The Relationship Between the Pedestrian Lighting Environment and Perceived Safety

Siyuan Wu[1], Mintai Kim[2]

[1]Virginia Tech, Blacksburg/USA
[2]Virginia Tech, Blacksburg/USA · mintkim@vt.edu

Abstract: This study aims to examine people's perceived nighttime safety in different pedestrian lighting environments. As discussed by VEITCH & NEWSHAM (2006), a behavioral science approach is adopted in this study to explore the lighting quality by testing people's perceptions. The perceived safety (or fear of crime) is a different concept from actual crime. Perceived danger is found to be the prominent factor affecting people's nighttime experience, and creates significant influence on their behaviors as it directly impacts people, elicits stress reactions, and puts constraints on their nighttime activities (VAN OSCH 2010).

The primary research objectives of this study included identifying key attributes of lighting environments and examining their influence on people's perceived safety. An online survey, including photos, was conducted with an aim to discover the environmental perceptions of the population on the Virginia Tech campus in the United States.

A total of 24 photos were taken from different pedestrian nighttime settings on the Virginia Tech campus. The campus lighting fixtures shown in all photos have a uniform design. The photos were chosen based on the quality of the photographs in terms of image resolution, lack of blur, clarity, and composition. A statistical analysis was then performed.

The findings from fifty two participants indicated that important lighting attributes influencing people's perceived safety are identified as: lighting uniformity, facial recognition, concealment, and perceived brightness. The findings further indicate that some environmental context attributes, environmental perception attributes, and socio-demographic attributes, also significantly influence people's perceived safety.

Keywords: Nightscape, lighting, perception

1 Introduction

As more and more people spend time outdoors after work or school, pedestrian-focused lighting design is becoming an important part of lighting design. Well-designed lighting can improve the sense of security and aesthetic quality within the nightscape, therefore improving nighttime quality of life. However, people's needs and perception of pedestrian lighting has not been explored thoroughly. The design guidelines that exist are generated from the designers' perspectives, not the users'.

This study aims to investigate lighting quality of the pedestrian environment through a behavioural science approach. The research objectives include discovering the relationships between the attributes of pedestrian lighting environment and people's perceived safety, and the influence of socio-demographic attributes on people's perceived safety. The research framework of the pedestrian lighting environment was developed based on the findings from literature in environmental behaviours, environmental psychology and criminology, that are related to the pedestrian lighting environment.

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2 Study Methods

In order to gain more comprehensive understanding of the effects of the urban lighting environment on people's perceived safety, the study takes six steps: identification of important attributes of the lit environment, sampling and presentation of environmental stimuli, the selection of participants, the design of the questionnaire, data collection, and data analysis.

Once the variables of the lighting environment were identified, the survey instrument, an online questionnaire, was designed so that the relationships between selected variables and the perceived safety (as the dependent variable) could be examined. The photo-questionnaire method was used to measure people's response towards environmental stimuli and to examine the relationships between the attributes of pedestrian lighting environments and perceived safety. In total, 24 photos reflecting various attributes of pedestrian lighting environments were chosen and included in the survey (Figure 1).

The results from the online survey were described and used as data for a simple descriptive statistical analysis, an inferential statistical analysis, a content analysis, and a heat map analysis. Statistical techniques adopted in this study include the Independent Sample T-Test, the Pearson's Correlation analysis, and the One-Way ANOVA. The analysis results were then compared to the findings in the literature review.

2.1 Summary of Findings

Fifty-two subjects participated in this online-survey study. Equal numbers of females and males were surveyed. 19.2 % of the participants identified as design majors and the remaining 80.8 % of participants surveyed came from disciplines outside of design. Most of the participants' ages ranged from 18 to 34. The data shows that almost half of the female participants (42.3 %) felt themselves very unconfident to defend themselves from anti-social behaviours. Meanwhile, the ratings of perceived self-defensibility among male participants are normally distributed from "very unconfident" to "very confident". Most of the males thought that they were neither confident nor unconfident to defend themselves against nighttime crimes. The frequencies of nighttime walks taken by participants are normally distributed from "never" to "very often". Three out of fifty-two participants had victimization experience. Although most other participants had never been attacked during their nighttime walk, they all perceived different levels of fear towards nighttime pedestrian area scenes. In addition, most of the participants noticed the presence of emergency call boxes on campus and most of these participants felt safer with the sight of these call boxes. The inferential statistical analysis reveals that men feel slightly safer than women when they are on a nighttime pedestrian footpath. In addition, younger people feel safer in these pedestrian situations than older participants. The frequency of nighttime walks undertaken by participants is not significantly related to perceived safety.

