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An Investigation of the Influence of the Night Lighting in a Urban Park on Individuals' Emotions

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Abstract: Outdoor urban lighting design is a complex issue. It involves multiple aspects (energy consumption, lighting pollution, aesthetics, and safety) that must be balanced to make sustainable decisions. Although the energy and environmental issues assumed a driving role in the optimization of the urban lighting design, its impact on the psychophysical well-being of individuals has received less attention. Artificial lighting has been shown to add several meanings to an individual's experience of space: affective (affect, emotion, mood), cognitive (attention, imagination, perception), associative (memory, judgment), and motivational (closeness, openness, communication). Traditionally, studies on the effects of lighting on individuals' emotions have mainly focused on indoor spaces, while the present study aims to investigate the influence of lighting on individuals' emotions in an outdoor environment. Participants experienced a simulated urban park through virtual reality. Specifically, the urban park was shown with different combinations of overall illuminance (high vs medium vs low) and correlated colour temperature (CCT) (warm vs intermediate vs cool). For each combination, participants were asked to judge how they felt. In general, results showed that high-intensity cool light made participants more nervous, while warm light made individuals feel more tired and less motivated to explore the park. In contrast, an intermediate CCT at low or medium illuminance impacted individuals positively. Finally, it was found that participants' mood predicted the impact that park lighting would have on them. These results suggest that assessing the influence of lighting on individuals' emotions allows the decision-makers to implement the type of artificial lighting that will simultaneously safeguard both the well-being of individuals and the environment.

Keywords: urban parks; lighting; virtual reality; emotional assessment; sustainability

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1. Introduction

Outdoor urban lighting design is a complex issue. It involves multiple aspects, e.g., energy consumption, lighting pollution, aesthetics and safety, which must be considered and balanced to make sustainable decisions. Recent research has demonstrated that public lighting in urban environments is becoming more and more satisfactory and cost-effective due to the use of LED technology [1] in new or retrofit interventions [2], reducing energy consumption. Nevertheless, the reduction of illumination cost has also been responsible for the increase of illuminated areas at a rate of 2.2% per year [3]. This growth leads to several consequences, as Artificial Light at Night (ALAN) is responsible for detrimental effects on plant [4] and animal life and behavior [5,6]. ALAN may induce a physiological response in plants, affecting their phenology, growth form, and resource allocation [7]. In flying insects, it may increase mortality due to collisions with hot lamps, exhaustion, or increased predation, or can turn them disoriented or inactive, leading to a failure to reproduce [8,9].

Lamps emitting light of 3223 K were found to attract more insects than at lower CCT, lamps emitting yellowish (2759 K) or amber (2254 K) light [10]. In addition, luminaires for outdoor application should be selected to ensure suitable light conditions [11–13], as well as to limit lighting pollution and the effect of blue light on human well-being [14,15]. Although the energy and environmental issues assumed a driving role in the optimization of the urban lighting design, its impact on the psychophysical well-being of individuals deserves more attention.

Urban parks are essential in urban environments for allowing people to engage in various social activities [16] and bringing many benefits to their users, thus playing a key role in improving the quality of life and well-being [17]. Effectively designed urban parks encourage relaxation and stress relief [18], and enhance the dwellers' social relations. Moreover, there is growing interest in the restorative effects and emotional impacts of urban parks on users [19,20]. In this context, lighting also plays a key role in maintaining the benefits of urban parks during nighttime [21]. In fact, lighting can influence individuals' moods and, depending on the amount and distribution of light, can also influence the sense of security and social ties [22]. Furthermore, it has been found that different lighting conditions are associated with different reactions, such as self-regulation behaviors [23–25] and visual performance [26–29]. Lighting can also affect emotions and feelings of safety. With regard to the first, the exposure to light at night, which has become pervasive, may have adverse effects on mood. The rate of major depression has increased in recent decades, increasing exposure to light at night. Strong evidence links circadian disruption to major depression and other mood disorders [30]. Regarding the sense of safety, lighting is one of the most important aspects affecting public spaces' perceived quality and attractiveness [31,32]. The sense of security in urban parks is mainly related to visibility [33]. Dark areas with low illuminance tend to be perceived as unsafe and avoided as a consequence [34].

Research on this topic used mainly two different approaches. Bi-dimensional images of outdoor lighting scenes (photos or simulations) have been considered for a long time as sufficiently adequate to investigate subjective impressions of space and light [35,36]. However, their use implies some limitations. Participants' point and field of view are set to a specific portion of the scene and are not changeable during the assessment phase. This strongly limits the participants' experience, who are forced to give their judgments without having a full view of the surrounding or without exploring them as they do in the real world. In situ walks have also been widely used for data collection [37,38]. Nevertheless, as in precedence, although participants are present in the environment they are asked to assess, it is very complex evaluating different types of solutions in on-site sessions and collecting data accordingly.

Cauwerts [39] showed the advantages of using Virtual Reality (VR) environments in lighting research. Iachini et al. [40] and Murdoch et al. [41] highlighted the importance of immersion and interactivity in the virtual scene. The only visual exploration of the scene allows interaction with lighting surrounding the environment, providing a complete evaluation of the scene, identifying the existence of uniformity or contrast of light in portions of the scene, leading to glare or eliciting negative emotions, just as darkness can do. Chen et al. tested the feasibility of using VR in representing lighting environments in indoor environments [42]. Their results support the claim that VR environments can provide perceptual feedback very close to the real lighted space, being significantly better than video and photos. Thus, VR gives us a great opportunity to provide an immersive experience. Despite some gaps to fill in knowledge on the accuracy that the game engines reproducing light distribution [43], immersive virtual reality may be an essential tool to assess lighting systems from different points of view, especially those linked with the city users' expectations [44]. Casciani [45] highlighted the use of virtual technology in lighting studies as an interesting and reliable tool to explore the psychological effects of lighting conditions on public streets. A novel study in this direction used VR to test whether illuminance levels and Correlated Color Temperature affected park users' preferences [46]. Considering the illuminance, the medium condition (6 lx) resulted significantly better in human lighting comfort than the low (2 lx) and high (10 lx) conditions. On the other hand, the change in color temperature had a significant effect with the subjects' comprehensive evaluation score being better under warm light (3000 K) conditions than under cool light (5600 K).

