Impact of Interior Lighting Color in Rural Bed Design

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In architectural spaces, the atmosphere created by lighting plays an important role in influencing people's emotions, often relying on the use of colour and light. The combination of cool white light and warm white light with coloured light significantly affected participants' arousal levels, but had relatively little effect on levels of pleasure, dominance and relaxation. When comparing the emotions experienced after exposure to cool white light and warm white light, warm white light triggered more positive emotions.

lighting design | cool and warm white light | visual perception | mood

1. Introduction

The service sector has always been an important part of the economy in all countries, accounting for 61 per cent of employment in China and 73 per cent of employment in the non-agricultural sector. The improvement of service offerings and service quality has become particularly important in the tourism industry in the context of a service model that is oriented towards customer value and providing differentiated benefits to consumers [1]. The quality of a company's environment is defined as the ability to meet customer expectations, and customer satisfaction is considered an important predictor of these behavioural trends. Factors such as physical space and environmental ambience affect consumer mood and managers must make decisions and adjustments based on consumer preferences, especially in the field of interior landscaping, where there are many key elements that can be used to change the overall ambience and quality of the indoor environment without increasing costs [2].

In this context, immersive experiences have become a new and rapidly growing global craze [3]. Immersive light and shadow space combines and matches light and shadow space, which can present a multi-sensory experience to the audience and bring a more novel consumption experience [4]. Then, in the development of rural tourism, to help people experience more new feelings, the rural landscape, rural culture and other experiences into the rural accommodation space, has also become the key to the development of rural tourism.

2. Rural accommodation space

Villages around the world face many common rural problems, including ageing populations, rural poverty, the need for rural modernisation and industrial transformation, and insufficient infrastructure and educational and medical resources. In order to promote rural development, countries around the world have implemented a series of rural revitalisation initiatives based on their own actual conditions, and the rural tourism service industry has emerged,

with B&Bs, as an indispensable part of the rural tourism industry, being welcomed by the audience. After the reform and opening up, there is a huge gap and imbalance between urban and rural areas in terms of survival and development environment. Since the introduction of the No. 1 Document of the Central Government in 2021, the national practice of "comprehensively promoting the revitalisation of the countryside" has come into effect; the rural revitalisation industry is in full swing [5].

Japan was in a stage of rapid industrialisation and urbanisation in the 1970s and 1980s, and the country's one-sided focus on urban industrial and commercial development led to a lag in rural development [6]. In order to revitalise the countryside, Japan launched a national village-building movement based on rural, self-reliance and future directions. Under the strong advocacy and support of the government, each region has cultivated a model of rural development rich in local characteristics based on its own actual situation and local conditions, which is renowned worldwide and echoes the idea of "one village, one product" [7]. In this process, B&B, as an important part of the sustainable development of the rural tourism industry, can greatly promote the local economic development, increase employment opportunities, and improve the living conditions of local residents; therefore, the Japanese government has given many subsidies and invested in the development of rural B&B, focusing on the creation of a farmhouse experience B&B, which can present the experience of local customs and local conditions [8].

Rural revitalisation in Germany is more like a long-term social practice, adopting a progressive governance model [9], where the government regulates and guides rural reforms through the adjustment of laws and regulations at the institutional level, and gradually pushes the countryside towards development and prosperity [10]. In Germany, the concept of sustainable development is integrated into village renewal and practice, and local old houses are renovated to ensure the comfort and safety of rural B&Bs and to maintain the rural environment and regional specificity [11]. Meanwhile, German countryside B&Bs are mainly located in traditional buildings in rural areas, which greatly protects and inherits the local traditional culture and architectural style, and their unique characteristics have attracted a large number of urban populations to experience and enjoy them [12][13][14][15].

Switzerland enhances rural tourism with its unique and beautiful ecological environment, and the Swiss government attaches great importance to the beautification of the natural environment and the improvement of rural infrastructure, focusing on the development of rural tourism [16]. Swiss folk accommodation focuses on immersive and idyllic style experiences, preserving and nurturing local customs in this transformation process [17]. Swiss folk music, the Alps, Swiss wrestling and other endemic features attract a large number of tourists to stay for a long period of time, and the local folk lodging industry generates a huge amount of income, which drives the development of the local economy [18].

