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**Examining the Effect of Entrapment, Lighting Levels, and Gender on Feelings of Safety**  
**and Lighting Policy Acceptability**

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## **Feeling Safe in the Dark: Examining the Effect of Entrapment, Lighting Levels, and Gender on Feelings of Safety and Lighting Policy Acceptability**

Policies on reducing energy use are more frequent as a result of the current economic climate and pressing environmental issues. Street lighting is a substantial energy user and thus contributes to carbon emissions. In 2007, public lighting points in the Netherlands were responsible for 30 to 70 percent of total municipality energy use (Ministry of Housing, Spatial Planning and the Environment [VROM], 2008). This also comes with considerable economic costs. A second environmental consequence of street lighting is light pollution, which can disrupt the life of wild animals and plants (McKinney & Schoch, 2003). Artificial lighting in public areas is increasing by 6 to 9 percent each year in the Netherlands (Department of Infrastructure and Transport [DIVV], 2007) which illustrates the urgency to tackle this problem. This can be achieved by dimming and switching off lights at certain times of the day (DIVV, 2007), and indeed, these types of measures have already been implemented across Europe (Cambridgeshire County Council, 2011; Baron, 2011; Department of Planning and Economic Affairs, 2007; Municipality of Heerenveen, 2007; Municipality of The Hague, 2010; Trondheim Smartcity, 2009).

Successful implementation of reduced lighting policies depends on public acceptability (Steg, Dreijerink & Abrahamse, 2005; 2006). But how can acceptability of reduced lighting levels be achieved? Acceptability of lighting level reflects an attitude based on weighting the costs and benefits of different lighting levels. Besides the positive effects of reduced street lighting on environmental quality discussed above, negative effects, notably on perceived social safety, may occur as well (e.g. Bremmers, Veltman, & Fernhout, 2000; DIVV, 2007; VROM, 2008). How do feelings of social safety affect the acceptability of reduced lighting policies? Moreover, is it possible to implement street lighting policies that reduce the detrimental impact on the environment but at the same time safeguard perceived social safety? It is important to gain more insight in these questions, as possible threats to perceived social safety can be a key barrier for the successful implementation of reduced lighting policies. To our knowledge, the current study is one of the first studies that examines under which conditions perceived social safety and acceptability of reduced street lighting can be enhanced.

### **Lighting and Perceived Social Safety**

Social safety can be defined as the protection or the feeling of being protected against danger caused by or threatened to be caused by human actions in the public sphere, and can refer

to both actual safety and perceived safety. Actual social safety reflects actual crime rates, and may not always result in perceived social safety, that is, people may not feel safe although no real dangers are present (Park, Calvert, Brantingham & Brantingham, 2008). Perceived social safety is similar to perceived personal danger (Blöbaum & Hunecke, 2005), perceived safety or risk (Loewen, Steel, & Suedfeld, 1993), and fear of crime (Fisher & Nasar, 1992; Nasar & Fisher, 1993; Nasar, 2000), and may reflect both cognitive and affective responses to risks. In this paper, we define perceived social safety as a general cognitive response: the perception of safety (cf. Kanan & Pruitt, 2002; Rountree & Land, 1996).

With respect to actual safety, lighting is often seen as an excellent way to enhance natural surveillance. By improving visibility and encouraging street usage crime can be decreased, increasing actual safety (Welsh & Farrington, 2009). Indeed, a review revealed that nine out of thirteen studies showed a positive impact of lighting on actual safety, while the remaining four studies showed no effect (Welsh & Farrington, 2007). The relationship between perceived social safety and lighting is less clear. Also, conditions that lead to actual safety are not necessarily in line with conditions that lead to perceived safety (Brantingham & Brantingham, 1995). Although various scholars have argued that perceived social safety needs to be taken into account when lighting levels are changed (Bremmers et al., 2000; VROM, 2008), it is not clear under which conditions reduced street lighting decreases perceived social safety. Moreover, little is known about how this in turn affects policy acceptability. This paper aims to address these issues. We argue that reduced lighting policies will not be accepted by the public when perceived social safety is threatened. So, lighting levels will only be accepted when the lighting level in the particular setting is perceived as safe. Support for this mediation effect of perceived social safety would indicate that acceptability of reduced lighting policies can be increased by safeguarding perceived social safety. But which factors need to be taken into account when attempting to reduce lighting with a limited effect on perceived social safety, and will these factors indeed affect the acceptability of reduced lighting policies? We propose that the effects of reduced street lighting on perceived safety and thus policy acceptability depend on individual characteristics as well as physical characteristics of the environment, as explained below (c.f. Austin, Furr, & Spine, 2002; Box, Hale, & Andrews, 1988; Killias & Clerici, 2000).

