Chapter 7

A dark and peaceful place:
Ambient darkness lowers approach motivation and renders people with high dispositional anger less easily angered

This chapter is based on: Veenstra, L., Schneider, I. K., & Koole, S. L. (revision submitted)
Chapter 7

Abstract

Ambient lighting influences virtually all aspects of human functioning. However, little is known about the impact of ambient lighting on basic motivational processes. The present research examined the influence of ambient lighting on approach motivation and anger as an approach-oriented emotion. Because dark environments are associated with sleep and inactivity, we hypothesized that approach motivation would be lower in dark than in well-lit environments. Consistent with this, participants in Experiment 1 ($N = 80$) reported less approach motivation in a dark room than those in a well-lit room. If darkness reduces approach motivation, then darkness (compared to light) may also reduce approach-oriented emotions like anger. To test this notion, participants with varying levels of dispositional anger in Experiment 2 ($N = 112$) reported their angry feelings to a hypothetical unfair situation in a street interview. When it was light outside, people's level of dispositional anger was related to more state anger. When it was dark outside, dispositional anger and state anger were unrelated. These findings suggest that ambient lighting conditions may moderate approach-oriented motivations and emotions, in line with modern theories of situated cognition.
Introduction

Ambient lighting is a pervasive ecological condition. Research has documented the influence of lighting on virtually all aspects of human functioning, including perception, cognition, communication, sleep, and health (for reviews, see Boyce, 2003; De Kort & Veith, 2014). Nevertheless, relatively little is known about the influence of ambient lighting on motivational processes. This is unfortunate, given that motivation is a core construct within psychology that relates to the direction and intensity of behavior (Austin & Vancouver, 1996; Braver et al., 2014; Shah & Gardner, 2008) and emotion (Carver & Harmon-Jones, 2009; Elliot & Thrash, 2010; Russell, 2003). In the present article, we seek to fill this gap, by considering the influence of ambient lighting on approach motivation and its downstream consequences for anger management.

In the following paragraphs, we develop the theoretical rationale underlying our hypothesis that dark environments, more than well-lit environments, are likely to decrease approach motivation. Building on this notion, we suggest that dark environments may lower approach-oriented emotions like anger, especially among people who are dispositionally prone to approach anger-related situations. Finally, we present two experiments that empirically tested our theoretical analysis.

Ambient Lighting and Motivation

Humans are diurnal animals. Consequently, their biology is evolved so that they become more active and alert in light environments. Indeed, research on sleep-rest rhythms indicates that people have an internal clock that is calibrated by natural lighting conditions, such that daytime light makes people alert, whereas nighttime darkness makes people drowsy (Cajochen, Chellappa, & Smidt, 2014). Moreover, higher artificial illumination increases subjective as well as objective indicators of alertness, vitality and mood (Smolders, de Kort, & Cluitmans, 2012), indicating that the effect of bright light on alertness is not dependent on time of the day.

Beyond alertness, ambient lighting conditions may also influence people’s motivations for approach and avoidance. Approach and avoidance systems are the most basic motivational structures that underlie behavior and emotions (Cacioppo & Berntson, 1994; Carver & Scheier, 1990; Elliot & Thrash, 2010; Higgins, 1998; Russell, 2003). The approach system motivates people to go toward (Harmon-Jones, Harmon-Jones, & Price, 2013), mostly with the goal to approach a reward or incentive. In contrast, the avoidance system motivates people to go away, in most cases with the goal to avoid a possible threat or punishment. Because well-lit environments make humans more active, and allow for easier navigation than dark environments, we suggest that people’s approach motivation becomes more potentiated in well-lit environments compared to dark environments.

