2023). The findings of this research indicate that, in terms of pleasure level, participants that exposed to cold white light have lower level of pleasure, participants in test room of red and yellow lights showed low pleasure level, whereas the participants in test room of blue and yellow lights showed a positive correlation with pleasure level, although the data were more variable. In term of arousal level analysis, test room of blue and red light after warm white light had high arousal level, whereas test room of blue and green light after both cold and warm white light showed low arousal level. Finally, in terms of relaxation level, blue-green and blue-yellow lights after exposure to warm light had higher relaxation levels, however all colour light combinations after exposure to cold white light showed lower relaxation levels compared to warm white light (Mostafavi, Xu, and Kalantari 2024).

In addition, for the anxiety states, exposure to red- yellow light after warm white light resulted in an unsettling feeling and increased anxiety values, and blue-red light generally led to lower visual comfort and higher anxiety states compared to other colour- light combinations (Wei et al. 2023).

In 2022, a study on the "Effects of coloured lights on an individual's affective impressions in the observation process" has been carried out to study individual's affective impressions from different coloured lights. It's finding shows that the blue light has a calming effect when an individual exposed under it, and the yellow light can create bright impressions and it is comfortable for processing visual information. Besides that, red light can produce a warm feeling ambient and cozy atmosphere, whereas the green light can create cool and refreshing ambient (Salsabila, Amir, and Nastiti 2023; Jiang et al. 2023).

In 2021 June, a study on "Effects of coloured lighting in the real-world environment and virtual reality" has been published on ResearchGate. The part of the research can be used to study the effects of coloured light to human mood, as this research conducted effects of coloured lighting in both real- world and virtual reality. In real-world, white colour light does not have any effect on human mood, and the blue colour light can create high level of relaxation to human. However, the red colour light will produce high level of anxiety to human mood (Zhang, Fort Mir, and Mateu 2022).

These 3 researches mainly focus on what are the effects of coloured lighting can cause to human psychologically. Throughout these researches published, there were lack of research how to improve lighting design in terms of light spectrum of a commercial interior. By using the finding and theory that found out from the previous researches, a guideline in terms of light spectrum for a commercial interior can be suggested or determined to enhance human well-being.

Methods

In this research, there are 3 case studies for commercial building or interior will be conducted to analysis the ambient created by different light spectrum and the effect will it brought to the human well-being. The findings from the literature review will be used to analysis the effects of the spectrum in selected buildings or interior. There are 3 commercial buildings had been chosen as the case studies for this research, which are the Control Bar in Zhangzhou designed by Cun Panda Nana (Archello 2021; Cun Panda Nana 2022), D-Edge electronic music club in Brazil (Saville 2012; Zemel+ ARQUITETOS 2010) and Restaurante El Merca'o in Spain. These 3 buildings or interior were selected as they have different light spectrum used for the interior, in which the Control Bar in Zhangzhou has blue, red, yellow spectrum, the D- Edge electronic music club in Brazil has red spectrum, and the Restaurante El Merca'o in Spain had green spectrum used for the interior. After that, a comparison of the psychological effects between each light spectrum cause will be made to determine the best light spectrum that benefits to human well- being in a commercial building or interior.

Case study
Case study 1: Control Bar in Zhangzhou

Figure 1 and 2. Archello, Control Bar in Zhangzhou
Source: (Archello 2021)

The Control Bar in Zhangzhou was designed by Cun Panda Nana in 2021. The interior spaces were designed in different light spectrum, and its major space and some few more spaces was designed using blue light spectrum. The interior building materials used mostly were the metal or aluminium board in which it can maximise the reflection of the blue light spectrum and allow the users to have better experiencing in the interior. The use of the metal or aluminium board on the wall can also maximised the psychological effects of blue light spectrum to human. And the blue light sources were mainly located at the lower part of the metal board.

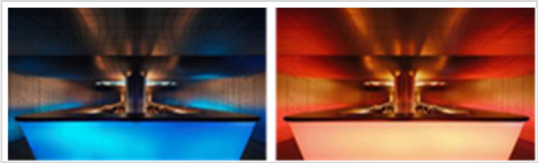

Figure 3 and 4. Bar station. Archello, Control Bar in Zhangzhou
Source: (Archello 2021)

For the bar station, the lighting's colour can be changed from blue light spectrum to red light spectrum. The installation of lighting under the bar station were designed to have both light sources where were red and blue. The lighting colour of the bar station can be changed for different purpose or even when playing different type of music to make it fit with the scenario or ambient wanted.

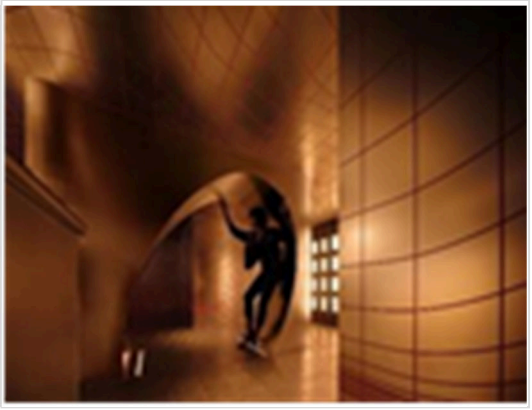

Figure 5. Walkway. Archello, Control Bar in Zhangzhou
Source: (Archello 2021)

For the minor spaces, the lighting design were in yellow light spectrum. The minor spaces such

as the corridor or the walkway that connect between spaces were designed in yellow spectrum.