### **Gender and Perceived Social Safety**

An important individual factor that affects perceived social safety is gender. Indeed, gender was found to be one of the strongest predictors of perceived social safety, with women generally perceiving lower levels of social safety in the same lighting situation compared to

men (Blöbaum & Hunecke, 2005; Loewen et al., 1993). College women are on average three times as fearful of being a victim of sexual violence at night on campus compared to college men (Fisher & Sloan, 2003). This may result from a fear of sexual violence resulting from images portrayed by the media, first-hand experience, and warnings from others (Pain, 2000; Valentine, 1989). As any crime against women can involve sexual assault, fear is heightened for other crimes involving face-to-face contact, such as robbery (Ferraro, 1996). Low perceived social safety influences behaviour: women avoid certain places and situations which they perceive as unsafe resulting in a restriction of daily activities (Keane, 1998; Valentine, 1989), which may affect their ability to participate in physical activity such as walking outdoors (Roman & Chalfin, 2008). In sum, the possibility of sexual violence leads to lower perceived social safety in women compared to men, which can affect women's behaviour. Would this imply that gender also affects acceptability of lighting policies? Extending previous research, this will be tested in the current study; as with safety we expect to find lower levels of acceptability in women compared to men.

### **Building and Street Design and Perceived Social Safety**

A factor that may increase feelings of safety, especially for women, is the design of the built environment (Valentine, 1989). Environmental factors provide signs for potentially frightening situations, reducing feelings of social safety even when crime is not imminent or in progress (Warr, 1990). Factors that have been shown to influence perceived social safety include the presence of others in the environment (Foster, Giles-Corti, & Knuiman, 2010; Warr, 1990), housing quality (Austin et al., 2002), racial composition (Chiricos, Hogan, & Gertz, 1997), and signs of disorder and incivility (Box et al., 1988; Brown, Perkins & Brown, 2004; Robinson, Lawton, Taylor & Perkins, 2003; Wilson & Kelling, 1982). In contrast to the factors above, the current study will focus on aspects of the physical environment which are almost entirely determined by building and street design.

The idea that physical characteristics of an environment influence perceived social safety is not new. In 1975, Appleton proposed the prospect and refuge theory which states that people feel safer in settings where they are able to see without being seen. Building on Appleton's theory, Nasar (2000) identified two characteristics of the built environment signalling immediate danger: concealment and entrapment. Concealment refers to "a physical occlusion of space big enough to hide a potential offender" (Nasar, 2000, p. 127), such as a tree, a wall, or a dark spot. Although concealed places can offer the ability to take refuge (Appleton, 1975), Nasar argues that concealed places mainly offer opportunities for potential

offenders to hide, thereby decreasing feelings of safety for the potential victim (Nasar, 2000; Nasar & Fisher, 1993). So, Nasar proposes that a low level of concealment, that is an open view and no hiding opportunities for attackers, is perceived as safer from the potential victim's perspective.

Entrapment reflects blocked escape, that is, "the difficulty a person would have escaping when confronted with a potential offender" (Nasar, 2000; p. 129). . The possibility of entrapment is enough to decrease feeling of social safety, even when there are no potential attackers present. It has been argued that opportunities to escape are particularly important for women (Valentine, 1989). Entrapment has two dimensions: a social dimension related to the inability of contacting people who can help, and a physical dimension which relates to an inability to escape because of physical elements in the environment (Nasar & Fisher, 1993).

Several studies have investigated the influence of physical characteristics on perceived social safety for different lighting levels. Loewen and colleagues (1993) showed that when asked to list items in the environment that increase feelings of safety, participants mentioned lighting most often, followed by open space (low concealment) and access to refuge. Participants also rated slides depicting outdoor scenes on safety; the results further supported lighting as an important factor in predicting feelings of safety. However, the above study did not include entrapment, which is expected to be an important predictor of perceived social safety. Fisher and Nasar (1992) did include entrapment in their studies. They conducted three field studies which showed that open spaces which offer the possibility to escape for potential victims (low entrapment) and no hiding places for potential offenders (low concealment) are perceived as safer compared to settings that do not offer these characteristics. Importantly, perceived darkness of settings did not determine perceived social safety. Some areas with high lighting were rated as safe, whereas others with similar lighting levels were rated as unsafe. Fisher and Nasar (1992) concluded that lighting is not the most important factor influencing perceived social safety, and that other elements in the physical surrounding (e.g. concealment and entrapment) play a crucial part. More recently, Blöbaum and Hunecke (2005) conducted a field experiment in which participants judged settings with different levels of entrapment (i.e. difficulty to escape), concealment (i.e. hiding places for offenders) and lighting on perceived social safety. Settings with high entrapment, low lighting and high concealment were perceived as less safe. Each factor had an independent impact on perceived social safety, with entrapment being the strongest predictor. As for the impact of lighting, Blöbaum and Hunecke (2005) reported an interesting finding. A high entrapment setting did not benefit from a change in lighting: independent of lighting levels, perceived safety was

low in settings from which it was difficult to escape. Individuals felt less safe in the high entrapment compared to the low entrapment setting, irrespective of the lighting level. Lighting levels only led to an increase in perceived social safety when settings offered escape opportunities, i.e. when entrapment was low.

In summary, physical characteristics of an environment such as entrapment and concealment have been shown to be important predictors of perceived social safety. However, previous research has not yet examined the relationship between physical characteristics and acceptability of reduced lighting levels. We aim to study these relationships. We propose that entrapment and concealment not only determine which lighting levels are perceived as safe, in particular for women, but also to what extent such lighting levels are acceptable.