As shown, lighting can impact people's mood differently, leading to different outcomes. Although the emotional impact of lighting has been considered, a different and perhaps more interesting point of view would be the consideration of how specific lighting combinations make people feel. Furthermore, although it has been shown that people's mood influences how they perceive and interpret everyday experiences [47], studies dealing with lighting have not considered the role that participants' mood may play in evaluating different lighting solutions.

The main purpose of the present study is to understand if and how some characteristics of urban park night lighting may positively affect individuals. Moreover, the effect of lighting on individuals' motivation to explore the park and the feeling of safety was also assessed. Finally, we explored if and how participants' mood predicts the emotional impact that park lighting may have on individuals. Regarding the emotional impact of park lighting, we expect that the mild conditions (medium illuminance and intermediate CCT) should make people feel more happy and less nervous, whereas the extreme (low vs high illuminance and warm vs cool CCT) conditions should have the strongest adverse outcomes, making them feel more nervous compared to the other conditions. For this reason, we expect that although high lighting intensity may foster a greater sense of safety, it may have a negative impact on the motivation to explore the park. Finally, we also explored the impact of individual mood on judgments about lighting in city parks.

2. Materials and Methods

The study was conducted with a dynamic, virtually simulated environment, and individuals' preferences were measured by employing an affective evaluation scale [19].

2.1. Materials

2.1.1. VR Environment

To simulate different lighting conditions of a realistic scenario, a virtual simulation of an existing urban park was built in Unreal Engine 4. Since no photometric data for the existing poles were available, the luminaries were realised by modelling the geometrical shape and placing a "point light" on the top of a pole. To ensure a plausible light distribution, the photometric data of a top-pole "fiamma" [48] was assigned to the point light. Even if the current version of the game engine does not allow computing upward scattered luminous flux, the position of point light in the modelled shape of existing luminaire was chosen to avoid light emission in any direction above the horizon. Once immersed in the virtual scenario, the participant sits on a virtual bench (corresponding to a real chair) and observes the scene. They could not explore the surrounding environment except by rotating their head and sight from their fixed position. Participants experienced 9 virtual lighting scenarios resulting from the combination of three luminous flux of the lamps: 250, 500, and 1000 lumen; and three CCT: 2500 K, Warm; 4500 K, Intermediate and 6500 K, Cool (see Figures 1 and 2). The three lighting conditions of the lamps' setting (at the three different luminous flux) produced three overall illuminance levels of the park that we call Low, Medium, and High.

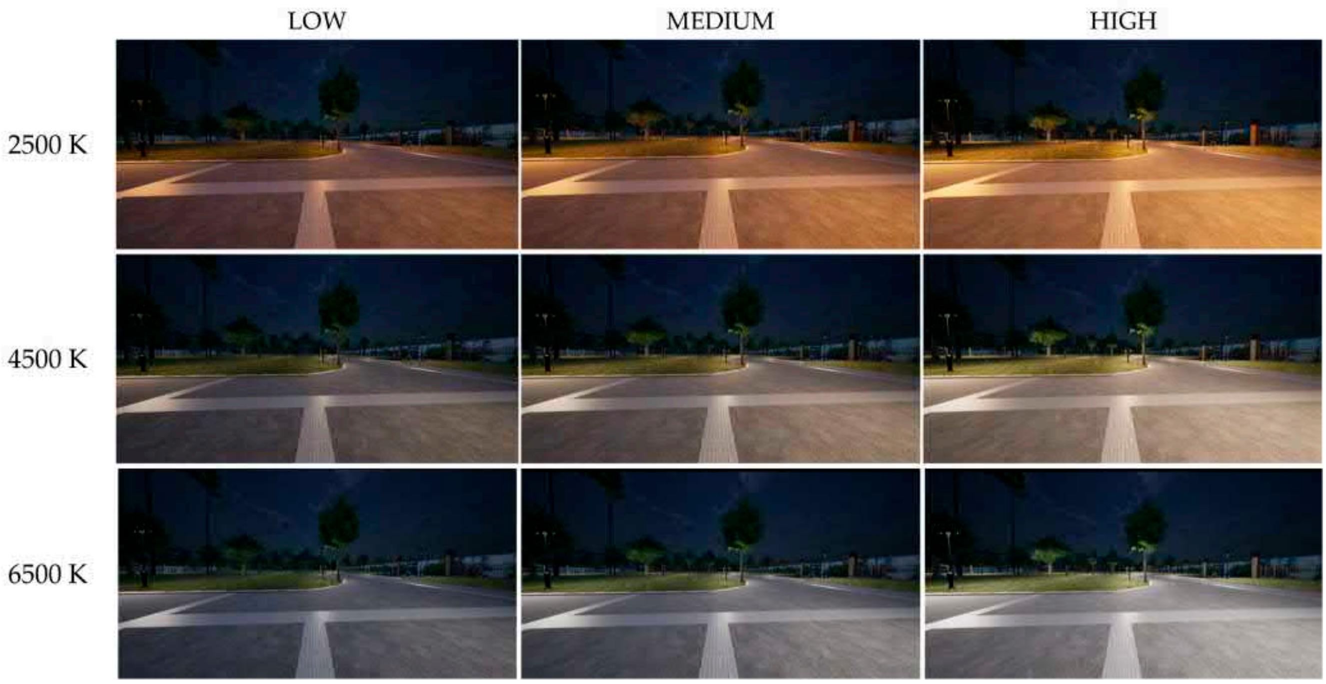

Figure 1. Matrix of the nine settings of the virtual scenario presented to participants. Rows show the three different CCT conditions. Columns show the three different overall illuminance levels.

Figure 2. Example of the participants' view during the experiment. The head is oriented toward the park entrance.