Among twenty-four photos tested in the study, the photo showing an open view with a low level of concealment was most preferred by participants. The same photo was also rated as one of the safest scenes (Figure 1). The photo showing the human figure's darkened face with a view obstructed by plants was the least preferred and also rated as the least safe scene. Pearson's correlation analysis shows that preference, familiarity, perceived self-defensibility, and perceived brightness are all positively correlated with perceived safety. Among these

four perceived attributes, perceived brightness has the strongest correlation with perceived safety.

Through One-Way ANOVA tests, the effects of lighting attributes were examined. The results show that among lighting with differing levels of uniformity, the uniform lighting results in a higher level of perceived safety than the discontinuous lighting. However, the sparse lighting (uniform darkness) also results in the same level of perceived safety as does the uniform lighting. Therefore, the sparse lighting and uniform lighting are not apparently different, and they can be treated as the same lighting condition in regards to the effects on people's perceived safety.

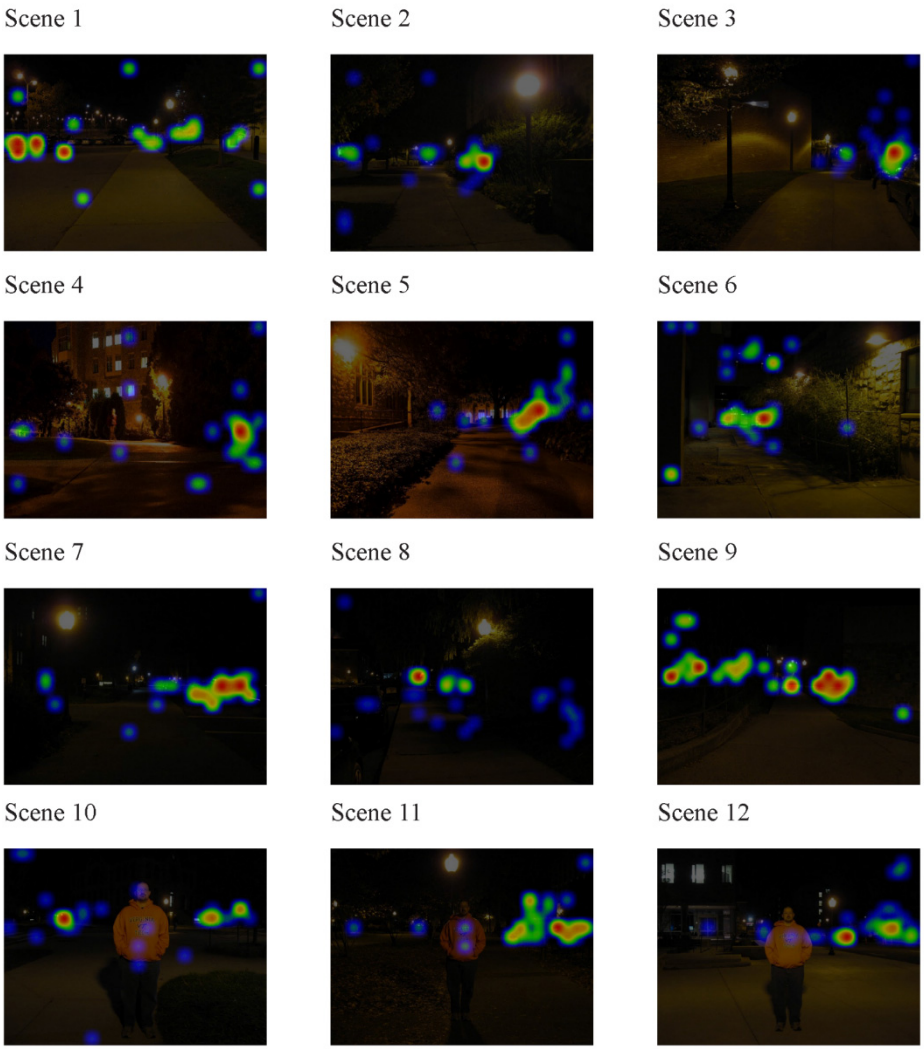

Fig. 1: 24 Scenes used for the study overlayed with hotspots of fear

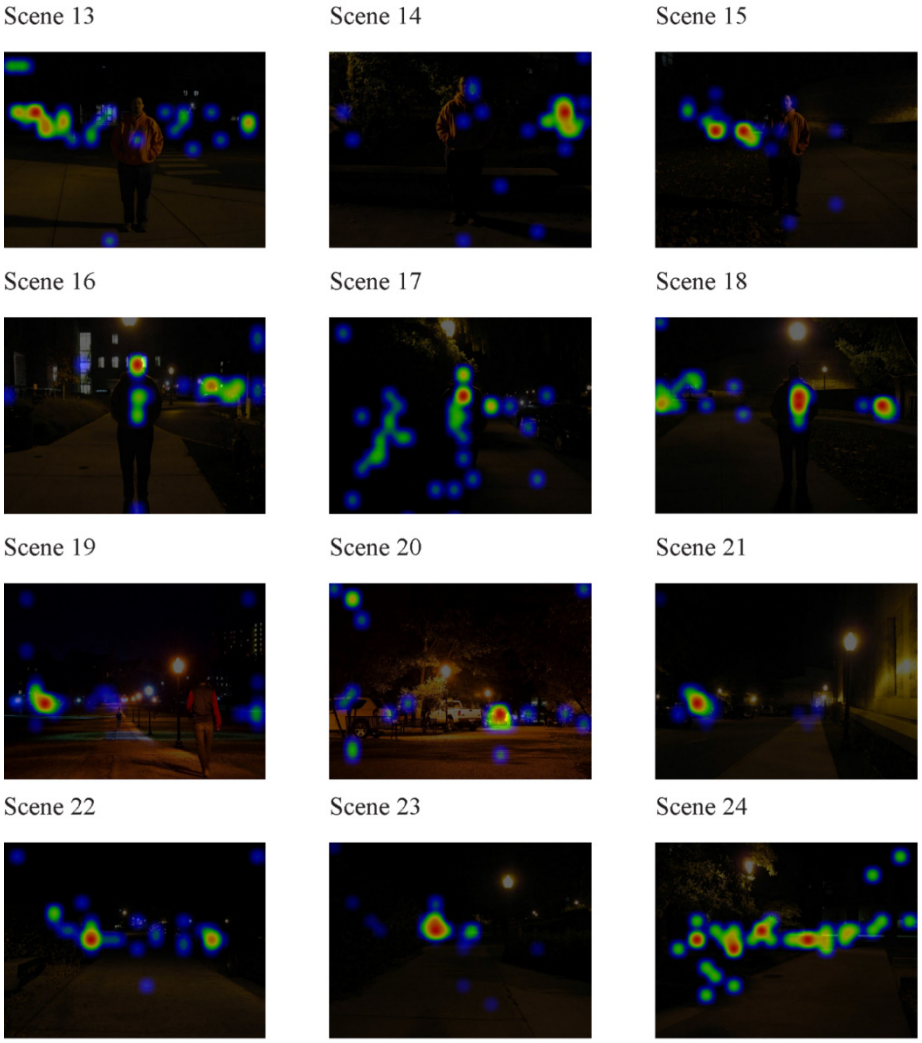

Fig. 1 (continued)

The results also reveal that people perceived the highest safety when they could recognize another pedestrian's face clearly. However, there is no clear difference when the human figure's face is darkened and when the human figure's face is half-lighted. Moreover, analysis suggests that pedestrian environments with little concealment will result in a higher level of perceived safety and the environments with more concealment will result in a lower level of perceived safety. For three different environmental contexts, pedestrian environments with views limited by plants will result in the lowest level of perceived safety. Pedestrian environments with views limited by buildings or an open view result in the same level of perceived safety.