### **The Current Study**

The current research studies the influence of entrapment and gender on perceived social safety and acceptability in situations with different lighting levels. We focus on entrapment because, compared to concealment, entrapment is a stronger predictor of perceived social safety (Blöbaum & Hunecke, 2005) and has a more direct impact on behaviour. Concealment is important for detecting a potential attacker but the presence of entrapment directly influences behaviour by constraining it. Entrapment influences which amount of lighting is required to feel safe. Therefore, we focus on low and high entrapment settings. In addition to previous studies, we also study how entrapment and gender affect the acceptability of lighting policies. We propose that the extent to which lighting levels influence perceived social safety depends on entrapment and gender, and that perceived social safety in turn influences acceptability. Based on the above, we tested six hypotheses listed below.

**Hypothesis 1.** Lighting levels are more acceptable when the relevant situation is perceived to be safe, so, perceived social safety will mediate the relationship between lighting and acceptability.

**Hypotheses 2a and 2b.** Low entrapment settings are perceived as safer (hypothesis 2a), and more acceptable (hypothesis 2b) than high entrapment settings.

**Hypotheses 3a and 3b.** High lighting settings are perceived as safer (hypothesis 3a), and more acceptable (hypothesis 3b) than low lighting settings.

**Hypotheses 4a and 4b.** Lighting level will particularly affect perceived safety (hypothesis 4a) and acceptability (hypothesis 4b) in low entrapment settings (cf. Blöbaum & Hunecke, 2005).

**Hypotheses 5a and 5b.** Women perceive the same lighting situation as less safe (hypothesis 5a) and less acceptable (hypothesis 5b) than men.

**Hypotheses 6a and 6b.** Women feel safer and judge the low entrapment setting as more acceptable compared to the high entrapment setting, while entrapment does not affect perceived safety and acceptability judgements of men (hypothesis 6 a and 6b) because of their higher levels of perceived social safety and acceptability.

## Method

### Participants

In this study 88 first-year psychology students from a Dutch University participated (27 men, 61 women). They received course credits as a reward for their participation. Age varied from 18 to 51 years ( $M = 22$ ,  $SD = 4.47$ ).

### Design and Procedure

A 2 x 2 x 2 mixed design was used with entrapment and lighting as within factors, and gender as a between factor.<sup>1</sup> Participants were seated alone in a dark room, about 60 cm in front of a monitor screen (17" monitor, 1024x768 resolution, 85 Hz refresh rate) and viewed on full screen four virtual environment movie-clips of different settings in which the levels of lighting and entrapment were systematically varied (see Figure 1 and Online Appendix). Participants were instructed to imagine themselves walking in the depicted scene. After each movie-clip participants rated the perceived social safety and acceptability of the lighting level in the street shown on the computer while a movie still of the movie-clip was depicted on the same screen. After the experiment all participants were thanked and any remaining questions were answered.

### Materials

Four 40-second virtual environment movie-clips were shown to participants in random order. Virtual environments enhance experimental control (Pals, 2011) and provide valid representations of real-life environments (Bishop & Rorhman, 2003; Pals, 2011; Nasar & Cubukcu, 2011). The clips were identical except for lighting levels and entrapment; no objects were present next to houses and lighting poles. The high lighting settings showed a lighting level above the current norm of street lighting (assessed to be 17 lux), the low lighting settings showed a lighting level below the current norm of street lighting (assessed to be 12 lux).<sup>2</sup> Entrapment was manipulated by systematically varying the width of the street, road widths were modelled on existing roads in the city where the study took place. In the low

entrapment settings a broad street was shown of approximately 20 metres wide. In the high entrapment settings a narrow street of approximately 5 metres wide was shown. After each movie-clip participants filled in the following questionnaire.

**Manipulation-check.** Two items were added as a manipulation-check for lighting and entrapment level, respectively. Participants were asked to rate on a scale ranging from 1 (strongly disagree) to 5 (strongly agree) whether the depicted scene was well lit, and whether it was easy to escape from the scene in case of an immediate threat.

**Perceived social safety.** An adapted version of the perceived personal danger scale developed by Blöbaum and Hunecke (2005) was used. The resulting scale comprised seven statements: I would not mind to walk along this place unaccompanied, I would take a long detour to avoid this place (recoded), I would quickly get away from this place (recoded), I have an unpleasant feeling at this place (recoded), I feel uneasy at this place (recoded), I feel safe in this place, and I feel anxious at this place (recoded). The last two items were added to the original scale in order to measure feelings of safety more directly; inclusion of these items increased Cronbach's alpha in all settings compared to the original scale. Participants rated items on a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Mean scores were computed for each setting; higher scores reflected higher feelings of safety. The scale proved to be reliable in all settings, Cronbach's alpha averaged .76 (ranging from .70 to .79 across conditions).

**Acceptability of lighting levels.** Two measures of acceptability were included. The first measure consisted of four items. First participants were asked to indicate whether they found the amount of lighting in the situation acceptable on a scale ranging from 1 (strongly disagree) to 5 (strongly agree). Next they indicated on a 5-point scale to what extent the amount of lighting in the particular setting was: bad (1) to good (5), negative (1) to positive (5), insufficient (1) to sufficient (5). Mean scores were computed for each setting; higher scores reflected higher acceptability. Cronbach's alpha averaged .92 (ranging from .88 to .96 across conditions). The second indicator of acceptability consisted of one item. Participants were asked to indicate on a 5-point scale whether they found the amount of lighting in the depicted situation too little (1) or too much (5).