2.1.2. Affective Questionnaire

While participants were immersed in the virtual environment, they were asked to judge the scenarios through a multi-item questionnaire (see Appendix A) [19]. Participants were asked to judge by using a 9-point Likert scale (1 = Not at all; 9 = Extremely) how much the environment they were watching made them feel Calm, Nervous, Energetic, Weak, Happy, and Sad. Furthermore, participants were asked two to indicate on 9-point Likert scale (1 = Not at all; 9 = Extremely) "How much this type of lighting will motivate you in exploring the park?" (*Motivation* question) and "How much this type of lighting makes you feel safe?" (*Feeling of Safety* question).

2.1.3. Participants

A priori analysis of statistical power and effect size was carried out to obtain the minimum number of participants needed to obtain statistically valid results. The power analysis was computed using G-Power software [49]. Thirty-four participants were enough to reach a significant level (α) of 0.05, considering an effect size f = 0.25 and test power $1 - \beta = 0.80$.

Thirty-six participants (20 M), aged 20–57 years (M = 28.75, SD = 8.40), were involved in the experiment. All the participants were recruited by e-mail among the students and the personnel of the Universitá degli Studi della Campania "Luigi Vanvitelli". All subjects gave their informed consent for inclusion before participating in the study. The protocol was approved by the Ethics Committee of Università degli Studi della Campania "Luigi Vanvitelli".

2.2. Method

After receiving information about the study and providing informed consent, the participants were first administered the PANAS Questionnaire [50] to collect data about their mood, and then the experimental session started. Participants wore the HTC Vive Pro Eye HMD and were first shown a different version of the park to make them comfortable with the device. When the participant felt comfortable, the first lighting combination was shown. At this stage, the experimenter read each adjective of the Questionnaire and asked participants to respond on a 1 to 9 scale (from not at all to extremely). Once the evaluations for each adjective were collected, the next scene was shown.

Two repeated-measures ANOVAs were conducted on the positive and negative adjectives, respectively. The analysis design featured three within-subjects variables: Emotions (Calm vs. Happy vs. Energetic, or Nervous vs. Sad vs Forceless), CCT (Warm vs Intermediate vs. Cool), and Overall Illuminance (Low vs Medium vs. High). The dependent variables were the ratings made by participants on the Likert scales (range: 1–9).

Moreover, to understand whether participants' mood predicted judgments about lighting in city parks, two stepwise multiple regressions with forward method were conducted on the mean of positive and negative emotional judgments (criterion variable) and with positive and negative mood as predictors.

3. Results

Positive Emotions. Results showed a statistically significant main effect of Overall Illuminance: $F(2, 68) = 22.68$, $p < 0.00001$, $\eta^2_p = 0.40$. The results of the post-hoc test showed that a Low (M = 5.77, SE = 0.17) and Medium (M = 5.48, SE = 0.21) illuminance level were rated more positively than a High illuminance level (M = 4.65, SD = 0.22) (at least $p < 0.0005$). In addition, a significant interaction effect emerged between *Positive Emotions* and Overall Illuminance: $F(4, 136) = 21.82$, $p < 0.00001$, $\eta^2_p = 0.39$. Results from the post hoc test showed (see Figure 3) that participants reported feeling calmer in the Low illuminance condition than in the Medium condition and calmer in the latter than in the High illuminance condition (at least $p < 0.005$). Similarly, regarding Happiness, participants reported feeling less happy in the High illuminance condition than in the other two conditions (at least $p < 0.0001$). In contrast, feeling energetic was not affected by the different Overall Illuminance.

Figure 3. Positive Emotions (Calm, Happy, Energy) scores as a function of the Overall Illuminance levels (Low, Medium, High). Significant differences are indicated with an *. Vertical thin black bars represent standard error (SE).

Finally, the Low illuminance condition made people feel calmer than happy and happier than energetic (at least $p < 0.005$). The same was true for the Medium illuminance condition, whereas no difference between the three emotions was observed in the High illuminance condition. No significant effects were observed for the variable CCT.

Negative Emotions. Results showed a statistically significant main effect of Overall Illuminance: $F(2, 70) = 9.75$, $p < 0.0002$, $\eta^2_p = 0.22$. The post-hoc test revealed that a Low (M= 2.26, SE = 0.17) and Medium (M = 2.19, SE = 0.16) illuminance level are evaluated less negatively than a High (M = 2.68, SE = 0.18) illuminance level (at least $p < 0.005$). Furthermore, results showed that *Negative Emotions* interacted significantly with both CCT ($F(4, 140) = 4.28$, $p < 0.005$, $\eta^2_p = 0.11$) and Overall Illuminance ($F(4, 140) = 15.18$, $p < 0.00001$, $\eta^2_p = 0.30$) respectively. Regarding CCT, the results of the post-hoc test showed that the Intermediate CCT made people less nervous than the Warm and Cool CCT (at least $p < 0.05$). In addition, Warm CCT made participants more tired than sad ($p = 0.005$) (see Figure 4).

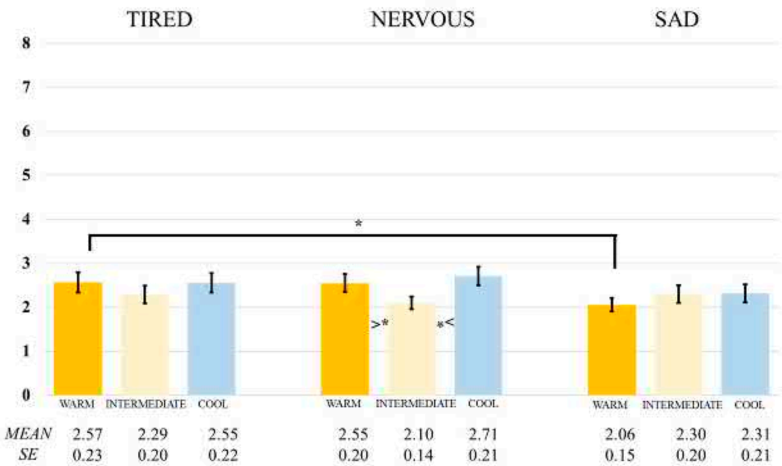

Figure 4. Negative Emotions (Tired, Nervous, Sad) scores as a function of CCT levels (Warm, Intermediate, Low). Significant differences are indicated with an * ($p < 0.05$). Vertical thin black bars represent standard error.

