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Lighting modes and their effects on impressions of public squares☆

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ABSTRACT

Lighting may affect impressions of public places after dark. Prospect-refuge theory suggests that people would favor uniform, bright, or overhead lighting to the alternatives. The study had 363 (161 men, 202 women) adult participants. An on-line survey displayed color slides of two simulated squares, each repeated for all mixes of lighting modes (order randomized across participants). One square also varied the peripheral lighting tilt (down or out). For ratings, each participant was assigned at random to use one of twelve items for evaluation, excitement, restfulness, or behavioral intent. Because the scales had high inter-item reliability, we combined them into a composite preference scale. In agreement with P-R theory, uniform, bright, and overhead lighting received the higher scores. The peripheral lighting tilt (down or out) did not affect preference. Lighting designs might do well to offer unobstructed views of information ahead. Research could test on-site experience and different aspects of lighting.
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1. Introduction

Outdoor squares draw people to gather, enrich neighborhoods and communities, and may enhance sense of community and well-being (Cattell, Dines, Gesler, & Curtis, 2008; Gehl, 2011; Project for Public Spaces, 2014). Observational and correlational studies of public squares have found that attributes, such as sittable space, food vendors, sculptures, and vegetation, strengthen their vitality (Joardar, 1977; Joardar & Neill, 1978; Mehta, 2007; Whyte, 1980, 1988). Controlled experiments confirm that sittable space, food vendors, and sculpture does improve vitality and restorativeness (Abdulkarim & Nasar, 2014a, b). In focusing on the daytime experience, these studies overlook lighting.

After dark, lighting affects people's impression of public squares and whether they choose to visit them (Durak, Olguntürk, Yener, Güvenç, & Gürçınar, 2007; Küller, Ballal, Laike, Mikellides, & Tonello, 2006; Miwa & Hanyu, 2006; Tiller, 1990). Fear of crime, which intensifies after dark, constrains behavior (Gates & Rohe, 1987). Darkness and shadows heighten fear, whereas well-lit areas or sidewalks heighten safety (Boyce, Eklund, Hamilton, & Bruno, 2000; Hanyu, 1997; Nasar & Jones, 1997; Painter, 1988, 1991; Tien, 1979). Improved lighting can also reduce crime (Farrington & Welsh, 2002), improve pedestrian confidence (Boyce et al., 2000; Vrij & Winkel, 1991), and increase the number of pedestrians in an area (Painter, 1994, 1996).

Although lighting designers face choices of lamps, spectral distributions, fixtures, shielding, reflection, brightness controls, and color filters (Moyer, 2005), research has found three lighting modes as the most important in the human perception of lighting (Flynn, 1988; Hawkes, Loe, & Rowlands, 1979; Veitch & Newman, 1998): the illumination level (a physical measure of brightness), the distribution (uniformity), and the position (overhead vs. peripheral). Studies show that each of these modes affects human impressions of environments (Durak et al., 2007; Flynn, 1988; Küller et al., 2006; Miwa & Hanyu, 2006). Although few studies have examined the effects of lighting in public squares after dark,[1] research has found that preference for offices increases with peripheral, non-uniform, and bright lighting, and that peripheral has the largest effect, and bright lighting has the smallest effect (Flynn, 1988). Other studies

☆ People can e-mail the first author for the data, images or other information in the study.

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[1] de Kort and Veitch (2014) found fewer than 37 articles on the experience or psychological effect of light or lighting, 10 of which were in their special issue of the *Journal of Environmental Psychology*. Our google scholar search of *Environment and Behavior* found 17 other articles with light or lighting in the title. Only 3 of these 54 articles dealt with outdoor lighting, primarily streets. Subsequent to that, we conducted one study of lighting in outdoor squares after dark (Nasar & Bokharaei, 2016).

confirm that for interiors, peripheral lighting increases perceived pleasantness (Durak et al., 2007; Miwa & Hanyu, 2006).

Because human responses differ across behavior settings (Wicker, 2002), lighting preferences for offices may not generalize to public squares after dark. Studies confirm that responses to lighting differ across settings (Boyce et al., 2000; Butler & Biner, 1987). Unlike offices, which are private, outdoor squares are public. In public settings, users have less control and certainty about what might happen next than they would in private settings (Altman, 1975). Public territories are also more prone to crime than are private territories (Cozens, Saville, & Hillier, 2005). Prospect-refuge theory suggests that in such situations of uncertainty and fear, blocked prospect (hiding places, or places of concealment ahead) intensify the perceived threat and lessen preference (Archea, 1985; Fisher & Nasar, 1992; Herzog & Flynn-Smith, 2001; Nasar & Fisher, 1993; Nasar & Jones, 1997). This theory has implications for the effects of lighting.