3. the significance of indoor space lighting colour research

Colour and light are two important attributes in environmental spaces that can be used in the design and transformation of interior spaces to improve human visual perception, mood and performance. When people enter an interior space they are most concerned about the colour of the lighting, choosing between cool white and warm

white lights of the same colour, or for some more adventurous people, trying colourful lighting. Lighting colour may affect the mood of the occupants. Chromotherapy and colour therapy are also modalities in the field of medical treatment where colour and light can be used to correct physical ailments.Rikard Küller and Seifeddin Gaafar Ballal et al. studied the psycho-emotional effects of light and colour in indoor work environments and found that the light and colour of the workplace itself affects the moods of the workers; when the lights are too dim, the workers were at their lowest point, when the lighting was just right their mood improved and reached its highest level, and when the lighting became too bright the mood dropped again [19].

Jiyoung Oh conducted a study on how changing environmental chromaticity affects heart rate variability (HRV) and stress, and concluded that the higher the chromaticity of the high-value conditions, the more positive was the mood of stress, and the lower the chromaticity, the more negative was the mood of stress [20]. Tsuyoshi Moriyama found that conventional indoor lighting consists of white light only, that the industry standard for optimal use of lighting is adjusted according to the colour temperature, and that the lighting used in daily life has been extended to allow for the use of full-colour lighting; however, the aforementioned standard has not yet taken into account the effects of coloured lighting on the human body. Therefore, Moriyama et al. investigated the effects of coloured lighting conditions on human cognitive abilities and found that most older adults showed greater emotional cognitive improvements under different coloured lighting conditions [21].

Na Yu investigated the effects of correlated colour temperature (CCT) in museums on visitors' perceptions and preferences in museum exhibitions and found that correlated colour temperature (CCT) was associated with eye movements, heart rate variability (HRV) and many perceptual dimensions were significantly correlated [22]. The correlations were significant [22]. Tiina Rosenqvist found that the main function of human colour vision is to enhance the performance of certain relevant abilities and that vision can be adapted and interpreted by the brain to cope with a wide variety of colour vision phenomena [23]. Xin Zhang, in order to change the dull and rigid atmosphere of some interiors, combined spatial principles, colours and visual illusion design techniques to design an aesthetic visual illusion scheme. As a result, the psychological effects of the experimenters were collected and the results showed that 90% of the experimenters had the same psychological sensation of the same colour and the colour and visual illusion experiments were verified through successful applications in graphic, interior and medical practices [24]. Xiao Hui investigated the effects of environmental lighting modulation on human physiological responses and psychological activities, and found that an increase in nighttime illuminance and correlated colour temperature (CCT) was positively correlated with melatonin suppression, thus affecting circadian rhythm responses and psychological activities. Meanwhile, high correlated colour temperature (CCT) facilitated the stimulation of positive emotions; high illuminance was positively correlated with subjective alertness during the day, with an increase in positive emotions in the morning and a decrease in positive emotions in the afternoon [25]. A study by Yingying Zhu investigated the effects of indoor illuminance and correlated colour temperature (CCT) on cognitive performance, subjective mood, and alertness during daytime office hours in healthy adults, as well as differences in temporal effects, and showed that inhibition, working memory, and facial expression task recognition were the slowest in low "warm" light [26].