## Results

### Manipulation Check

The manipulation-check revealed that our manipulations of lighting and entrapment were successful. The high lighting settings were indeed perceived as better lit ( $M = 3.73$ ,  $SD$



= .75) compared to the low lighting settings ( $M = 2.29$ ,  $SD = .94$ ),  $F(1, 87) = 222$ ;  $p < .001$ ,  $partial \eta^2 = .72$ . Also, participants also indicated that they would find it easier to escape a low entrapment setting ( $M = 3.40$ ,  $SD = 1.03$ ) compared to a high entrapment setting ( $M = 1.99$ ,  $SD = .84$ ),  $F(1, 87) = 116$ ;  $p < .001$ ,  $partial \eta^2 = .57$ .

### Mediation Effect of Perceived Social Safety

We expected that lighting levels need to be perceived as safe in order to be evaluated as acceptable. A mediation analysis revealed that perceived social safety indeed mediated the relationship between lighting level and acceptability of lighting levels (see Figure 2). The bottom arrow in Figure 2 indicates that lighting level was negatively related to acceptability ( $b = -.38$ ,  $t = -2.86$ ;  $p < .005$ ). Since a score of 1 equalled high lighting, and a score of 2 equalled low lighting, this negative relationship indicates that low lighting levels were evaluated as less acceptable. The left arrow in Figure 2 indicates a negative relationship between lighting level and the mediator, perceived social safety ( $b = -.46$ ,  $t = -5.61$ ;  $p < .001$ ), so low lighting led to lower perceived social safety. As the right arrow in Figure 2 indicates, perceived social safety in turn was positively related to acceptability ( $b = .66$ ,  $t = 8.57$ ;  $p < .001$ ), so when perceived social safety increased, acceptability also increased. As expected, the relationship between lighting level and acceptability was no longer significant when perceived safety was entered in the analysis as well ( $b = -.07$ ,  $t = -.54$ ;  $p = .589$ ). A bootstrapping procedure (Preacher & Hayes, 2004) revealed that the indirect effect between lighting level and acceptability equalled  $-.31$  (95%  $ci = -.44$ ;  $-.19$ ). As the indirect effect of lighting level on acceptability through perceived safety is significantly different from zero (i.e., zero is not in the 95% confidence interval) we can conclude that perceived social safety fully mediated the relationship between lighting level and acceptability of lighting levels. Thus, lighting levels have to be perceived as safe before they are accepted by the public.

### Influence of Entrapment and Lighting on Perceived Social Safety and Acceptability

First, as expected, participants felt safer in the low entrapment setting ( $M = 3.93$ ,  $SD = .56$ ) compared to the high entrapment setting ( $M = 3.53$ ,  $SD = .75$ ),  $F(1, 86) = 23.29$ ;  $p < .001$ ,  $partial \eta^2 = .21$ . Also, lighting levels in the low entrapment settings were evaluated as more acceptable ( $M = 3.32$ ,  $SD = .84$ ) compared to lighting levels in high entrapment settings ( $M = 2.94$ ,  $SD = .94$ ),  $F(1, 86) = 21.57$ ;  $p < .001$ ,  $partial \eta^2 = .20$ . Furthermore, lighting levels in the low entrapment setting were perceived as more appropriate ( $M = 2.79$ ,  $SD = .75$ ), compared to lighting levels in the high entrapment setting ( $M = 2.51$ ,  $SD = .84$ ),  $F(1,$

86) = 12.44;  $p = .001$ ,  $partial \eta^2 = .13$ , again supporting a main effect of entrapment on acceptability of lighting levels.

Second, as expected, participants felt safer in the high lighting conditions ( $M = 3.89$ ,  $SD = .56$ ) compared to the low lighting conditions ( $M = 3.56$ ,  $SD = .75$ ),  $F(1, 86) = 33.08$ ;  $p < .001$ ,  $partial \eta^2 = .28$ . Furthermore, participants evaluated high lighting levels as more acceptable ( $M = 3.88$ ,  $SD = .75$ ) compared to low lighting levels ( $M = 2.38$ ,  $SD = 1.13$ ),  $F(1, 86) = 175$ ;  $p < .001$ ,  $partial \eta^2 = .67$ . Also, the high lighting level was evaluated as appropriate, if even slightly too much ( $M = 3.28$ ,  $SD = .75$ ), while the low lighting level was evaluated as inappropriate ( $M = 2.01$ ,  $SD = .84$ ),  $F(1, 86) = 228$ ;  $p < .001$ ,  $partial \eta^2 = .73$ , again supporting a main effect for lighting level on acceptability.