Regarding the Overall Illuminance, the results showed that the High Illuminance condition made participants more nervous than all other conditions (at least $p < 0.0001$). In contrast, the Low Illuminance condition made participants feel more tired than nervous ($p = 0.04$) (see Figure 5).

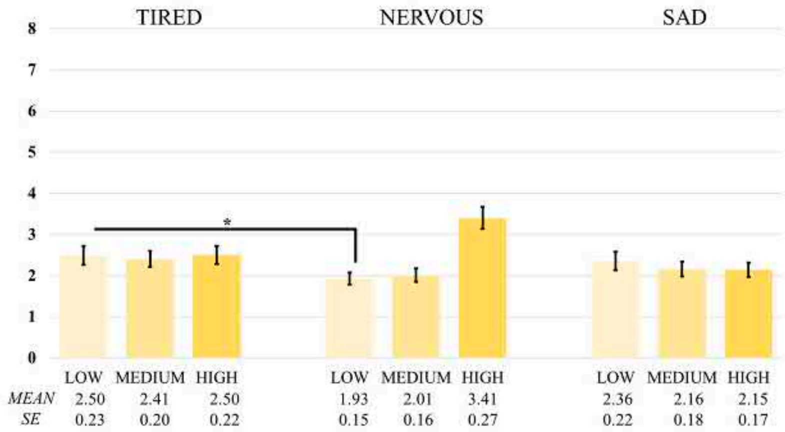

Figure 5. Negative Emotions (Tired, Nervous, Sad) scores as a function of Overall Illuminance (Low, Medium, High). Significant differences are indicated with an * ($p < 0.05$). Vertical thin black bars represent standard error (SE).

Finally, an interaction effect between CCT and Illuminance emerged: F(4, 140) = 6.14, $p < 0.0002$, $\eta^2_p = 0.15$. The effect is because the High illuminance and Cool light condition is the one to be evaluated most negatively of all (at least $p < 0.05$) except compared to the High illuminance and Warm light ($p = 0.14$). The latter makes one feel worse than the Cool Low illuminance ($p = 0.03$) (See Figure 6). No other significant differences emerged.

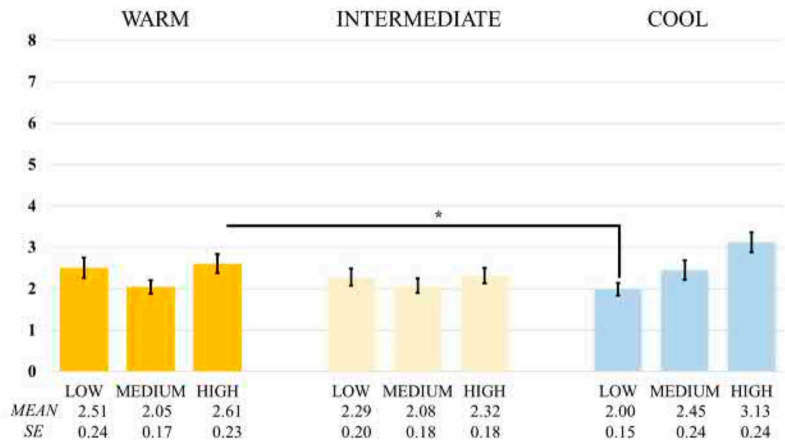

Figure 6. Negative Emotions (average of Tired, Nervous, Sad) scores as a function of CCT (Warm, Intermediate, Cool) and Overall Illuminance (Low, Medium, High). Significant differences are indicated with an * ($p < 0.05$). Vertical thin black bars represent standard error.

Motivation. Results showed a main effect of the Overall Illuminance: F(2, 68) = 4.93, $p < 0.05$, $\eta^2_p = 0.13$. Specifically, participants were more motivated to explore the park when lighting was at low (M = 6.60, SE = 0.19) and medium (M = 6.56, SE= 0.18) illuminance compared to high illuminance (M = 5.84, SE = 0.26) (at least $p < 0.05$). In addition, a significant interaction effect between CCT and the Overall Illuminance emerged: F(4, 136) = 3.51, $p < 0.01$, $\eta^2_p = 0.09$. The post-hoc test revealed that the lighting condition with High illuminance and Warm light was the one that motivated participants the least to explore the park compared to all other conditions (at least $p < 0.05$) except compared to the one with High illuminance and Cool light ($p = 0.86$). In addition, the latter motivated less than Medium illuminance Cool light ($p = 0.01$) (see Figure 7).

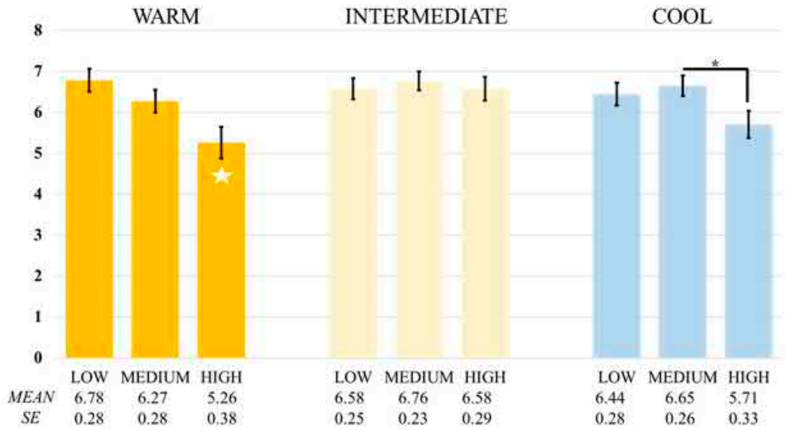

Figure 7. Scores of the Motivation to explore the park as a function of CCT (Warm, Intermediate, Cool) and Overall Illuminance levels (Low, Medium, High). Significant differences are indicated with an asterisk ($p < 0.05$). The white star indicates that the score in that condition was statistically different from all other conditions ($p < 0.05$). Vertical thin black bars represent standard error (SE).