The idea that ambient lighting fosters approach motivation is supported by several lines of research. First, on a cognitive level, ambient light improves cognitive task performance (Boyce, Beckstead, Eklund, Strobel, & Rea, 1997; Huiberts, Smolders, & de Kort, 2015; Smolders, et al., 2012) and reflective self-regulation (Steidle, & Werth, 2014).
On a physiological level, ambient light increases physiological arousal (Badia, Myers, Boecker, & Culpepper, 1991; Rüger, Gordijn, Beersma, de Vries, & Daan, 2006), and higher objective as well as subjective alertness (Cajochen, Zeitzer, Czeisler, & Dijk, 2000). Moreover, on a behavioral level, ambient light promotes more active behavior, for instance, research has found that brighter ambient lighting conditions led consumers to handle more items more actively than darker lighting conditions (Areni & Kim, 1994; Summers & Hebert, 2001). These studies indicate that ambient light, compared to ambient darkness, is associated with increased approach behavior.

Intuitively, it seems plausible that ambient darkness would be associated with relatively more avoidance motivation. Indeed, several lines of research suggest that darkness is associated with threat and careful behavior, possibly because darkness renders potential environmental dangers harder to observe or detect (Schaller, Park, & Mueller, 2003). Moreover, people display a greater startle reflex in dark environments, a physiological indicator of fear (Grillon et al., 1999), an emotion that is closely related to avoidance motivation (e.g., Lang, Bradley, & Cuthbert, 1998). Driving in dark tunnel, for instance, is associated with facilitated startle reactions, and more negative feelings (Muhlberger, Wieser, & Pauli, 2008). However, ambient darkness may also make it easier for people to hide themselves (Steidle, Hanke, & Werth, 2013), which is likely to lower feelings of threat. The effect of darkness on avoidance motivation therefore seems complex and dependent on additional moderating factors, such as how much confidence people experience in a certain situation (Schaller et al., 2003), or the intensity of threat. In relatively safe environments, darkness may not necessarily cause anxiety or avoidance (Steidle, et al., 2013).

In sum, several research lines suggest that ambient light increases approach motivation behavior. The effects of ambient lighting on avoidance motivation seem more complex, though there is some reason to believe that people may experience more avoidance motivation in dark environments. Note however, that approach and avoidance systems interact in determining behavior. Although, in some cases, approach and avoidance tendencies can be jointly activated (e.g., McNaughton & Corr, 2014), typically one system overrules the other, i.e., when approach is increased, avoidance is decreased, or the other way around. Thus, ambient lighting may increase approach motivation directly (e.g., by heightening alertness) and indirectly, by lowering avoidance motivation.

**Ambient Lighting and Emotion**

If ambient light promotes approach motivation, then it seems plausible that ambient light will also increase the occurrence of approach-oriented emotions. In line with this, research has shown that people feel happier and more vital when they are exposed to brighter lighting conditions (Smolders & de Kort, 2014). In the clinical domain, bright light has been used to treat depression (Lam et al., 2016). Because depression is associated with low approach motivation (Dimidjian, Barrera Jr., Martell, Munoz, & Lewinsohn, 2011), depression-reducing effects of light therapy are consistent with the idea that increased lighting fosters approach-oriented emotions. However, evidence on the
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effectiveness of light therapy is mixed (see Mårtensson, Pettersson, Berglund, & Ekselius, 2015; Perera, et al., 2016). It thus seems important to consider the potential effects of lighting conditions on other types of approach-oriented emotions.

Approach-oriented emotions are typically thought of as positive, presumably because the approach system is closely involved in reward processing (Simon, et al., 2010). Nevertheless, some emotions that are experienced as negative may still arise from the approach system. One of the clearest examples of a negative approach-oriented emotion is anger (Carver & Harmon-Jones, 2009). Anger is a basic human emotion that arises from the obstruction of one’s goals (Berkowitz, 1993), and typically involves a sense of being offended or intentionally hurt by another person (Frijda, 1986; Ortony, Clore, & Collins, 1988). Although people experience anger as negative, angry feelings are characterized by heightened approach motivation (Carver & Harmon-Jones, 2009). For instance, state anger is positively associated with reward sensitivity and negatively with threat sensitivity (Harmon-Jones, 2003a; Smits & Kuppens, 2005), and people high in approach motivation respond with more anger to provocations (Carver, 2004; Harmon-Jones & Peterson, 2008). Also, anger and approach motivation both involve activations in the left anterior cortex (Hortensius, Schutter, & Harmon-Jones, 2012; Murphy, Nimmo-Smith, & Lawrence, 2003) which is involved in approach behavior (Tops, Quirin, Boksem, & Koole, 2017).