4. Effects of white light in space on mood

Bright light can enhance both positive and negative emotions, and warm white tones or warm lighting help us achieve deeper levels of relaxation and feel more comfortable [27]. One study showed that ambient lighting was more effective at calming anxious older adults than neutral atmospheres [28]. Lighting clearly attracts attention; in a study by Eugene W. Sucov and Lyle H. Taylor, when people had to cross a path, they tended to choose a lighter, brighter, and more light-feeling path over a dimly lit one [29]. Cooler shades of white light can help improve visual clarity at work [30], and a study conducted by B. Plitnick showed that blue light stimulates the brain more than any other light, with study participants rating themselves as "less sleepy", with faster reaction times and less concentration in performance tests [31]. On the other hand, natural white light can be a mood booster as it can help people feel more energised, alert and motivated as it increases the body's serotonin levels [32]. According to Liberman J in his book Light: the Future of Medicine, "Most people prefer daylight environments because sunlight consists of a balanced spectrum of colours, with a slight energy peak in the blue-green region of the visible spectrum" [33]. In Lighting: design and analysis, Robbins C states that exposure to natural light improves mood, boosts morale and reduces fatigue. It reduces depressive symptoms and improves our sense of well-being [34]. One of the important indicators of lighting quality is correlated colour temperature (CCT), and in general, studies on the effects of correlated colour temperature (CCT) have shown that high correlated colour temperature (CCT) (warm light) reduces positive mood compared to low CCT (warm light) with the same illuminance [35]. A study by Nguyen, T.K.L., found that different wavelengths of white LED illumination also have an effect on the growth and quality of lettuce in a vertical farming system [36]. Seong Jae Kim investigated whether white light could positively affect sleep and cognition in patients with mild-to-moderate Alzheimer's disease, and found that white light enriched with blue light had a significantly better effect on the Pittsburgh Sleep Quality Index, and also had a better improvement in the effect on the total sleep time [37]. Kyungah Choi stated that blue light-rich LED lights are a simple and effective potential countermeasure to the problem of college students' drowsiness and dozing off in class, especially in indoor spaces of schools with insufficient daylight [38]. The research article investigated whether young children could associate colour with mood and whether there were any changes in development, finding that white was the most popular colour in the bedroom [39]. Wang, J investigated the effect of breathing light in light cool and warm white colours on the effects of users' mood regulators and found that over a 5-second cycle, breathing light significantly reduced the EDA values and heart rates of people experiencing extreme emotions, which in turn reduced the level of tension, while colour temperature had little effect on the effectiveness of the breathing light intervention [40]. Dr Seung Hyun Cha investigated whether indoor colour schemes affect mood, task performance and heart rate in virtual environments (IVEs) and found that significantly fewer mistakes were made in white immersive spaces [41]. The above study proved that white light has a greater impact on people's emotional perception in daily life, and that the rational use of white light can soothe people's emotions. In addition, white light CCT with different colour temperatures has been the focus of researchers' attention, with the most attention being paid to the effects of cool white light and warm white light on people's emotional perception.

5. Emotional responses to coloured light in space

The colours and lighting conditions of urban architectural spaces have an effect on human emotions and bodies, and one of the criteria for good architectural spaces is the selection of appropriate colours and lighting conditions for the space. Xie Xing studied the effect of coloured lights on individual emotions and concluded that red light decreases the feelings of calmness, relaxation, stability and pleasure and increases the feelings of irritation and tension; blue light decreases the feelings of relaxation and stability and increases the feelings of irritation; green light decreases the feelings of pleasure; and yellow light decreases the feelings of irritation. At the same time, this study showed that the interaction between artefact type and illumination correlates with the perception of visual objects [42]. The brain is an electrochemical machine that is affected by all the frequencies it experiences, which are generated by light, sound and colour. Information enters the amygdala, which is a key area for emotion regulation, and is then processed into the emotional body for interpretive responses. With this in mind, Judy Theodorson explored human responses to coloured lighting in space using light emitting diodes (LEDs) with the aim of understanding preferences and emotional responses, demonstrating that stimuli from monochromatic lighting (red, blue and green) conferred a distinctive subjective impression of spatial environments, and that warm colours were preferred when mixed-colour illumination was introduced, and that red illumination was consistently perceived to be the most vibrant [43].

