Intelligent Street Lighting and Perceptions of Personal Safety

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Introduction

Street lighting in its present-day form serves various utilitarian purposes, such as the prevention of crime and traffic accidents, or providing people with a sense of safety when they walk down the street at night. However, in light of the discussion on climate change, fossil fuel reserves, and light pollution, conventional street lighting systems are currently also the subject of considerable debate (e.g., because they waste energy by providing light when there are no street users). One solution is the implementation of LED lamps, which are not only more energy-efficient, but also allow the fluent control of output levels. These characteristics of LEDs make possible the dimming of street lighting when there is less demand or need.

Nevertheless, the goal of saving energy can also undermine a major purpose of street lighting: providing people with a sense of safety. Intuitively, we feel that there is a trade-off to be made between the dimming of lights (and thus a reduction in energy usage) and the sense of personal safety that people experience when they walk down the street at night. Such a tradeoff can be attenuated by integrating sensing technologies to recognize the number, type, and location of street users. This will result in intelligent street lighting systems that can adapt continuously to the environment and provide lighting where it is needed, while selectively dimming the rest of the environment.

However, the implementation of these new types of lighting systems, capable of intelligent selective dimming, is not as straightforward as it may seem. The main issue is that we do not yet have a sufficient understanding of how (street) lighting affects people's sense of safety to determine which important areas should be lit and which areas

can be dimmed without affecting subjective appraisals of safety.

In the current paper we aim to (a) provide the reader with a short overview of relevant literature on the effects of street lighting on both objective and subjective safety, and (b) identify the most important issues that need to be resolved in order to reach a comprehensive understanding of the mechanisms underlying lighting effects on perceived personal safety.

State of the art I: Street lighting and crime

There is a substantial body of literature investigating the effects of street lighting interventions on objective measures of safety (e.g., crime rates). Yet, this body of research is characterized by considerable debate. For example, early Home Office reviews (e.g., Tien, O'Donnell, Barnett, & Mirchandani, 1979) have reported absolutely no effects of street lighting on the deterrence of criminal behavior. In a reaction to the apparently diverging conclusions from Home Office reviews and other studies which did show marked effects on deterrence of crime, Pease (1999) has criticized the Home Office reviews, for example for relying too much on a single evaluation study (i.e., Atkins, Husain, & Storey, 1991) - a study performed by the Home Office which he subsequently criticized for being methodologically flawed (for the complete criticisms, see Pease, 1999).

In a recent meta-analysis, Welsh and Farrington (2008) compared the effects of 13 different studies on lighting interventions, and concluded that these interventions indeed significantly decrease overall crime rates. A majority of the studies under consideration reported significant decreases in crime rates, while the remaining studies reported neither decreases nor increases in crime rates. The carefulness displayed by Welsh and Farrington in selecting which studies to

include (e.g., the studies required before-and-after measures) and the criticisms on the Home Office reviews at least appear to lend some credibility to the conclusion by Welsh and Farrington's meta-analysis. Thus, at present, it seems safe to conclude, in spite of relatively mixed evidence (see also Boyce & Gutkowski, 1995), that street lighting interventions can be relatively successful in decreasing crime rates. This conclusion seems to fit the popular intuition that street lighting acts as a deterrent of criminal behavior by making criminal acts more visible.

However, there are some findings that do not quite fit such a simple explanation of lighting effects on crime. For example, some of the studies described in the Welsh and Farrington (2008) meta-analysis report that lighting interventions lead to decreases in crime rates during nighttime as well as during daytime. The lack of explanations offered for these kinds of findings points out a hiatus in our understanding of how lighting affects crime. There may yet be many more factors that play a role in explaining the effects of street lighting implementations on crime rates (e.g., social capital, see Pease, 1999).

In addition, the objective risks that an individual is exposed to do not necessarily have to correspond to an individual's subjectively experienced personal safety (e.g., Vrij & Winkel, 1991). Since we are mostly concerned with how street lighting affects *subjectively experienced feelings* of safety, we now turn to a short overview of relevant literature on the effects of street lighting on more subjective measures of safety.

State of the art II: Street lighting and perceived personal safety

For the sake of clarity in discussing the effects of street lighting on subjective safety, we define a person's perceived personal safety here as a person's immediate sense of security, or an absence of the anxiety of becoming a victim of crime, when traveling through an environment. People's subjective appraisals of personal safety can have a profound impact on their felt freedom to go out at night. For example, Warr observes that decreases in people's perceptions of safety lead to an increase in the number of people who avoid leaving their home after dark, most prominently in urban areas (e.g., Warr, 1990).

An important question then is whether street lighting interventions can influence people's perceptions of safety. Interestingly, the same Home Office reviews that reported no significant effects of street lighting interventions on crime rates do report (somewhat cautiously) that street lighting may affect the public's fear of crime (e.g., Tien et al., 1979). Further evidence is presented by Painter and Farrington, who have collected extensive data during several studies evaluating the subjective impact of street lighting interventions (e.g., Painter, 1994; Painter & Farrington, 1999). Their research strategy included assessing both people's attitudes toward specific criminal behaviors as well as measures targeted at assessing behavioral consequences (e.g., counting the number of pedestrians using the street) and they consistently found that lighting improvement programs resulted in a decrease in people's fear of crime and an increase in pedestrian street use at night (but see Boyce & Gutkowski, 1995 for a critical discussion of these studies).