The content analysis reveals that facial recognition, brightness, concealment, uniformity, prospect or enclosure of a pedestrian environment, possibility of informal surveillance, presence of emergency responding system, and reputation of a neighbourhood, are all associated with perceived safety. Moreover, the heat map analysis supports the idea that facial recognition and concealment significantly correlates to the perceived safety of people in nighttime pedestrian environments.

In the online survey, participants were asked to click on the spots in which they felt least safe based on the statement by NASAR & FISHER (1993): "Crime and fear of crime concentrate in some areas called 'hot spots'." Figure 1 shows the results for all of the scenes based on a heat map analysis of hot spots of fear. Scene 23 has the most spots of fear and Scene 1 has the fewest. For most of the scenes, the dark areas were identified as sources of fear amongst participants. The best examples are Scene 23, Scene 21, and Scene 19. However, Scene 16, Scene 17 and Scene 18 show that participants perceived fear when they couldn't see the adult male's face in the nighttime pedestrian paths. Figure 2 shows the illustration of heat map analysis.

Fig. 2: Heat map analysis: People are most fearful of the darkened face and are also fearful of the dark areas

3 Discussion

Many studies that are related to fear of crime and perceived personal safety suggest that women have a lower level of perceived safety than men. According to EVANS & FLETCHER (2000), the reason for this difference between gender groups may be that men and women have different levels of vulnerability. Women are generally considered to be less confident at defending themselves against crimes. The results show that perceived self-defensibility significantly explains the perceived safety, and perceived self-defensibility among men and women is significantly different. The results of this study confirm the findings from the literature. Another reason suggested by the literature is that women are vulnerable to sexual attack, which is a serious risk that men do not normally encounter. In addition, findings from the literature show that elderly people also show a lower level of perceived safety. Previous research also reported that low levels of perceived personal safety could not be adequately

explained by exposure to risk or the victimization rate of sensitive groups. Compared to young adult males, victimization rates among females and elderly people are actually lower in urban areas (WARR 1993). The explanation provided by previous studies for the findings mentioned above was that the lower perceived safety may not be strongly related to an experience of victimization, but a simple reflection of pedestrians' higher vulnerability and lower perceived self-defensibility (WARR 1993).

ÜNVER (2009) suggests that people from design majors and people from non-design majors may have different perceptions towards the urban environment because people who studied the design of the built-environment may have a pre-conceived judgment of a place, therefore they may introduce a bias evident in the research outcome. However, the results of this study show no difference of perceived safety between people from design majors and people outside of the design-realm. This may suggest that people's perceived safety at night might be more related to gender, age, and the environmental cues of fear than to the fields of study. Another possible explanation may be that people's perceived safety at night is not closely related to the design of a built-environment. During a nighttime walk, people will not pay much attention to the design of a pedestrian environment if their fear is elicited by the poor lighting conditions.