Third, we found partial support for our hypotheses that an increase in lighting particularly led to an increase in perceived social safety and acceptability of lighting levels if entrapment was low. For perceived social safety, the effect of lighting level on feelings of safety did not depend on entrapment,  $F(1, 86) = 0.56$ ;  $p = .457$ ,  $partial \eta^2 = .01$ . The mean scores indicated that participants felt safer in the low entrapment setting, for both low and high lighting ( $M = 3.74$ ,  $SD = .75$  for low lighting;  $M = 4.11$ ,  $SD = .66$  for high lighting), compared to the high entrapment setting ( $M = 3.39$ ,  $SD = 1.03$  for low lighting;  $M = 3.68$ ,  $SD = .75$  for high lighting). A significant interaction between lighting and entrapment was found for acceptability,  $F(1, 86) = 13.76$ ;  $p < .001$ ,  $partial \eta^2 = .14$ . However, instead of the expected effect (that lighting levels only influence acceptability ratings when entrapment is low) we found that entrapment only influenced acceptability ratings when lighting levels were high. The bars on the left in Figure 3 show that there was no difference in acceptability between low ( $M = 2.49$ ,  $SD = 1.19$ ) and high entrapment ( $M = 2.36$ ,  $SD = 1.08$ ) in the low lighting setting,  $t(87) = 1.26$ ;  $p = .212$ ,  $d = .13$ . In the high lighting setting on the other hand, depicted in the right bars in Figure 3, acceptability was higher in the low entrapment setting ( $M = 4.18$ ,  $SD = .77$ ) compared to the high entrapment setting ( $M = 3.57$ ,  $SD = .86$ ),  $t(87) = 6.16$ ,  $p < .001$ ,  $d = .65$ . A similar pattern was found for evaluation of lighting level,  $F(1, 86) = 10.02$ ;  $p = .002$ ,  $partial \eta^2 = .10$ . The low lighting level was judged below the appropriate lighting level in both the low ( $M = 2.07$ ,  $SD = .92$ ) and high entrapment setting ( $M = 2.01$ ,  $SD = .90$ ),  $t(87) = 0.58$ ;  $p = .567$ ,  $d = .07$ . However, the high lighting level was judged as appropriate in the high entrapment setting ( $M = 3.07$ ,  $SD = .83$ ) and as too much in the low entrapment setting ( $M = 3.51$ ,  $SD = .82$ ),  $t(87) = 4.52$ ;  $p < .001$ ,  $d = .48$ .

### **Influence of Gender on Perceived Social Safety and Acceptability**

As expected, in general, men felt safer ( $M = 3.97$ ,  $SD = .94$ ) in the settings compared to women ( $M = 3.49$ ,  $SD = .66$ ),  $F(1, 86) = 14.66$ ;  $p < .001$ ,  $partial \eta^2 = .15$ . However, in contrast to our expectations, men did not evaluate lighting levels as more acceptable ( $M = 3.09$ ,  $SD = 1.31$ ) than women ( $M = 3.18$ ,  $SD = .84$ ),  $F(1, 86) = 0.31$ ;  $p = .579$ ,  $partial \eta^2 < .01$ . For the other indicator of acceptability, evaluation of lighting level, we also did not find significant differences between men ( $M = 2.60$ ,  $SD = 1.13$ ) and women ( $M = 2.69$ ,  $SD = .75$ ),  $F(1, 86) = 0.37$ ;  $p = .542$ ,  $partial \eta^2 < .01$ . Thus, although a main effect was found for gender on perceived social safety with men feeling safer than women, we did not find a main effect for acceptability of lighting level. Finally, we examined whether entrapment levels influenced feelings of safety and acceptability differently for men and women. We found an interaction effect between gender and entrapment for perceived social safety ( $F(1, 86) = 4.83$ ;  $p = .031$ ,  $partial \eta^2 = .06$ ). Men felt approximately equally safe in the low ( $M = 4.07$ ,  $SD = .94$ ) and high entrapment setting ( $M = 3.86$ ,  $SD = 1.31$ ),  $F(1, 26) = 3.17$ ;  $p = .087$ ,  $partial \eta^2 = .11$ , whereas women felt safer in the low entrapment setting ( $M = 3.77$ ,  $SD = .66$ ) compared to the high entrapment setting ( $M = 3.21$ ,  $SD = .84$ ),  $F(1, 60) = 36.77$ ;  $p < .001$ ,  $partial \eta^2 = .38$ . However, we did not find an interaction between entrapment and gender for acceptability,  $F(1, 86) = 0.06$ ;  $p = .808$ ,  $partial \eta^2 < .01$ , and for evaluation of lighting levels,  $F(1, 86) = 0.87$ ;  $p = .354$ ,  $partial \eta^2 = .01$ . Thus, men feel safe irrespective of the level of entrapment, whereas women feel safer in a low entrapment setting than in a high entrapment setting. However, no gender differences were found in acceptability for settings with different levels of entrapment, possibly because acceptability did not differ for men and women.

### **Discussion**

The present study examined relationships between lighting levels, perceived social safety, and acceptability, and to what extent perceived social safety and acceptability in turn depend on individual factors (gender) and physical factors (entrapment). In line with previous studies, we expected that gender and entrapment would affect perceived social safety. In addition, we extended the literature by examining whether the effects of lighting levels on acceptability depend on perceived social safety, and by studying how acceptability of lighting policies may be enhanced by increasing perceived social safety. As expected, we found that perceived social safety mediated the effects of lighting levels on acceptability: lighting levels were perceived as more acceptable when perceived social safety was not threatened. So, to

ensure public support for lighting policies the lighting level in question must be perceived as safe.