The broad conceptualizations of 'street lighting interventions' in the aforementioned studies do not necessarily provide an answer to the practical question of how street lighting should be designed to positively affect people's sense of safety. Boyce and Gutkowski (1995) offer some (mixed) evidence on this issue in their review on the effects of street lighting on street crime. The authors discuss several studies and cautiously offer some general recommendations, for example on adaptation luminance (vertical illuminance should be in the range of 10 to 30 lx) and illuminance uniformity (average horizontal illuminance should be 5 lx, with a minimum of 2.5 lx).

An interesting reflection on the studies highlighted above (and, more in general, many studies investigating the impact of

street lighting on subjective measures of safety) is that while the findings seem to suggest that street lighting indeed influences people's perceptions of personal safety, they generally do not provide any empirically grounded answers to the question *how* street lighting affects safety perceptions. Some authors have proposed an explanation for their findings. For example, Boyce and Gutkowski suggest that the major factor mediating the effect of lighting on safety perceptions is the extent to which people are able to perform long-range detection of possible threats and make confident facial recognitions of other people on the street. On the other hand, Painter (1994) lists altered public perceptions due to physical improvement of the environment, increased social dynamics (related to social capital, see Pease, 1999), and a "general feel good factor" (p. 118) among the possible ways in which street lighting could increase safety perceptions.

However interesting these suggestions (and others) may be, there is no empirical work known to us that provides solid evidence for any of the suggested alternatives. We believe that, in the light of new developments in (street) lighting technology, it is essential to advance our understanding of how street lighting affects people's cognitions, emotions, and, ultimately, their behavior. To this end, we have identified two main issues that should be addressed by future research investigating the relationship between lighting and safety perceptions.

Current issues

The perception of safety

On a very basic level, the first issue is that we need to understand how people arrive at an interpretation of their environment. Or, more in terms of our interests, how do people form their perception of personal safety? Viewed from an environmental perspective, the question remains how people perceive and process environmental features (e.g., Brunswik, 1952; Gibson, 1979) and how these interpretations subsequently influence how people assess certain environmental

qualities. Gaining a good understanding of how safety perceptions come into existence is an essential theoretical condition for investigating how specific objective environmental features and subjective environmental appraisals may influence these perceptions.

One way to look at this is by adopting a functionalist approach to environmental preferences (e.g., Appleton, 1975; Kaplan & Kaplan, 1989), which entails the assumption that people prefer environments that offer opportunities to fulfill human needs crucial to our survival. From this perspective, safety may be regarded as one of the most important basic needs and people should prefer environments that maximize their potential safety.

According to Fisher and Nasar (1992), who elaborated on Appleton's prospect-refuge model, people's safety feelings result from their subjective appraisal of three safety-related characteristics of a street (so-called proximate cues): prospect, concealment and escape. The findings from their studies show that people feel more safe in environments that offer (a) a good overview of the situation (or good prospect), (b) minimal opportunities for possible offenders to hide (or low refuge), and (c) enough escape routes (or high in escape). The application of this framework provides us with a basic understanding of what (subjective) aspects of an environment may be important when it comes to people's judgments of personal safety, and thus proves to be a fruitful starting point for conducting further research. Nevertheless, this theoretical framework cannot fully explain the psychological mechanisms underlying environmental assessments. Put differently, we may now have some knowledge on *how* these perceptions come to be, but we still do not understand *why*.

Street lighting and perceptions of safety

A second issue then is to understand the role of lighting, or the relationship between street lighting and perceptions of personal safety. Although this relationship seems intuitively strong, literature on the subject is quite limited and indecisive. In light of the

prospect-refuge model (e.g., Fisher & Nasar, 1992), lighting may be regarded as an objective characteristic of the environment. Yet, how does it affect the more subjective proximate cues and thus people's safety perceptions? When we think about it, street lighting is a somewhat ambiguous concept; on the positive side, it provides people with good vision at night, but light also casts shadows. These diverse effects can affect our sense of safety in a number of ways, and we just do not know whether the balance in the end is positive or negative. Do we actually need street lighting at all to feel safe?

Conclusion

The main aim of this paper was to bring together literature, providing the reader with a basic frame of reference to understand the relationship between street lighting and people's sense of safety. Our discussion has provided us with some valuable insights, but the main insight has been that we do not yet have sufficient knowledge of the mechanisms underlying the relationship between street lighting and people's perceived personal safety to draw any definite conclusions. However, with an eye to future research, we have identified some important issues; we need to (a) gain a deeper understanding of how safety perceptions come into existence and (b) investigate in which ways lighting influences these safety perceptions. Only then will we be able implement adaptive lighting systems that both reduce energy usage and continue to serve all the functions they are intended for.

Acknowledgement

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