Feeling of Safety. Results showed a main effect of Overall Illuminance: $F(2, 68) = 4.55$, $p < 0.05$, $\eta^2{}_p = 0.11$. Specifically, participants felt less safe in the low illuminance condition (M = 6.18, SE = 0.19) compared to the medium (M = 6.65, SE = 0.13; $p = 0.08$) and high (M = 6.80, SE = 0.16; $p = 0.01$) illuminance conditions, respectively.

For positive emotions, the results showed that the model was significant ($F(1,34) = 7.25$, $p = 0.01$, $R^2 = 0.17$) and that the positive mood dimension predicted participants' positive judgments (b = 0.42, t(34) = 2.69, $p = 0.01$). Specifically, the better the mood the more positively the lighting was rated. With regard to negative emotions, the results showed that the model tended toward significance ($F(1,34) = 2.58$, $p = 0.08$, $R^2 = 0.13$) and that the negative dimension of mood predicted participants' negative ratings (b = 0.37, t(34) = 2.22, $p = 0.03$). Specifically, the worse the mood, the more negatively the scenarios were rated.

Effect of mood on lighting preference, motivation, and feeling of safety. Since participants' mood was a statistically significant predictor of lighting judgment, we conducted an additional analysis of variance to test whether participants with a different mood preferred a different type of lighting. To this end, we split participants into two groups (18 participants per group) based on the median value of the positive mood scores (i.e., 34.5). Afterwards, we analyzed the data for each emotion separately using the level of positive mood, i.e., high (scores ≥ 35; M = 39.39, SD = 2.97) vs. low (scores ≤ 34; M = 29.33, SD = 4.13), as a between-subjects factor, and the CCT and the Overall Illuminance levels as within-subjects factors. Results showed no statistically significant interaction among CCT, Overall Illuminance, and mood level for both positive and negative emotions.

The same analyses were carried out on the level of motivation to visit the park and the feeling of safety. With regard to motivation, results showed a statistically significant interaction between positive mood level (high vs. low) and Overall Illuminance (low vs. intermediate vs. high): $F(2, 66) = 4.18$ $p = 0.02$, $\eta^2{}_p = 0.11$. The post-hoc test showed that under illumination at high intensity, participants with lower positive mood reported lower motivation (M = 5.2, SD = 2.14) to visit the park than the group with higher positive mood (M = 6.5, SD = 1.72) ($p = 0.03$). In short, high intensity lighting demotivated those with more negative mood. Regarding the sense of security, no interaction between lighting and mood level emerged.

4. Discussion

The present study aimed to understand better which combination of lighting intensity and CCT had the most positive emotional impact on potential urban park users. To this end, nine different virtual scenarios were obtained, combining three overall illuminance levels (Low, Medium, and High) and three CCT (Warm, 2500 K; Intermediate, 4500 K; and Cool, 6500 K). Participants were asked to judge how much the lighting of each scenario made them feel Calm, Nervous, Energetic, Tired, Happy, and Sad. Furthermore, participants were asked to rate how much each lighting combination would influence their *Motivation* to explore the park and their *Feeling of safety*. As summarized in Table 1, the results showed that high illuminance generally made people more nervous, whereas Low illuminance made people feel calmer. On the other hand, Low illuminance showed adverse effects, making participants feel more tired than in other conditions. Overall, the combination with the Cool CCT and High illuminance condition produced the worst impact for participants. We also found that High illuminance and Warm CCT resulted in the worst combination at motivating participants to explore the park. High illuminance resulted positively only in making participants perceive the park as safer than other conditions, and this is reasonable because Higher illuminance provides better vision at night. Nevertheless, this did not motivate people to explore the park. This seemingly contradictory finding can be explained by the fact that, as our results suggest, although High illuminance promotes better vision, it can still be annoying and, when combined with Warm lighting, even tiring. In other words, it is the specific combination of illuminance and CCT that determines whether a park will be explored or not. In line with this, Oi showed that different combinations of illuminance and colours were preferred based on the context of judgment [51]. Therefore, preferences can change based on the type of activity people are to perform.

Table 1. Findings' summary.

	General Findings	Specific Findings
Positive Emotions	- High overall illuminance induces less *positive emotions*.	- Greatest *calm* in the low overall illuminance. - Greatest *happiness* in low and medium overall illuminance. - Overall illuminance does not affect feeling *energetic*.
Negative Emotions	- High overall illuminance induces more *negative emotions*. - Most *negative emotions* with high overall illuminance and cool light.	- Greatest *nervousness* in the high overall illuminance. - Low overall illuminance makes people feel more *tired* than *nervous* - Least *nervousness* in the intermediate CCT. - Warm CCT makes people feel more *tired* than *sad*.
Motivation	- Less motivation to explore the park with high overall illuminance, especially if combined with hot light; - High overall illuminance with cool CCT motivated less than at low overall illuminance and cool CCT.	
Sense of Safety	- Less sense of safety in low light conditions	
Mood	- The positive is the mood of the participants, the higher their evaluation of the scenarios is. - The negative is the mood of the participants, the negative their evaluation of the scenarios is.	- The participants' mood level (high versus low) did not influence their preference for a specific type of lighting. - Participants with a low positive mood were more demotivated than those with a high positive mood exploring the park.