However, interior colour psychology is much more complex than the meaning of colour. This is because there are several colour attributes that can also evoke specific emotions and feelings in occupants. Some of the most common colour or hue attributes that should be considered when creating an interior design palette include tint, shade, hue, value, saturation, and chroma.Reham Sanad found that interior design students responded to all bright greens less than oranges in four different interior colour schemes. Red is responsible for evoking negative emotional views, including anger, tension, and exhaustion. Blue can be effectively used to design interior spaces for people experiencing negative emotions to stimulate and enhance their emotional feelings [44]. An office study of biophilic design and blue light by Jiarong Xie found that blue-illuminated spaces resulted in lower ratings of most perceptual attributes [45]. Dr H Lee, by examining the emotional impact of coloured lighting on races with different cultural gaps, found that there was a significant effect of different races on the perception of lighter colours, but not on arousal, and that Asians were significantly less attracted to the colours red and purple in lighting were significantly less pleasant than all other colours and tended to be happier than Caucasians, who were less pleasant [46]. Ashwini Sunil Nair studied the effect of light colours in the built environment on the behaviour of children with autism using a number of neutral tones, soft tones proved to be autism friendly and had a calming and soothing effect whereas bright, bold and strong colours led to autistic children's behavioural changes and they are prone to light sensitivity [47]. Ahmadreza Khalili used augmented reality to simulate various environments based on different light and colour parameters and found that neutral colours are more attractive than other colours in two-colour spaces [48].

References

1. Liu, C.; Dou, X.; Li, J.; Cai, L.A. Analyzing government role in rural tourism development: An empirical investigation from China. J. Rural Stud. 2020, 79, 177–188.
2. Chi, X.; Lee, S.K.; Ahn, Y.-J.; Kiatkawsin, K. Tourist-Perceived Quality and Loyalty Intentions towards Rural Tourism in China. Sustainability 2020, 12, 3614.
3. Jeon, J.-E. The impact of XR applications' user experience-based design innovativeness on loyalty. Cogent Bus. Manag. 2023, 10, 2161761.
4. Cui, Z.; Cao, K.; Xu, H. On the Possibilities of Light Environment Art in Digital Scenes: From the Perspective of Metaverse Research; Springer International Publishing: Cham, Switzerland, 2022.
5. Shi, J.; Yang, X. Sustainable Development Levels and Influence Factors in Rural China Based on Rural Revitalization Strategy. Sustainability 2022, 14, 8908.
6. Takahashi, Y.; Kubota, H.; Shigeto, S.; Yoshida, T.; Yamagata, Y. Diverse values of urban-to-rural migration: A case study of Hokuto City, Japan. J. Rural Stud. 2021, 87, 292–299.
7. Shen, J.; Chou, R. Rural revitalization of Xiamei: The development experiences of integrating tea tourism with ancient village preservation. J. Rural Stud. 2022, 90, 42–52.
8. Rustiadi, E.; Saizen, I.; Pravitasari, A.; Wulandari, S.; Mulya, S.; Rosandi, V. AsianRuralFuture2030; The Association of Rural Planning: Tokyo, Japan, 2022.
9. Gerend, J. Lessons in Rural Persuasion: Village Infill Development in Bavaria, Germany. Sustainability 2020, 12, 8678.
10. Zabel, R.; Kwon, Y. Evolution of urban development and regeneration funding programs in German cities. Cities 2021, 111, 103008.
11. Xu, L.; Zhao, H.; Chernova, V.; Strielkowski, W.; Chen, G. Research on Rural Revitalization and Governance From the Perspective of Sustainable Development. Front. Environ. Sci. 2022, 10, 839994.
12. Schiller, M.; Jonitz, E.; Eur, P.S.; Pettrachin, A.; Caponio, T. Local Integration Policies and Multi-Level Policymaking Interactions in Small-and Medium-Sized Towns and Rural Areas; Whole-COMM: Brooklyn, NY, USA, 2022.
13. Sept, A. Thinking together digitalization and social innovation in rural areas: An exploration of rural digitalization projects in Germany. Eur. Countrys. 2020, 12, 193–208.
14. Maroto-Martos, J.C.; Voth, A.; Pinos-Navarrete, A. The Importance of Tourism in Rural Development in Spain and Germany. In Neoendogenous Development in European Rural Areas: Results and Lessons; Cejudo, E., Navarro, F., Cejudo, E., Navarro, F., Eds.; Springer International Publishing: Cham, Switzerland, 2020; pp. 181–205.