To the extent that anger is an approach-oriented emotion, factors that lower approach motivation - such as ambient darkness - may be expected to help in down-regulating anger. Moreover, because this environmental regulation process is not based on self-regulatory skills, it may be especially pronounced among people who have difficulties self-regulating their angry feelings. Such self-regulatory difficulties are most prevalent among people with high (rather than low) trait anger (Wilkowski & Robinson, 2008), a personality disposition that relates to the frequency, intensity, and duration with which people experience angry feelings (Spielberger, Jacobs, Russell, & Crane, 1983; for a recent review, see Veenstra, Bushman, & Koole, 2017, Chapter 2). Moreover, there is also a positive association between approach motivation and trait anger (Harmon-Jones, 2007; Harmon-Jones, 2003; Veenstra, Schneider, Bushman, & Koole, 2016, Chapter 3). The effects of trait anger on state anger might thus be caused by the elevated levels of approach motivation in people with high trait anger. Consequently, blocking approach motivation may prevent trait anger from developing into state anger.

Consistent with the aforementioned notions, we recently found that body postures and hand movements associated with avoidance behavior attenuates the relation between higher levels of trait anger and state anger and aggression (Veenstra, Schneider, Dillon, Domachowska, Bushman, & Koole, unpublished results, Chapter 4; Veenstra, Schneider, & Koole, unpublished results, Chapter 6). However, postures and movements are physically very different from ambient lighting conditions, even though both types of variables are similarly related to basic motivation systems. It thus remains to be seen if ambient lighting conditions have a similar influence on anger management processes.
The Present Research and Hypotheses

In the present research, we sought to empirically examine the effects of ambient lighting on approach motivation and the approach-oriented emotion of anger. Experiment 1 was a lab experiment that examined whether ambient lighting may influence self-reported approach motivation. We hypothesized that a dark room would evoke less approach motivation than a well-lit room. Experiment 2 was a field experiment that investigated whether the influence of ambient lighting conditions extends to anger, as an approach-oriented emotion. Prior work has shown that anger is especially driven by approach motivation among people high in trait anger (Harmon-Jones, 2007; Veenstra et al., in press, Chapter 2). Thus, we expected that the influence of ambient lighting conditions would be moderated by individual differences in trait anger. Specifically, we hypothesized that a dark (compared to a light) environment would inhibit the translation of high trait anger into state anger.

Experiment 1

Experiment 1 examined the influence of ambient darkness compared to ambient light on self-reported approach motivation. We used the behavioral activation and behavioral inhibition scales (BAS/BIS; Carver & White, 1994; Franken, Muris & Rassin, 2005) to measure participants’ motivational dispositions. The behavioral activation scale measures people’s behavioral approach system, which regulates rewarding motives for drive, fun seeking, and reward responsiveness. The behavioral inhibition scale measures people’s behavioral avoidance or inhibition system, which regulates aversive motives. Based on the idea that poorly lit environments lower people’s approach related processes such as cognitive activity and physiological alertness (e.g., Huiberts, et al., 2015; Rüger, et al., 2006; Smolders & de Kort, 2014), we expected that participants’ ratings of their behavioral activation would be lower in a dark room than in a light room. Because the effect of lighting on avoidance motivation is probably moderated by level of threat, and the level of threat in our laboratory is relatively low compared to less familiar, or outdoor surroundings, we expected smaller, if any, effects of ambient lighting on behavioral inhibition ratings.

Method

Participants and design. Participants were 80 undergraduate students (46 females, $M_{age} = 20.36$, $SD_{age} = 2.48$, range = 17-29) from the Vrije Universiteit Amsterdam who were paid €3.50 (about $4.00) for their participation. Participants were randomly assigned to one of the lighting conditions (light cubicle ($n = 39$) vs. dark cubicle ($n = 41$)). The main dependent variable was participants’ behavioral activation\(^8\).