Our results suggest the Medium Overall Illuminance as the most positive. Regarding the correlated colour temperature, results showed that intermediate CCT (4500 K) was the most positive as it made participants feel less nervous compared to Cool and Warm CCT

(6500 K and 2500 K, respectively). Furthermore, an interesting result of this study was that participants' moods predicted their judgements. The better the mood at the beginning of the experiment, the better the judgments. Moreover, results showed that a park with high lighting intensity would demotivate those with a less positive mood to explore it. This is probably related to the fact that high lighting intensity has, in general, a negative impact on emotions. Therefore, with the importance of the evaluation context [51], participants' mood should be an important factor to consider when assessing emotional impact, as it is predictive of individual evaluations, an aspect not emphasized enough. In conclusion, results showed that the best combination was the Medium Overall Illuminance combined with intermediate CCT (4500 K).

Although the article's findings are in line with the previous research findings [46], there are still some limitations related to the calibration and control of the virtual environment metrics of lighting simulation, especially when they are reproduced to the participants by head-mounted displays.

In fact, on the one hand, taking advantages of the high sense of presence experienced in immersive virtual reality environments means that Virtual Reality will increasingly become the tool that designers and administrators will use to select alternatives, not exclusively based on the target values of the lighting metrics indicated in international standards, but by a human-centric and participative approach, as well as on expectations, preferences, satisfaction and feeling of citizens. This will help them consider peculiarities and sensibilities of local communities toward several lighting related aspects having direct or indirect consequences on citizens' behavior (accessibility, safety) [31,52,53] and health (biological functions and rhythms) [9,54], tourists (landmarks, lighting gates) [55,56], animals and vegetation (attraction, reproduction) [6,8,9], as well as light pollution [57,58].

On the other hand, actual challenges in the use of VR for lighting research still limit the studies on the human feedback (i.e., psychological and physiological responses) about lighting to qualitative simulations rather than quantitative. In fact, although recent research considering indoor VR environment provided satisfactory procedures to combine IES curves with the lighting objects available in game engines [43], or to control the colour appearance of objects in colour constancy experiments when a head-mounted displays is used [59], no investigations are to date available to evaluate the effects of these methodologies in outdoor applications or when complex environments are considered. The advances in this field will allow the next years to update our findings, making possible the comparison of the characteristics of the scenario presented via HMS with the value suggested by the international standard about outdoor lighting.

5. Conclusions

Results suggest that improving the emotional feelings of people who use urban parks by adapting lighting characteristics of lighting systems may have positive consequences on other aspects. Low illuminance levels produced by lighting systems help make people feel calmer, significantly reducing the feeling of being nervous due to high illuminance levels. Cool lighting induces negative emotions in individuals, making them nervous, and is not suggested. This solution is also in line with the negative effects of high CCT on nocturnal insects [60,61]. Observing the outcomes about the overall illuminance, we can say that by using a human-centric approach in urban parks lighting design it is possible, beyond improving the well-being of users, to get convergent feedback with other issues such as the energy saving and reduction of the impact on insects and plants. Nevertheless, quantitative studies are needed in the future to extend the research in this field.

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Institutional Review Board Statement: The study was approved by the Ethics Committee of the Department of Architecture and Industrial Design, Università degli Studi della Campania "Luigi Vanvitelli" (Pr. No.: CERS-202106).

Informed Consent Statement: Participants read the necessary instructions on confidentiality and signed an informed consent form prior to their participation.

Data Availability Statement: The materials and the data that support the findings of this study are available from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Appendix A—Saliency of stimuli Questionnaire [19].

How much the scenario you're looking at makes you feel:

CALM	**1** not at all	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9** Extremely
WEAK	**1** not at all	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9** Extremely
HAPPY	**1** not at all	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9** Extremely
NERVOUS	**1** not at all	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9** Extremely
SAD	**1** not at all	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9** Extremely
ENERGIC	**1** not at all	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9** Extremely

References

1. Pattison, P.M.; Hansen, M.; Tsao, J.Y. LED lighting efficacy: Status and directions. *Comptes Rendus Phys.* **2018**, *19*, 134–145. [CrossRef]
2. Beccali, M.; Bonomolo, M.; Lo Brano, V.; Ciulla, G.; Di Dio, V.; Massaro, F.; Favuzza, S. Energy saving and user satisfaction for a new advanced public lighting system. *Energy Convers. Manag.* **2019**, *195*, 943–957. [CrossRef]
3. Kyba, C.C.; Kuester, T.; Sánchez de Miguel, A.; Baugh, K.; Jechow, A.; Hölker, F.; Bennie, J.; Elvidge, C.D.; Gaston, K.J.; Guanter, L. Artificially lit surface of Earth at night increasing in radiance and extent. *Sci. Adv.* **2017**, *3*, e1701528. [CrossRef] [PubMed]
4. Supronowicz, R.; Fryc, I. Urban park lighting as a source of botanical light pollution. *Photonics Lett. Pol.* **2019**, *11*, 90–92. [CrossRef]
5. Bennie, J.; Davies, T.W.; Cruse, D.; Gaston, K.J. Ecological effects of artificial light at night on wild plants. *J. Ecol.* **2016**, *104*, 611–620. [CrossRef]
6. Sodani, R.; Mishra, U.N.; Chand, S.; Anuragi, H.; Chandra, K.; Chauhan, J.; Bose, B.; Kumar, V.; Singh, G.S.; Lenka, D.; et al. Artificial Light at Night: A Global Threat to Plant Biological Rhythms and Eco-Physiological Processes. In *Light Pollution, Urbanization and Ecology*; IntechOpen: London, UK, 2021.
7. Nord, E.A.; Lynch, J.P. Plant phenology: A critical controller of soil resource acquisition. *J. Exp. Bot.* **2009**, *60*, 1927–1937. [CrossRef]
8. Owens, A.C.; Lewis, S.M. The impact of artificial light at night on nocturnal insects: A review and synthesis. *Ecol. Evol.* **2018**, *8*, 11337–11358. [CrossRef]
9. Boyes, D.H.; Evans, D.M.; Fox, R.; Parsons, M.S.; Pocock, M.J.O. Is light pollution driving moth population declines? A review of causal mechanisms across the life cycle. *Insect Conserv. Divers.* **2021**, *14*, 167–187. [CrossRef]
10. Deichmann, J.L.; Ampudia Gatty, C.; Andía Navarro, J.M.; Alonso, A.; Linares-Palomino, R.; Longcore, T. Reducing the blue spectrum of artificial light at night minimises insect attraction in a tropical lowland forest. *Insect Conserv. Divers.* **2021**, *14*, 247–259. [CrossRef]