The undesirability of blocked prospect in public places suggests that unlike in offices, in public squares people would prefer *uniform*, *bright*, and *overhead* lighting. Although research has studied effects of lighting properties, such as illuminance, spectral power distribution, and spatial distribution, on human impressions of outdoor spaces (Boyce et al., 2000; Fotios, Unwin, & Farrall, 2015), for public places after dark, where safety (clear view of obstacles) and security (deterring offenders) take priority, studies find that uniformity (evenly distributed) and illumination (brightness) are most important (Boyce, 2003; Van Santen, 2006). Consider uniform lighting. Uniform lighting affords a person better prospect than does non-uniform lighting; non-uniform lighting has dark spots, that could hide someone. Research has found that people perceive uniform lighting more favorably for goodness of illumination, ability to see around and at a distance, and perception of safety (Narendran, Freyssinier, & Zhu, 2015). This also can result in less energy use and glare. Compared to dim lighting, bright lighting brings more information into view, and this affords viewers better predictions about what may happen if they move into the square. Research confirms that bright lighting improves perceived safety and preference (Boomsma & Steg, 2014a, b; Boyce, 2003; Johansson, Pedersen, Maleetipwan-Mattsson, Kuhn, & Laike, 2014; Johansson, Rosén, & Küller, 2011; Van Santen, 2006), with the effect mediated by prospect and concealment (Haans & de Kort, 2012). Finally, overhead lighting allows one to see nearby places, but hides the more distant edges in darkness. Peripheral lighting lessens one's ability to see places nearby, but lightens the more distant edges. As a result, people may feel safer and prefer overhead to peripheral lighting. In sum, prospect-refuge theory points to the desirability of bright, uniform and overhead lighting for public squares after dark.

One study manipulated the mode of lighting to test affective appraisals of non-uniform versus uniform, peripheral versus overhead, and dim versus bright lighting (Nasar & Bokharaei, 2016). In 24 virtual environments, it covered each combination of the three modes of lighting in each of three squares. College students from one university rated each environment on three items, unappealing-appealing, dull-exciting, and unsafe-safe from crime. These items represented the three key aspects of emotional appraisal of places (Posner, Russell, & Peterson, 2005; Russell & Pratt, 1980; Russell, 1980; Russell, Lewicka, & Nitt, 1989): preference, excitement, and restfulness. The analyses revealed high inter-item reliability between the three items, perhaps because they share an evaluative component, and because the squares did not elicit a low or high enough arousal to separate safety (pleasant low arousal), exciting (pleasant arousal), or appealing (pure evaluation). As predicted by prospect-refuge theory, participants favored uniform over non-uniform, and bright over dim lighting. They also favored overhead over peripheral lighting, but the differences achieved statistical significance in only one of the three squares.

The present study extended that study in five ways. 1) It replaced the student sample with a more diverse national sample of adults. 2) It replaced the single-item measures with three items for each aspect of emotional appraisal. Although well-crafted single item measures may have good predictive validity (Bergkvist & Rossiter, 2007, 2009), multiple-item measures are likely to have better predictive validity (Diamantopoulos, Sarstedt, Fuchs, Wilczynski, & Kaiser, 2012). Using multiple items also allowed a test of the accuracy of the single-item measures. 3) It added three items to gauge behavioral intent. 4) To avoid the semantic bias from each participant doing multiple ratings of each square, It had each participant rate each square on one item. This prevents semantic bias, in which ratings on one item may bias ratings on the others. 5) It included a variation on the peripheral lighting. Recall that in offices, people preferred the peripheral to the overhead mode (Flynn, 1988). Perhaps, the favorable responses to overhead mode in the squares resulted from the form of the peripheral mode. Unlike the peripheral mode in the offices which tilted out illuminating the walls, in the squares it tilted downward illuminating the ground. Because the squares were not enclosed, the downward tilted peripheral lighting left dark spots along and beyond the edges, which might increase fear and depress appeal. In addition, the well-lit areas may have accentuated the darkness of the unlit areas, further increasing fear and depressing appeal. Furthermore, lighting engineers suggested that people might prefer peripheral to overhead lighting in outdoor spaces if the peripheral lighting illuminated the walls at the edge (Burkett, 2014). For example, in one Walmart parking lot, the mode of lighting that most improved user responses involved lighting the Walmart façade (Clanton, 2014). Thus, the study tested responses to peripheral lighting tilted downward or outward.

Theory and research suggested five research questions for the modes of lighting in outdoor squares after dark:

Q1: Would the twelve items have high inter-item reliability?
Q2: Would adults prefer uniform to non-uniform lighting?
Q3: Would they prefer bright to dim lighting?
Q4: Would adults prefer overhead to peripheral lighting when the peripheral lighting tilted down (lighting the ground) or when it tilted out (lighting the edges)?
Q5: Would the angle of the peripheral lighting (tilted down versus tilted out) affect their preferences?

2. Method

2.1. Participants

363 people (161 men, 202 women) in the U.S. volunteered to participate in the study. They were assigned at random and in equal proportions to one of twelve items to rate each of 20 squares (described in the section on stimulus materials, and instruments and procedures, which follow). The random assignment resulted in either 30 or 31 respondents for each item. The reported ages ranged from 18 to 76 (median = 42) years old. Most participants reported that they were married (52.6%), but many said they had never married (32.70%). Most participants said they had no children under the age of 18 living at home (74.86%). Participants reported every level of education, but the highest numbers had either graduated college (36.19%), a master's degree (22.65%), or completed some college or an associate degree (25.69%). Participants reported living in 42 states, with higher numbers reporting Ohio (21.27%), Tennessee (9.11%), New York (8.84%), California

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