\(^8\) The first experiment was conducted as part of a half-hour experimental block in which another study investigated the effects of arm movement (pull versus push), on the
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**Sampling plan.** Due to a lack of previous research on the effects of lighting on motivational behavior, we did not have information on the effect size. We decided to include 40 participants per lighting condition, based on the assumption that the effect would correspond to a medium to large effect size ($d > 0.50$). A post-hoc power calculation using G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) for an independent t-test with the actual observed effect size ($d = 0.47$), alpha of .05, and two groups of $N_{light} = 39$ versus $N_{dark} = 41$ resulted in an estimated power of 67%.

**Procedure and materials.** Participants were seated in separate cubicles behind a computer screen. After reading the information brochure and signing informed consent, participants in the dark condition were instructed to call the experimenter to turn off the light in the cubicle, and then started answering the behavioral activation and inhibition questionnaires on the computer screen. Participants in the light condition started with the questionnaires immediately.

We measured approach-related behavioral tendencies with the behavioral activation scale (BAS, 13 items, $M = 70.95$, $SD = 9.32$, Cronbach’s $\alpha = .77$), which is divided into three different subscales (BAS-reward, 5 items, $M = 79.21$, $SD = 9.56$, Cronbach’s $\alpha = .67$, e.g., “When I get something I want, I feel excited and energized.”; BAS-drive, 4 items, $M = 71.10$, $SD = 15.09$, Cronbach’s $\alpha = .76$, e.g., “I go out of my way to get things I want.”; and BAS-fun, 4 items, $M = 60.28$, $SD = 16.13$, Cronbach’s $\alpha = .67$, e.g., “I will often do things for no other reason than that they might be fun.” (Carver & White, 1994; Franken, et al., 2005). We also included the behavioral inhibition scale (BIS, 7-items, $M = 64.53$, $SD = 17.87$, Cronbach’s $\alpha = .88$, e.g., “I feel pretty worried or upset when I think or know somebody is angry at me.”). The items were answered on a computerized slider scale (1 = very strongly, 100 = not at all), and were re-coded by the researchers before data analysis such that higher scores indicate a higher level of behavioral activation or behavioral inhibition.

**Results**

To test whether lighting (light versus dark cubicle) affected people’s behavioral activation and inhibition, we conducted independent t-tests. Table 1 gives an overview of the descriptives of the behavioral and inhibition activation scale, its subscales, and the corresponding test results. Lighting predicted participants’ behavioral activation, such that participants reported more behavioral activation when they were sitting in a light cubicle, $M = 73.13$, $SD = 8.18$, than when they were sitting in a dark cubicle, $M = 68.87$, $SD = 9.94$, $t(78) = 2.08$, $p = .040$, Cohen’s $d = 0.47$, 95%CI [0.02, 0.91]. More differentiated tests of the separate subscales of behavioral activation showed that lighting mainly affected participants’ self-reported behavioral drive. Lighting did not affect participants’ level of reported behavioral inhibition, $M_{light} = 67.38$, $SD_{light} = 16.90$, $M_{dark} = 61.82$, $SD_{dark} = 18.56$, $t(78) = 1.40$, $p = .166$, Cohen’s $d = 0.31$, 95%CI [-0.12, 0.75]. See Figure 1 for a visual display of the effects of lighting on behavioral activation and inhibition.

relation between trait and state anger. To prevent the studies from influencing each other, study order was counterbalanced.
Table 1. Effect of lighting condition (dark vs. light cubicle) on behavioral activation and inhibition (BAS/BIS) and their different subscales.