15. Petrovič, F.; Petrikovičová, L. Landscape tranformation of small rural settlements with dispersed type of settlement in Slovakia. Eur. Countrys. 2021, 13, 455–478.
16. Van Der Borg, J. The role of the impacts of tourism on destinations in determining the tourism-carrying capacity: Evidence from Venice, Italy. In Handbook of Tourism Impacts; Edward Elgar Publishing: Cheltenhem, UK, 2022; pp. 103–116.
17. Fischer, A.; Adolf, H.; Bender, O. Are the Skiing Industry, Globalisation, and Urbanisation of Alpine Landscapes Threatening Human Health and Ecosystem Diversity? Springer: Berlin/Heidelberg, Germany, 2022.
18. Neacsu, N.A.; Zamfirache, A. Sustainability Measures Implemented in the Hotel Industry. Case study: Romania. In Proceedings of the International Conference on New Trends in Sustainable Business and Consumption, Graz, Austria, 25–27 May 2022; pp. 186–192.
19. Küller, R.; Ballal, S.; Laike, T.; Mikellides, B.; Tonello, G. The impact of light and colour on psychological mood: A cross-cultural study of indoor work environments. Ergonomics 2006, 49, 1496–1507.
20. Oh, J.; Park, H. Effects of Changes in Environmental Color Chroma on Heart Rate Variability and Stress by Gender. Int. J. Environ. Res. Public Health 2022, 19, 5711.
21. Moriyama, T.; Shimada, T.; Sakai, T.; Nakamura, S.; Kasahara, K.; Urata, I. Comparative Analysis on the Effect of Illumination Color in Clinical Environment of Preventive Care. J. Photogr. Soc. Jpn. 2020, 83, 114–115.
22. Yu, N.; Lv, Y.; Liu, X.; Jiang, S.; Xie, H.; Zhang, X.; Xu, K. Impact of Correlated Color Temperature on Visitors' Perception and Preference in Virtual Reality Museum Exhibitions. Int. J. Environ. Res. Public Health 2023, 20, 2811.
23. Rosenqvist, T. Color and Competence: A New View of Color Perception. In Life and Mind: New Directions in the Philosophy of Biology and Cognitive Sciences; Springer International Publishing: Cham, Switzerland, 2023; pp. 73–103.
24. Zhang, X.; Zhang, X. Test and Design of Colors and Visual Illusion Based on Changing Spatial Characte. E3S Web Conf. 2020, 179, 02131.
25. Xiao, H.; Cai, H.; Li, X. Non-visual effects of indoor light environment on humans: A review☆. Physiol. Behav. 2021, 228, 113195.
26. Zhu, Y.; Yang, M.; Yao, Y.; Xiong, X.; Li, X.; Zhou, G.; Ma, N. Effects of illuminance and correlated color temperature on daytime cognitive performance, subjective mood, and alertness in healthy adults. Environ. Behav. 2019, 51, 199–230.
27. Kong, Z.; Liu, Q.; Li, X.; Hou, K.; Xing, Q. Indoor lighting effects on subjective impressions and mood states: A critical review. Build. Environ. 2022, 224, 109591.