11. *EN 12464-2:2014*; Light and Lighting—Lighting of Work Places—Part 2: Outdoor Work Places. European Committee for Standardization: Brussels, Belgium, 2014.
12. *UNI 11248:2016*; Road Lighting—Selection of Lighting Classes. Italian Committee for Standardization: Milan, Italy, 2016.
13. *EN 13201-2:2015*; Road Lighting—Part 2: Performance Requirements. European Committee for Standardization: Brussels, Belgium, 2015.
14. *UNI 10819:2021*; Luce e Illuminazione—Impianti di Illuminazione Esterna—Grandezze Illuminotecniche e Procedure di Calcolo per la Valutazione della Dispersione verso l'Alto del Flusso Luminoso. Italian Committee for Standardization: Milan, Italy, 2021.
15. Donatello, S.; Rodríguez Quintero, R.; Gama Caldas, M.; Wolf, O.; Van Tichelen, P.; Van Hoof, V.; Geerken, T. *Revision of the EU Green Public Procurement Criteria for Road Lighting and Traffic Signals, EUR 29631 EN*; Publications Office of the European Union: Luxembourg, 2019.
16. Goličnik, B.; Ward Thompson, C. Emerging relationships between design and use of urban park spaces. *Landsc. Urban Plan.* **2010**, *94*, 38–53. [CrossRef]
17. Santos, T.; Mendes, R.N.; Vasco, A. Recreational activities in urban parks: Spatial interactions among users. *J. Outdoor Recreat. Tour.* **2016**, *15*, 1–9. [CrossRef]
18. Wang, X.; Rodiek, S.; Wu, C.; Chen, Y.; Li, Y. Stress recovery and restorative effects of viewing different urban park scenes in Shanghai, China. *Urban For. Urban Green.* **2016**, *15*, 112–122. [CrossRef]
19. Masullo, M.; Maffei, L.; Iachini, T.; Rapuano, M.; Cioffi, F.; Ruggiero, G.; Ruotolo, F. A questionnaire investigating the emotional salience of sounds. *Appl. Acoust.* **2021**, *182*, 108281. [CrossRef]
20. Rapuano, M.; Ruotolo, F.; Ruggiero, G.; Masullo, M.; Maffei, L.; Galderisi, A.; Palmieri, A.; Iachini, T. Spaces for relaxing, spaces for recharging: How parks affect people's emotions. *J. Environ. Psychol.* **2022**, *81*, 101809. [CrossRef]
21. Ngesana, M.R.; Karimb, H.A.; Zubirc, S.S. Human Behaviour and Activities in Relation to Shah Alam Urban Park during Nighttime. *Procedia-Soc. Behav. Sci.* **2012**, *68*, 427–438. [CrossRef]
22. Calvillo Cortés, A.; Falcón Morales, L. Emotions and the urban lighting environment. *SAGE Open* **2016**, *6*, 215824401662970. [CrossRef]
23. Steidle, A.; Werth, L. In the spotlight: Brightness increases self-awareness and reflective self regulation. *J. Environ. Psychol.* **2014**, *39*, 40–50. [CrossRef]
24. De Kort, Y.; Veitch, J.A. From blind spot into the spotlight. *J. Environ. Psychol.* **2014**, *39*, 1–4. [CrossRef]
25. De Kort, Y. Tutorial: Theoretical considerations when planning research on human factors in lighting. *Leukos* **2019**, *15*, 85–96. [CrossRef]
26. Blackwell, H.R. Development and use of a quantitative method for specification of interior illumination levels on the basis of performance data. *Illum. Eng.* **1959**, *54*, 317–353.
27. Boyce, P.R. Age, Illuminance, visual performance and preference. *Light. Res. Technol.* **1973**, *5*, 125–140. [CrossRef]
28. Rea, M.S.; Ouellette, M.J. Relative visual performance: A basis for application. *Light. Res. Technol.* **1991**, *23*, 135–144. [CrossRef]
29. Veitch, J.A.; Newsham, G.R. Determinants of lighting quality II: Research and recommendations. In Proceedings of the Annual Meeting of the American Psychological Association, Toronto, ON, Canada, 12 August 1996.
30. Bedrosian, T.A.; Nelson, R.J. Influence of the modern light environment on mood. *Mol. Psychiatry* **2013**, *18*, 751–757. [CrossRef]
31. Portnov, B.A.; Saad, R.; Trop, T.; Kliger, D.; Svechkina, A. Linking nighttime outdoor lighting attributes to pedestrians' feeling of safety: An interactive survey approach. *PLoS ONE* **2020**, *15*, e0242172. [CrossRef] [PubMed]
32. Mulliner, E.; Maliene, V. An introductory review to the special issue: Attractive places to live. *Urban Des. Int.* **2011**, *16*, 147–152. [CrossRef]
33. Mahrous, A.M.; Mustafa, Y.M.; Abou El-Ela, M.A. Physical characteristics and perceived security in urban parks: Investigation in the Egyptian context. *Ain Shams Eng. J.* **2018**, *9*, 3055–3066. [CrossRef]
34. Nasar, J.; Jones, K. Landscape of fear and stress. *Environ. Behav.* **1997**, *29*, 291–323. [CrossRef]
35. Chamilothori, K.; Wienold, J.; Andersen, M. Adequacy of immersive virtual reality for the perception of daylit spaces: Comparison of real and virtual environments. *Leukos* **2019**, *15*, 203–226. [CrossRef]
36. Rozman Cafuta, M. Sustainable City Lighting Impact and Evaluation Methodology of Lighting Quality from a User Perspective. *Sustainability* **2021**, *13*, 3409. [CrossRef]
37. Rahm, J.; Johansson, M. Assessment of outdoor lighting: Methods for capturing the pedestrian experience in the field. *Energies* **2021**, *14*, 4005. [CrossRef]
38. Rahm, J.; Sternudd, C.; Johansson, M. "In the evening, I don't walk in the park": The interplay between street lighting and greenery in perceived safety. *Urban Des. Int.* **2021**, *26*, 42–52. [CrossRef]
39. Cauwerts, C. *Influence of Presentation Modes on Visual Perceptions of Daylit Spaces*; Université Catholique de Louvain (UCL): Louvain-la-Neuve, Belgium, 2013.
40. Iachini, T.; Maffei, L.; Masullo, M.; Senese, V.P.; Rapuano, M.; Pascale, A.; Sorrentino, F.; Ruggiero, G. The experience of virtual reality: Are individual differences in mental imagery associated with sense of presence? *Cogn. Process.* **2019**, *20*, 291–298. [CrossRef] [PubMed]
41. Murdoch, M.J.; Stokkermans, M.G.M.; Lambooij, M. Towards perceptual accuracy in 3D visualizations of illuminated indoor environments. *J. Solid State Light.* **2015**, *2*, 12. [CrossRef]