<table>
<thead>
<tr>
<th></th>
<th>M (SD)</th>
<th>t-value</th>
<th>p-value</th>
<th>Cohen’s d; 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BAS</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Light</td>
<td>73.13 (8.18)</td>
<td>-2.08</td>
<td>.040</td>
<td>0.47; 0.02, 0.91</td>
</tr>
<tr>
<td>Dark</td>
<td>68.87 (9.94)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Overall</td>
<td>70.95 (9.32)</td>
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<tr>
<td><strong>BAS-drive</strong></td>
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<tr>
<td>Light</td>
<td>74.46 (14.24)</td>
<td>-1.98</td>
<td>.051</td>
<td>0.44; -0.002, 0.89</td>
</tr>
<tr>
<td>Dark</td>
<td>67.90 (15.34)</td>
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<tr>
<td>Overall</td>
<td>71.10 (15.09)</td>
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<tr>
<td><strong>BAS-fun</strong></td>
<td></td>
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</tr>
<tr>
<td>Light</td>
<td>61.87 (15.29)</td>
<td>-0.86</td>
<td>.391</td>
<td>0.19; -0.25, 0.63</td>
</tr>
<tr>
<td>Dark</td>
<td>58.76 (16.94)</td>
<td></td>
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<tr>
<td>Overall</td>
<td>60.28 (16.13)</td>
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<tr>
<td><strong>BAS-reward</strong></td>
<td></td>
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<tr>
<td>Light</td>
<td>80.89 (8.05)</td>
<td>-1.54</td>
<td>.127</td>
<td>0.34; -0.10, 0.79</td>
</tr>
<tr>
<td>Dark</td>
<td>77.61 (10.65)</td>
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</tr>
<tr>
<td>Overall</td>
<td>79.21 (9.56)</td>
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<tr>
<td><strong>BIS</strong></td>
<td></td>
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<tr>
<td>Light</td>
<td>67.38 (16.90)</td>
<td>-1.40</td>
<td>.166</td>
<td>0.31; -0.12, 0.75</td>
</tr>
<tr>
<td>Dark</td>
<td>61.82 (18.56)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>64.53 (17.87)</td>
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</table>

Note: N_{total} = 80, N_{dark} = 41, N_{light} = 39

Figure 1. Effect of ambient lighting (dark versus light) on behavioral activation (BAS) and behavioral inhibition (BIS; * p < .05, N = 80).
Finally, the correlations between behavioral activation and behavioral inhibition in Table 2 show that all BAS subscales were positively related to each other (\(p < .031\)), except for behavioral drive and behavioral fun, \(r = .03, p = .805\). Behavioral inhibition was consistently not related to the behavioral activation subscales: Higher levels of behavioral inhibition were related to higher levels of behavioral reward, \(r = .33, p = .003\), but to lower levels of fun, \(r = -.26, p = .021\), and unrelated with behavioral drive, \(r = .17, p = .124\). Overall, behavioral inhibition and behavioral activation were unrelated, \(r = .09, p = .454\), consistent with the idea that they are discrete psychological systems (Carver & White, 1994).

Table 2. Correlations between behavioral activation (BAS), behavioral inhibition (BIS) and their different subscales (BAS-drive, BAS-fun, BAS-reward).

<table>
<thead>
<tr>
<th></th>
<th>BAS</th>
<th>BAS-drive</th>
<th>BAS-fun</th>
<th>BAS-reward</th>
<th>BIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAS</td>
<td>--</td>
<td>.72*</td>
<td>.64***</td>
<td>.76***</td>
<td>.09</td>
</tr>
<tr>
<td>BAS-drive</td>
<td>--</td>
<td>.03</td>
<td>.51***</td>
<td>.17</td>
<td></td>
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<tr>
<td>BAS-fun</td>
<td>--</td>
<td>--</td>
<td>.24*</td>
<td>-.26*</td>
<td></td>
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<tr>
<td>BAS-reward</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>.33**</td>
<td></td>
</tr>
<tr>
<td>BIS</td>
<td>--</td>
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</table>