28. Chen, Y.; Guo, Y.; Liu, Q.; Liu, Y.; Lei, Y. Therapeutic lighting in the elderly living spaces via a daylight and artificial lighting integrated scheme. Energy Build. 2023, 285, 112886.
29. Taylor, L.H.; Socov, E.W. The movement of people toward lights. J. Illum. Eng. Soc. 1974, 3, 237–241.
30. He, S.; Yan, Y. Impact of advance light exposure on assembly-line workers' subjective work alertness and sleep quality. Light. Res. Technol. 2023, 55, 105–128.
31. Plitnick, B.; Figueiro, M.G.; Wood, B.; Rea, M.S. The effects of red and blue light on alertness and mood at night. Light. Res. Technol. 2010, 42, 449–458.
32. Nishi, R.; Fukumoto, T.; Asakawa, A. Possible effect of natural light on emotion recognition and the prefrontal cortex: A scoping review of near-infrared (NIR) spectroscopy. In Advances in Clinical and Experimental Medicine; Official Organ Wroclaw Medical University: Wrocław, Poland, 2023.
33. Liberman, J. Light: Medicine of the Future: How We Can Use It to Heal Ourselves Now; Inner Traditions/Bear & Co.: Rochester, VT, USA, 1990.
34. Robbins, C.L. Daylighting: Design and Analysis; OSTI.GOV; Van Nostrand Reinhold: New York, NY, USA, 1985.
35. Li, Y.; Ru, T.; Chen, Q.; Qian, L.; Luo, X.; Zhou, G. Effects of illuminance and correlated color temperature of indoor light on emotion perception. Sci. Rep. 2021, 11, 14351.
36. Nguyen, T.K.L.; Cho, K.M.; Lee, H.Y.; Cho, D.Y.; Lee, G.O.; Jang, S.N.; Lee, Y.; Kim, D.; Son, K.-H. Effects of White LED Lighting with Specific Shorter Blue and/or Green Wavelength on the Growth and Quality of Two Lettuce Cultivars in a Vertical Farming System. Agronomy 2021, 11, 2111.
37. Kim, S.J.; Lee, S.H.; Suh, I.B.; Jang, J.W.; Jhoo, J.H.; Lee, J.H. Positive effect of timed blue-enriched white light on sleep and cognition in patients with mild and moderate Alzheimer's disease. Sci. Rep. 2021, 11, 10174.
38. Choi, K.; Shin, C.; Kim, T.; Chung, H.J.; Suk, H.J. Awakening effects of blue-enriched morning light exposure on university students' physiological and subjective responses. Sci. Rep. 2019, 9, 345.
39. Baniani, M. The association between colors, color preferences, and emotions among Japanese students: From elementary school to university. Color Res. Appl. 2022, 47, 992–1004.
40. Wang, J.; Lu, J.; Xu, Z.; Wang, X. When Lights Can Breathe: Investigating the Influences of Breathing Lights on Users' Emotion. Int. J. Environ. Res. Public Health 2022, 19, 13205.
41. Cha, S.H.; Zhang, S.; Kim, T.W. Effects of interior color schemes on emotion, task performance, and heart rate in immersive virtual environments. J. Inter. Des. 2020, 45, 51–65.

42. Xie, X.; Cai, J.; Fang, H.; Tang, X.; Yamanaka, T. Effects of colored lights on an individual's affective impressions in the observation process. Front. Psychol. 2022, 13, 938636.
43. Theodorson, J.; Scott, J. Colored LED Lighting as a Primary Interior Spatial Condition, Human Preference and Affectual Response. In Proceedings of the 4th International Congress on Ambiances, Alloaesthesia: Senses, Inventions, Worlds, Réseau International Ambiances, E-conference, 2–4 December 2020; pp. 102–107.
44. Sanad, R.; Ali, F.S. A Study of Interior Design Colour Scheme Impact on Undergraduate Students' Mood. Asian J. Arts Cult. Tour. 2023, 5, 1–8.
45. Xie, J.; Sawyer, A.O.; Ge, S.; Li, T. Subjective Impression of an Office with Biophilic Design and Blue Lighting: A Pilot Study. Buildings 2023, 13, 42.
46. Lee, H.; Lee, E. Effects of coloured lighting on pleasure and arousal in relation to cultural differences. Light. Res. Technol. 2022, 54, 145–162.
47. Nair, A.S.; Priya, R.S.; Rajagopal, P.; Pradeepa, C.; Senthil, R.; Dhanalakshmi, S.; Lai, K.W.; Wu, X.; Zuo, X. A case study on the effect of light and colors in the built environment on autistic children's behavior. Front. Psychiatry 2022, 13, 1042641.
48. Khalili, A.; Soltanzadeh, H.; Ghoddusifar, S.H. Effect of lights and colors on the environmental perception and legibility using augmented reality technology. Iran. Evol. Educ. Psychol. J. 2020, 2, 148–159.