The findings reveal that all the perceived attributes (preference, familiarity, perceived brightness and perceived self-defensibility) are significant in explaining the perceived safety of a pedestrian lighting environment. Among these attributes, preference, familiarity, and perceived brightness affect people's cognitive responses toward pedestrian lighting environments, and perceived self-defensibility is related to people's individual characteristics. The analysis indicates that pedestrian lighting environments with higher levels of human's perceived safety are also associated with higher levels of human's preference. The literature review also suggests that places providing people with a sense of security and other desirable feelings may increase their preference of those places and therefore attract them to stay and conduct activities there. On the contrary, places evoking the feeling of fear may result in a decrease in human preference and thus lead to actions including escape and avoidance (HANYU 2000). In addition, the findings of this study reveal that familiarity is significantly correlated with perceived safety. The literature suggests that familiarity with a certain pedestrian environment may contribute to people's reassurance in the nighttime walking footpath (UNWIN & FOTIOS 2011). However, some studies suggest that people's perceived safety may dramatically decrease if the place they are familiar with has a reputation of high crime incidence (NASAR & FISHER 1993). People may feel like prisoners in their homes and their personal radius at night may be very limited if their neighborhood is considered unsafe. One possible explanation may be that familiarity will increase people's sense of safety in general, but the crime rate of a certain neighborhood may outweigh the significance of people's familiarity of the environment. The results also show that the brightness of the pedestrian environment, which is measured as the perceived brightness, is the most significant variable in explaining perceived safety within the nighttime pedestrian path. The literature review suggests that perceived darkness can elicit a feeling of fear by reducing the visibility of a pedestrian road (HOUTKAMP & TOET 2011). Without appropriate lighting, people may perceive a pedestrian area as ill-lit, and their visual control of the environment may decrease. In addition, the possibility of the environment concealing potential crime may increase. Within this kind of lighting environment, it may be difficult for people to navigate their way and escape from potential anti-social behaviors. Also, the chance for informal surveillance may decrease

as well. In addition, the analysis indicates that perceived self-defensibility is also correlated with perceived safety. Although among four subjective attributes, perceived self-defensibility has the least significant correlation with perceived safety in the nighttime pedestrian environment, it greatly explains the reasoning behind the differences in gender groups and age groups. Literature indicates that people's subjective judgments, such as perceived vulnerability and perceived defensibility, are also possible causes of fear of crime (EVANS & FLETCHER 2000). This study introduces the influence of self-perceived defensibility in lighting research and introduces the significance of people's individual characteristics on their perceived safety. This study revealed that among all perceived attributes, perceived brightness is the most significant variable, followed by preference, familiarity, and perceived self-defensibility.

The findings show that the objective variables (uniformity, facial recognition, and concealment) of lighting environments are significant in explaining perceived safety. The significant differences between different levels of uniformity in explaining perceived safety are validated in this study. Discontinuous lighting results in lower perceived safety, while, uniform and sparse lighting result in higher perceived safety. There is no difference between uniform lighting and sparse lighting. The literature review indicates that discontinuous lighting may result in discontinuous perception of the pedestrian environment because of sudden light level drops (IES, 2003). Frequent changes of light levels may result in visual discomfort, visual fatigue, loss of visual control, and thus may elicit a fear of crime. The findings of this study confirm this literature finding. However, ÜNVER (2009) suggests that the pedestrian environment with sparse lighting caused by shadows can evoke people's fear reactions.

The analysis of this research reveals that facial recognition is significant in explaining perceived safety. Many findings of the literature review show that facial recognition plays an important role in perceived safety. It is suggested that people become more sensitive to an approaching person at night because the effectiveness of facial recognition allows people to take evasive or defensive action if necessary (FOTIOS & PETER 2011). The research results correspond with the literature and further reveal that a half-lit face and a darkened face elicit the same level of fear. Only when the approaching pedestrian's face is well lit and recognizable, is a person's sense of safety ensured. In addition, the result of this research indicates that levels of concealment significantly explain the perceived safety. In a pedestrian footpath with a lower level of concealment, people's perceived safety and preference dramatically increases. On the contrary, in a pedestrian pathway with a higher level of concealment, people's perceived safety significantly increases. Findings of the literature review overlay with this research result: concealment within a nighttime pedestrian environment implies the possibility of potential crimes. Dark areas provide opportunities for potential offenders to hide and reduce people's visual control of pedestrian environments.

Furthermore, among all the pedestrian lighting environments tested in this study, pedestrian pathways with the presence of the adult human figure's face darkened were rated as the most unsafe scenarios and environments with high level of concealment were rated as the second most unsafe lighting environments.

Combined with content analysis and the heat map analysis, another pedestrian's ill-lit face and concealment area are the most significant cues of fear. It seems that among three objective lighting attributes, facial recognition is the most important variable, concealment is the

second, and uniformity is the least significant variable. According to ÜNVER (2009), "distribution of light", or uniformity of light, is not significant in explaining people's preference and perceived safety in pedestrian lighting environments. In this sense, this study confirms the significance of the lighting uniformity variable, although it is not weighted as important as facial recognition and concealment.