Our second question was: which issues need to be taken into account when trying to limit the negative effect of reduced street lighting on perceived social safety? And, further extending previous research, how do these issues in turn affect acceptability? In general, factors known to influence perceived social safety had a similar effect on acceptability of lighting levels. In line with previous research (Blöbaum & Hunecke, 2005; Fisher & Nasar, 1992), participants felt safer in settings offering opportunities to escape for potential victims in case of an attack (i.e. low entrapment), and in settings with high lighting levels. Importantly, entrapment and lighting levels affected acceptability of lighting levels in a similar way. Previous research (Blöbaum & Hunecke, 2005) found that an increase in lighting levels only led to an increase in perceived social safety in a low entrapment setting, probably because the lack of escape opportunities in a high entrapment setting will inevitably lead to low perceived social safety. We did not replicate this finding. This may be due to a ceiling effect: respondents felt relatively safe in all conditions, that is, in all conditions mean scores were above the scale mean. However, we did find an interaction effect between entrapment and lighting for acceptability. A high lighting level was particularly judged as more acceptable in a low entrapment setting, whereas acceptability of a low lighting level was similar for low and high entrapment settings. Importantly, we found the same pattern for both indicators of acceptability, suggesting that these results are robust. Although expressed by a different pattern, this result is similar to what Blöbaum and Hunecke (2005) found for perceived social safety: acceptability was highest when lighting levels are high in a setting offering opportunities to escape (i.e. low entrapment). Interestingly, high lighting levels were perceived as too much in a low entrapment setting and as appropriate in a high entrapment setting, while low lighting levels (that reflected lighting levels below the current Dutch street lighting norms) were evaluated as too low. This indicates that compared to high entrapment, low entrapment settings offer better opportunities for decreasing lighting levels while remaining acceptable by the public.

Interestingly, not all findings were similar for perceived social safety and acceptability of lighting levels, emphasizing the importance of studying both simultaneously. This was particularly true for the relationship between gender and lighting levels. We found no gender effect on acceptability of lighting levels, whereas, in line with previous research, (e.g. Pain, 2000; Valentine, 1989) women perceived the same settings as less safe than men. In support of Valentine (1989), ill-considered building or street design might decrease feelings of safety

even more in women. For men opportunities to escape made no difference to their feelings of safety, they felt safe in both low and high entrapment setting, whereas women felt safer in a low entrapment setting compared to a high entrapment setting. However, this effect was not found for acceptability, arguably because men and women evaluated lighting levels similarly on acceptability. There is a wealth of research into the relationship between gender and perceived social safety, but the current results indicate that although men and women differ on how safe they perceive certain settings to be, they do not necessarily differ on in their acceptability judgements.

The present study also extended the literature by using movie-clips of virtual environments. By replicating findings from previous studies support was found for the use of virtual environments as an additional and complementary method to study individual's responses to environments. Both field experiments and lab experiments relying on virtual reality have their strengths and weaknesses. Field experiments are strong in ecological validity, whereas lab experiments are easier to manipulate and allow for more experimental control, by only varying the variables of interest while keeping all other factors constant. Ideally, both methods should be combined, as the weaknesses of one method may be compensated by the strengths of another method.

Furthermore, in linking reduced street lighting and perceived social safety to environmental issues, this research combines two main lines of research within environmental psychology. Firstly, the issues discussed in this paper relate to how the environment can influence our well-being (in this case perceived social safety). Secondly, this paper discussed which factors affect the acceptability of policies (in this case lighting policies) that aim to enhance environmental quality.

Some issues need to be taken into account when considering the results of this study. Our sample consisted mainly of young students. This has to be kept in mind when generalizing the findings to other populations. Even though young university students are a relevant sample since they are often outside when it is dark, it would be interesting to investigate if the current findings can be replicated using older segments of the population. Also, a large percentage of our sample consisted of women, which is important to consider when looking into gender differences. The present study did not include a condition in which participants were exposed to the current policy situation, i.e. a lighting level in line with the norm (15 lux). Although this would have provided us with additional information on the issue, current policy aims either to increase street lighting in order to increase safety, or decrease lighting in order to decrease the environmental impact. So, comparing these

alternative policy implications provided us with relevant information on this issue. Similarly, we did not include a condition representing an intermediate level of entrapment, as we thought that stronger feelings of low and high entrapment could be evoked using street widths on either end of the spectrum. Future studies could also include settings with intermediate levels of entrapment. Also, future research could look into how other factors that are known to influence perceived social safety relate to acceptability of lighting levels, such as the presence of others and signs of disorder. With respect to the use of virtual environments, more immersive techniques such as dynamic virtual reality could be used. Furthermore, information could be collected to examine how participants experience the virtual settings (e.g. perceived presence), to further test the validity of virtual environments. Finally, stronger effects might be found when using photographs of real environments to build the virtual environment instead of a simulated environment, as was done in the studies by Nasar and Cubukcu (2011). However, considering our results the current method seems sufficient to elicit feelings of safety and acceptability.