42. Chen, M.; Lin, H. Virtual geographic environments (VGEs): Originating from or beyond virtual reality (VR)? *Int. J. Digit. Earth* **2018**, *11*, 329–333. [CrossRef]
43. Scorpio, M.; Laffi, R.; Teimoorzadeh, A.; Ciampi, G.; Masullo, M.; Sibilio, S. A calibration methodology for light sources aimed at using immersive virtual reality game engine as a tool for lighting design in buildings. *J. Build. Eng.* **2022**, *48*, 103998. [CrossRef]
44. Scorpio, M.; Laffi, R.; Masullo, M.; Ciampi, G.; Rosato, A.; Maffei, L.; Sibilio, S. Virtual reality for smart urban lighting design: Review, applications and opportunities. *Energies* **2020**, *13*, 3809. [CrossRef]
45. Casciani, D. The Psycho-Social Influence of Lighting in Space Perception an Experimental Proof of Concept. *Int. J. Architecton. Spat. Environ. Des.* **2020**, *14*, 15–37. [CrossRef]
46. Zhang, J.; Dai, W. Research on night light comfort of pedestrian space in urban park. *Comput. Math. Methods Med.* **2021**, *2021*, 3131747. [CrossRef]
47. Elen, M.; D'Heer, E.; Geuens, M.; Vermeir, I. The influence of mood on attitude–behavior consistency. *J. Bus. Res.* **2013**, *66*, 917–923. [CrossRef]
48. Available online: https://www.iguzzini.com/it/aet7/ (accessed on 1 July 2022).
49. Faul, F.; Erdfelder, E.; Lang, A.G.; Buchner, A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav. Res. Methods* **2007**, *39*, 175–191. [CrossRef]
50. Watson, D.; Clark, L.A.; Tellegen, A. Development and validation of brief measures of positive and negative affect: The PANAS scales. *J. Personal. Soc. Psychol.* **1998**, *54*, 1063. [CrossRef]
51. Oi, N. Preferred combinations between illuminance and color temperature in several settings for daily living activities. *Proc. 26th CIE* **2007**, *2*, 178.
52. Feigusch, G.; Steffan, I.T.; Ossberger, D. Good Lighting and Visual Contrast to Improve Accessibility in the Built Environment—A Literature Study. In Proceedings of the 21st Congress of the International Ergonomics Association (IEA 2021), Online, 13–18 June 2021; Lecture Notes in Networks and Systems, 220. Black, N.L., Neumann, W.P., Noy, I., Eds.; Springer: Cham, Switzerland, 2021.
53. Kaplan, J.; Chalfin, A. Ambient lighting, use of outdoor spaces and perceptions of public safety: Evidence from a survey experiment. *Secur. J.* **2021**. [CrossRef]
54. Blume, C.; Garbazza, C.; Spitschan, M. Effects of light on human circadian rhythms, sleep and mood. *Somnologie* **2019**, *23*, 147–156. [CrossRef]
55. Lowery, B.C. Outdoor Advertising: Landmark of the Experience Economy. *Interdiscip. J. Signage Way Find.* **2019**, *3*, 21–28. [CrossRef]
56. Shi, Y.; Chung, J.H. A case study of modern urban night-lighting. *J. Digit. Converg.* **2018**, *19*, 365–371.
57. Benfield, J.A.; Nutt, R.J.; Derrick Taff, B.; Miller, Z.D.; Costigan, H.; Newman, P. A laboratory study of the psychological impact of light pollution in national parks. *J. Environ. Psychol.* **2018**, *57*, 67–72. [CrossRef]
58. Jägerbrand, A.K.; Bouroussis, C.A. Ecological Impact of Artificial Light at Night: Effective Strategies and Measures to Deal with Protected Species and Habitats. *Sustainability* **2021**, *13*, 5991. [CrossRef]
59. Gil Rodríguez, R.; Bayer, F.; Toscani, M.; Guarnera, D.; Guarnera, G.C.; Gegenfurtner, K.R. Colour Calibration of a Head Mounted Display for Colour Vision Research Using Virtual Reality. *SN Comput. Sci.* **2022**, *3*, 22. [CrossRef]
60. Donners, M.; van Grunsven, R.I.I.; Groenendijk, D.; van Langevelder, F.; Bikker, J.W.; Longcore, T.; Veenendaal, E. Colors of attraction: Modeling insect flight to light behavior. *J. Exp. Zool. Part A Ecol. Integr. Physiol.* **2018**, *329*, 434–440. [CrossRef]
61. Menzel, R.; Greggers, U. Natural phototaxis and its relationship to colour vision in honeybees. *J. Comp. Physiol. A* **1985**, *157*, 311–321. [CrossRef]