The results indicate that environmental context is significant in explaining perceived safety. People have a higher perceived safety in pedestrian environments with an open view or with a limited view due to buildings. Pedestrians with views limited by plants have lower perceived safety. The literature review provides several possible explanations. According to ÜNVER (2009), urban features and greeneries are closely related to restorativeness and perceived safety. FISHER & NASAR (1992) also suggested that prospects of an environment will influence perceived safety. These two studies explain that people feel safer in pedestrian pathways with open views as they can gain the highest visual control of their environments and find ways to escape from potential danger. However, ÜNVER (2009) did not suggest that environments with more natural elements decrease perceived safety.

The results of the content analysis also reveal that the presence of people and better emergency response systems will be factors that improve people's sense of safety during nighttime activities. Participants from this research pointed out that the presence of policemen and police stations in particular are the anticipated emergency response system.

Although the scope of this research is perceived safety in pedestrian environments, the lessons learned in this research could be applied to other outdoor environments, such as urban parks and plazas. More studies of other outdoor environments could strengthen the findings of this study.

4 Conclusion

The appearance of the pedestrian lighting environment has important effects on people's experience within it. Different lighting conditions can evoke varied emotional responses. They can either evoke desirable feelings and attract people, or they can elicit fear reactions leading people to avoid a specific area.

Perceived safety is an important affective indicator of lighting quality. It is a prominent factor that directly influences people's behaviour at nighttime in pedestrian areas. By providing a better perspective and a higher possibility of surveillance and deterrence of crime, good quality lighting can ensure pedestrians' sense of safety. However, better lighting quality does not necessarily mean brighter lighting. "The brighter, the better" is a common misconception about urban lighting design (ÜNVER 2009). Although it is important to provide a sufficient amount of light for people's visual task during walking and physical exercise, there is always a light level above which further increases in brightness do not improve lighting quality. In this case, a further increase will result in extra energy consumption and light pollution affecting both human and wildlife. Also, strong luminance, or glare, may even decrease people's perceived safety as it can result in reduction of visual control of the pedestrian environment. Therefore, in order to investigate lighting quality, brightness is not the sole attribute that requires attention. There are several other attributes of the lit environment that influence lighting quality and people's perceptual outcomes.

In this study, selected lighting attributes, perceived environmental attributes, environmental context attributes, and socio-demographic attributes were all examined in regards to their effects on perceived safety. Results indicate that four selected lighting attributes (perceived brightness, uniformity, facial recognition, and concealment) are all significant in explaining perceived safety. In this sense, lighting quality can be decided and evaluated using these four attributes. It was also confirmed that there are other perceived environmental attributes which are significantly related to people's perceived safety. The effects of preference and familiarity were validated through statistical analysis. The research reveals that environmental context attributes are significantly related to perceived safety. Pedestrians perceive footpaths with an open view or with a limited view due to buildings as safer than footpaths with a limited view due to plants. Furthermore, gender and age differences were found in pedestrians' perceived safety. This finding indicates that females and the elderly are more sensitive and fearful of pedestrian lighting environments at night. Therefore, special attention should be paid to these sensitive groups when professionals design the pedestrian lighting environment and make suggestions to design guidelines.

Based on the findings of this the study, suggestions for pedestrian lighting design guidelines are made for future design practice and lighting research. The suggestions include:

1. Pedestrian lighting should provide adequate illuminance levels for walking, navigation, physical exercise and responding to anti-social behaviours.
2. Pedestrian lighting should be uniformly and continuously distributed without sudden light level drops along the pathway.
3. Pedestrian lighting should provide adequate illuminance for people to recognize each other's face from a distance.
4. Pedestrian lighting should be placed with careful consideration of nearby objects to avoid concealment within the walking environment.
5. Plants and shrubs need to be planted a sufficient distance away from lighting fixtures to avoid concealment caused by shadows.

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