### **Notes for Policy Makers**

Potential policy implications of the current findings include considering policy acceptability when reducing street lighting levels. Importantly, enhancing feelings of safety through street design can increase acceptability of reduced lighting levels. Considering acceptability next to feelings of safety is critical as gender differences can be found for feelings of safety but not acceptability. Also, it is interesting to note that respondents felt on average reasonably safe in all settings. Average perceived safety was above the mid-point of the perceived safety scale, even for the high entrapment and low lighting settings. Because respondents knew they were participating in an experiment feelings of safety might have been slightly higher than they would have been in a real-life situation. It should be noted that average acceptability of lighting level was below the mid-point of the acceptability scale at the low lighting levels. So, even though perceived social safety was reasonably high in most settings, in some cases safety levels may need to be increased in order to be acceptable, which again underlines the importance of including acceptability of lighting levels in research on lighting levels.

### **Conclusion**

Increased street lighting has the potential to increase actual and perceived social safety, but this comes with costs for the environment. On the other hand, reducing street lighting in

order to alleviate these environmental impacts may result in reducing perceived social safety. This can be problematic, because these social costs are potentially vital in bolstering support for new policies (Steg et al., 2006). This research aimed to provide a better understanding of the relationship between lighting levels, perceived social safety, and acceptability of lighting levels, and looked at ways to reduce lighting without reducing perceived social safety. In summary, lighting levels were more acceptable once the setting was perceived as safe. Interestingly, reducing street lighting did not automatically lead to a reduction in perceived social safety and low policy acceptance; this depended on gender and the level of entrapment. Streets need to be designed from the viewpoint of their users: opportunities to escape in case of an attack need to be included and this is especially important for women. The subsequent potential increase in perceived social safety could increase the likelihood that reduced lighting policies are accepted. Creating opportunities to limit the environmental impact of street lighting bring us one step closer to a more sustainable future.

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## Footnotes

<sup>1</sup>In addition half of the participants received some additional information on the environmental benefits of reduced street lighting. This was for purposes not relevant to the hypotheses discussed here and did not have any effect on the relevant analyses. Therefore, we do not elaborate on this factor.

<sup>2</sup> To establish the lighting level used in the low and high lighting movie-clip, two light experts judged the lighting level of a total of five movie-clips. The light experts compared the lighting level in all five movie-clips to what they considered to be the current norm of street lighting in an urban setting in The Netherlands (which is 15 lux). The selected lighting levels' steps above and below the norm are not equal in size since lighting level could only be estimated after the movie-clips were made.

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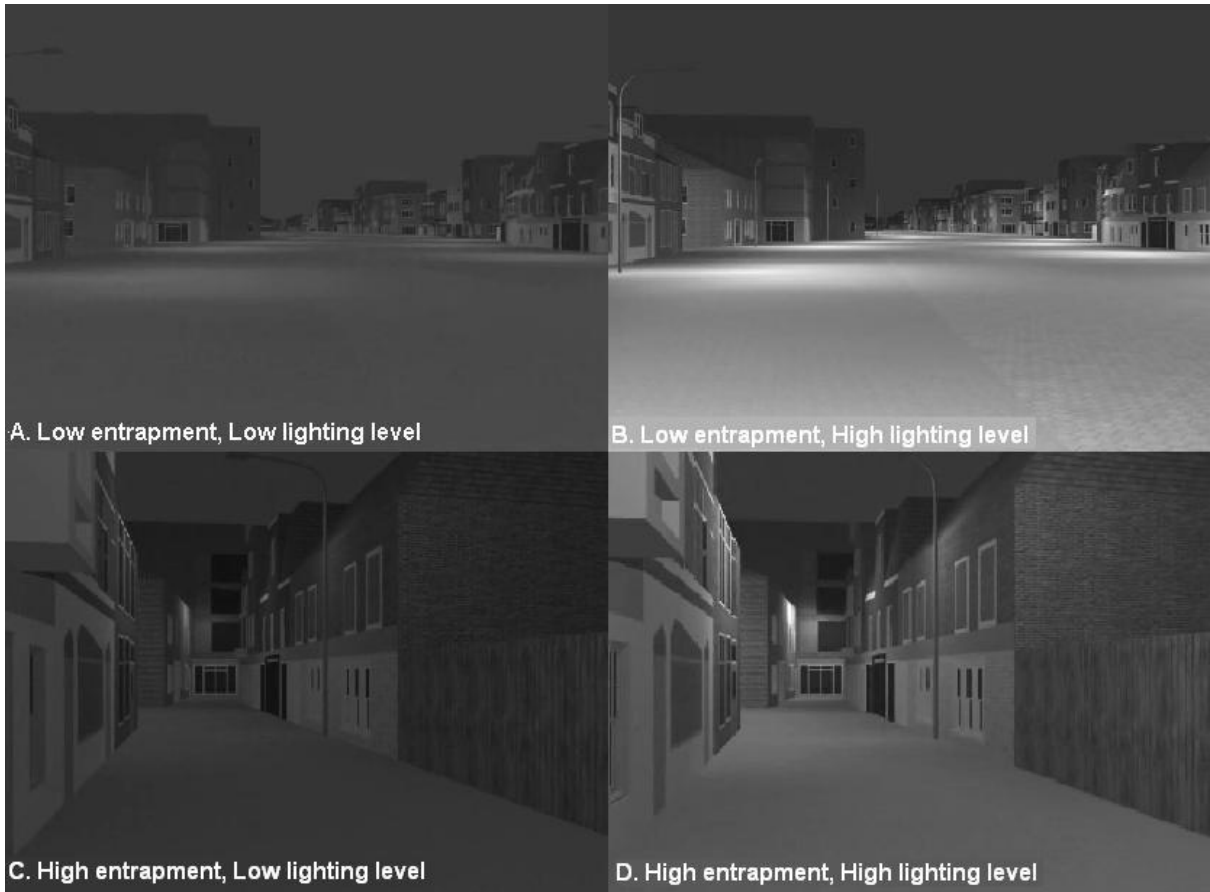
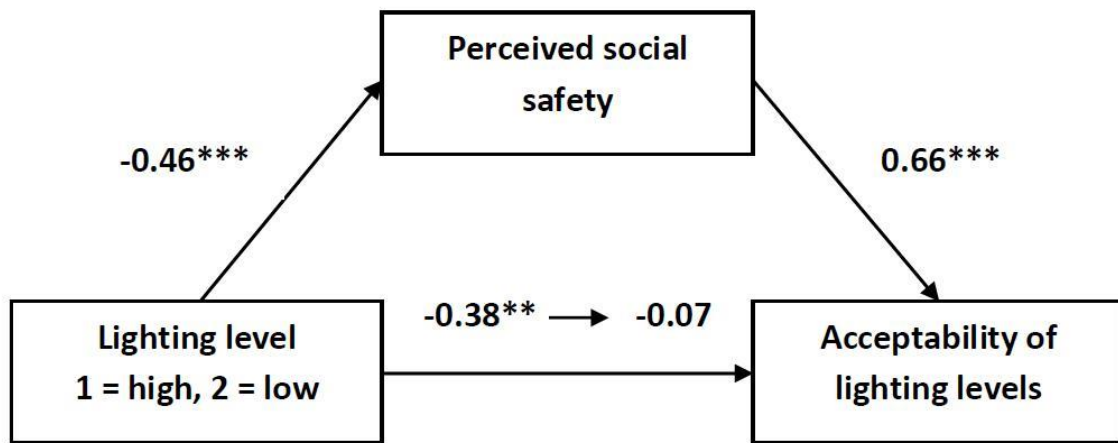