Case study 2: D-Edge electronic music club in Brazil

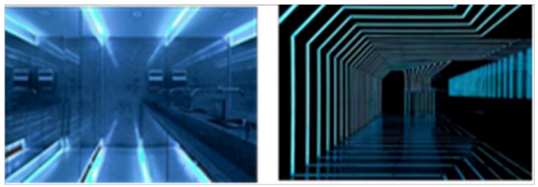

Figure 6 and 7. Archdaily, D-Edge electronic music club in Brazil
Source: (ArchDaily 2010)

The D-Edge electronic music club in Brazil had use multiple light spectrums for the interior spaces design. The spaces such as washroom or lounge area were designed using blue light spectrum. Besides that, the designer had also use high reflective materials for the interior spaces such as mirror, or gloss finishes black board to maximise the reflection of the lighting spectrum. Similar to the Case Study 1, Control Bar in Zhangzhou, the lighting installation of it were specially designed to allow it can emit various light spectrums to the spaces.

Figure 8. Private lounge area. Archdaily, D-Edge electronic music club in Brazil
Source: (ArchDaily 2010)

The lighting of the private lounge area was designed to emit different light spectrum based on the ambient the users wanted to achieve. Same as the public lounge area, the lighting can be change to different spectrum according to the user's mood or even the type of the music.

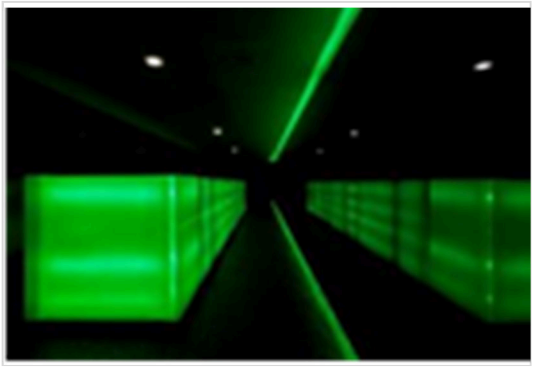

Figure 9. Walkway. Archdaily, D-Edge electronic music club in Brazil
Source: (ArchDaily 2010)

The walkway was designed in green spectrum, so that the user can have multiple different experiences on different light spectrums when the users were passed by from it.

Case study 3: Restaurante El Merca'o in Spain [Gaete, J.]

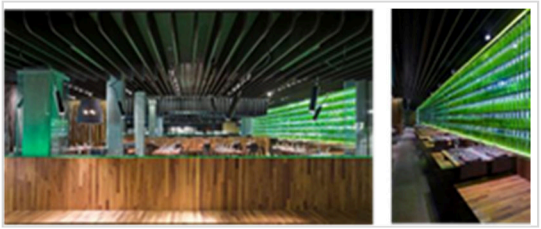

Figure 10 and 11. Archdaily, Restaurante El Merca'o in Spain
Source: (ArchDaily 2008)

The Restaurante El Merca'o in Spain had designed with some green spectrum lighting. There was green colour linear lighting strip surround the dining area right next to the dining table. There were almost some green colour glass bottles designed as exhibition between the wall and glasses, which made the lighting travel through from the outside also became green light spectrum. The users will be exposed under green light spectrum when the dining in this restaurant.

The most suitable commercial building that can be act as a guideline to enhance human well-being is the case study 2, the D-Edge electronic music club in Brazil as its lighting spectrums were controllable based on the ambient wanted, and the light spectrums used for each space were reasonable and the effects of the light's spectrum were suitable for each various function's spaces and rooms.

Results and discussion

Among the 3 case studies that carried out earlier of this research, the D-Edge electronic music hub in Brazil is the best example of a commercial building that have the best light spectrum design for each respective space with different functions.

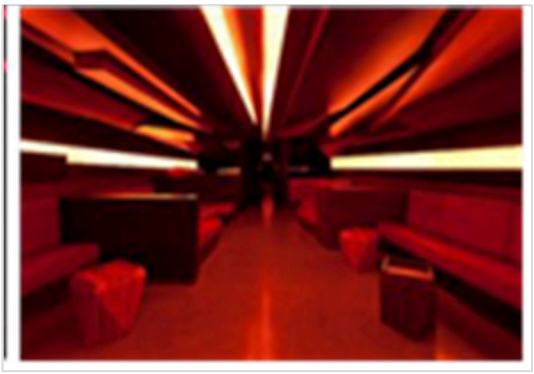

Figure 12. Private lounge area. Archdaily, D- Edge electronic music club in Brazil
Source: (ArchDaily 2010)

Based on the study of "Effects of coloured lighting in the real-world environment and virtual reality" that have been carried out and published in 2021 (Xia et al. 2021), the red colour light will increase the level of anxiety for the users. The light spectrum designed for both private lounge and public lounge area in the D-Edge electronic music hub were quite good and reasonable because the red-light spectrum increase the user excitement level and allow the users to more easily to enjoy the rock and roll or fast paced music and finally achieve satisfaction psychologically.