Figure 1. Movie stills of the virtual environment movie-clip settings

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*Figure 2.* The mediation effect between lighting level, perceived social safety and acceptability of lighting levels. Standardized regression coefficients are presented, asterisks indicate the significance of the coefficients (\*\* $p < .01$ , \*\*\* $p < .001$ ).

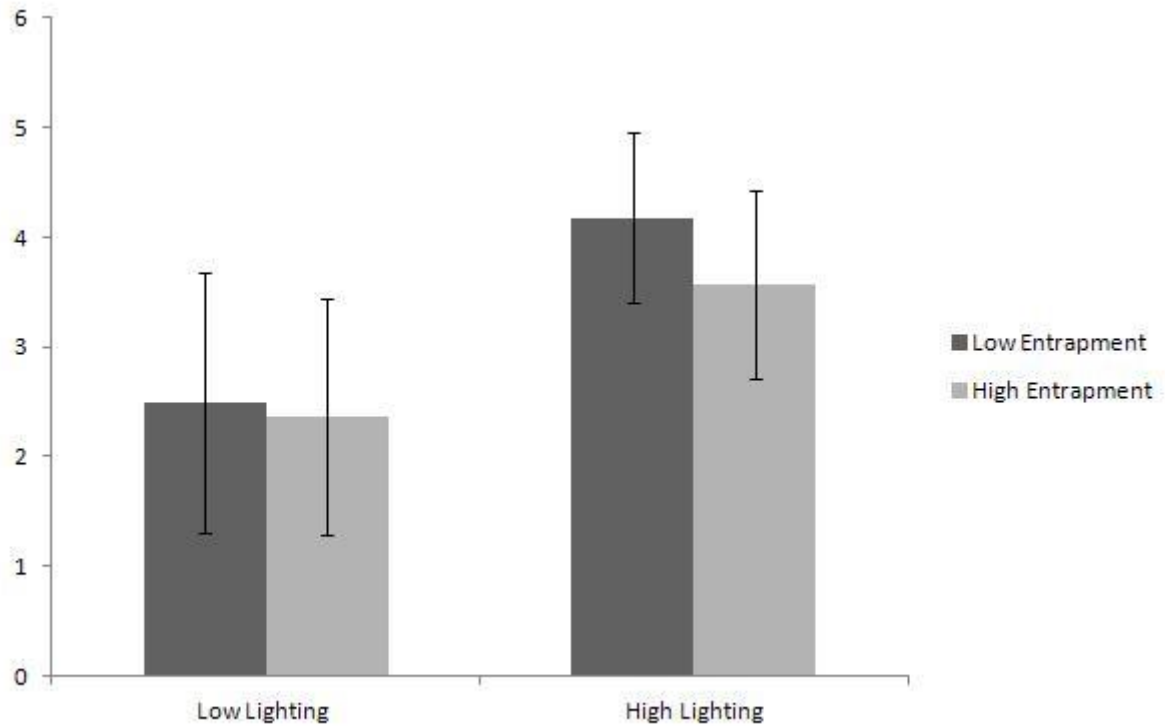


Figure 3. Interaction effect between entrapment and lighting for acceptability of lighting levels.

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