Besides that, in the study of "Effects of coloured lights on an individual's affective impressions in the observation process" which has been carried out in 2022 (Xie et al. 2022), the study shows that red light spectrum can also affect human' mood become warmer and cozy. For the spaces such as lounge area which its main function is to provide resting place for the users, red light spectrum is the one of the best light spectrums can be used.

In addition, the light spectrum for the private and public lounge area were controllable, in which the light spectrum can be change according to user's need. Thus, in a commercial building, red light spectrum should be used in resting area, waiting area, lounge area, dining area, etc in which the main space function was to provide resting area to the users.

Figure 13 and 14. Washroom. Archdaily, D-Edge electronic music club in Brazil
Source: (ArchDaily 2010)

Based on the study of "Effects of coloured lighting in the real-world environment and virtual reality", the blue light spectrum can create high level of relaxation to human (Xie et al. 2022). Blue light spectrum should be used for those functional spaces such as washroom, entrance staircase, etc.

That is because blue light can enlighten the spaces, and allow the users use the spaces properly without causing any damage or danger.

The reasons were because blue light spectrum can help on calming the users down by lower down user's blood pressure. The stress level will be lesser under blue light spectrum, so that the users can really enjoy the moment with clear mindset. In this music hub, soften music or lyric songs can be played under blue light spectrum to enhance the immersive feeling that the songs or music brought to the users.

In short, blue light spectrum should be used for functional spaces in a commercial building, such as toilet, staircase, retail, etc. In which the users must be calm enough to use the function of the spaces.

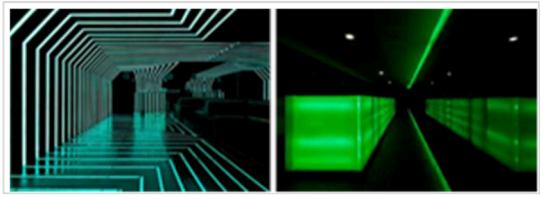

Figure 15 and 16. Lounge and corridor. Archdaily, D-Edge electronic music club in Brazil
Source: (ArchDaily 2010)

In D-Edge electronic music hub, green light spectrum had been used at the corridor and lounge area. The green light spectrum can bring cool and refreshing mood to the users that exposed under it based on the study of "Effects of coloured lights

on an individual's affective impressions in the observation process" (Xie et al. 2022). The green light spectrum used in corridor were an excellence decision. The reason behind it is because the corridor or the walkway are act as a transition space between 2 spaces. The lighting spectrum in both ends of a corridor might be different or even counteraction, in which might cause mental damage to user if without a buffer space such as corridor.

In addition, green light spectrum is also good for human eyesight and reduce visual fatigue after the users took large amounts of visual impacts in terms of lighting spectrum.

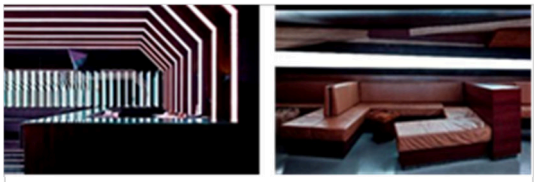

Figure 17 and 18. Public and private lounge. Archdaily, D-Edge electronic music club in Brazil Source: (ArchDaily 2010)

The best part of the lighting design in D-Edge electronic music hub were the controllable lighting spectrum design of most of the spaces and the commercial building should learn from it in term for light spectrum design. It is because in private and public lounge area, as the light spectrums used were too much and each light spectrum have different effect towards human in terms of psychologically, a white colour light was also designed in these spaces. The white colour light can be turned occasionally to avoid the users experience negative effects such as dizzy when they change the light spectrum too often.

In a well design lighting spectrum building, especially commercial building, white lights spectrum was the most importance light spectrum as it can act as an insurance lighting if the users feeling unwell under certain lighting spectrum. The white light can remove or reduce the negative effect cause by any lighting spectrum.

Conclusions

As the result, the D-Edge electronic music hub in Brazil can be act as the guideline when designing a commercial building with proper lighting spectrum. The controllable lighting spectrum design can be very flexible when creating the ambient wanted. For the spaces such as lounge area or washroom and toilet can be designed using more blue light spectrum as it can allow those users that exposed under it feeling calmer and more relaxing. The spaces such as music hub, or bar that the ambient of it were very intense, can be designed in red light spectrum, whereas the green light spectrum can be used for some place that required more refreshing ambient such as restaurant or lounge area. However, the white light is still needed for better visual of the environment and maintenance, and it is better if it installs together with the coloured light so it can provide a backup option for the interior lighting if the users feeling uncomfortable in certain light spectrum.

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Author(s) contribution

Wong Ming Yang contributed to the research concepts preparation, methodologies, investigations, data analysis, visualization, articles drafting and revisions.

Safial Aqbar Zakaria contribute to the research concepts preparation and literature reviews, data analysis, of article drafts preparation and validation.

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