Note: * \(p < .05\), ** \(p < .01\), *** \(p < .001\), N = 80

Discussion

The results of Experiment 1 show that people report less approach motivation in a dark environment than a light environment, as indicated by the behavioral activation scale (Carver & White, 1994). These findings support the idea that ambient light cues promote approach motivation (e.g., Huiberts, et al., 2015; Mehrabian, 1976; Rüger, et al., 2006; Smolders & de Kort, 2014; Summers & Hebert, 2001). Notably, our ambient lighting manipulation did not affect participants’ self-reports of behavioral inhibition. This null finding may seem surprising, given that darkness may be expected to arouse feelings of threat, and thereby the avoidance system. However, our laboratory was a relatively safe environment, which is less likely to give rise to anxiety or avoidance (Steidle, et al., 2013).

Experiment 2

In Experiment 2, we turned our attention to the effects of ambient lighting on the approach-oriented emotion anger. In prior studies, we found that postures and movements that impede approach behavior moderate the effects of trait anger on state anger (Veenstra et al., unpublished results, Chapter4). Consequently, we wondered if we could achieve the same result by varying ambient lighting conditions. To test this idea, we conducted a quasi-experiment (Campbell & Stanley, 2015) in a field setting with naturally occurring variations in ambient lighting from the daytime to the nighttime.
Angry feelings are especially driven by approach motivation among people high in trait anger (Harmon-Jones, 2007; Veenstra et al., 2016, Chapter 3; Veenstra et al., in press, Chapter 2). We therefore predicted that ambient lighting conditions would interact with trait anger in predicting participants’ state anger in response to an anger-arousing vignette. Specifically, we reasoned that during the daytime, when it was light outside, participants should be in a more approach-oriented state. This should lead higher levels of trait anger to be related to higher levels of state anger. By contrast, we predicted that during nighttime, when it was dark outside, participants approach motivational state would be lower than when it was light. The latter should attenuate the relationship between trait and state anger.

Method

Participants and design. Participants were 112 Dutch adults living in Utrecht (58 females, $M_{age} = 22.46$, $SD_{age} = 2.49$, $range = 17-33$). Time of day determined which of the experimental conditions participants were assigned to (lighting condition: daytime ($n = 61$) vs. nighttime ($n = 51$)). Trait anger was assessed using a standardized self-report measure (Spielberger, 1988). The main dependent variable was participants’ state anger in response to an anger-provoking situation.

Sampling plan. We determined the required sample size using G*Power (Faul, et al., 2007). Due to a lack of previous research on the effects of ambient lighting on the trait- and state- anger relationship, we assumed a small to medium effect size ($f^2 = 0.10$; corresponding with $R^2 = .091$). Based on the present multiple linear regression model with three predictors, a G*Power analysis indicated that for a two-sided test with an alpha of .05, a desired statistical power of .80, a sample size of 114 participants was required. Our recruited sample fell two participants short of this sample size, due to time constraints in data collection.

Procedure and materials. To alternate ambient lighting condition between participants, we took advantage of naturally occurring diurnal variations in ambient lighting conditions. Participants were recruited outdoors, in front of a 12-storey student-housing complex in the city of Utrecht, the Netherlands. Participants who arrived or left the building were asked to fill out a short survey of the Vrije Universiteit Amsterdam. Participants from the daytime group were approached between 1 PM and 4 PM, whereas participants from the nighttime group were approached between 9 PM and 11 PM on multiple days in August and September 2012. Participants who reported having ingested alcohol that evening were not included, because alcohol may increase approach motivation (e.g., Steele & Josephs, 1990), and may by itself cause aggression, especially among high trait-anger people (e.g., Parrott & Zeichner, 2001).

To rule our pre-existing differences in anger levels prior to the time-of-day assignment, participants first rated their current level of anger on seven adjectives (e.g., “irritated”, “furious”) using 5-point Likert scales ($0 = not at all$, $5 = very much$), and their current level of negative mood on five adjectives (e.g., “depressed”, “worried”) on 11-point Likert scales ($1 = not at all$, $11 = very much$). Both type of adjectives were averaged into two single indices (Cronbach $\alpha = .75/.62$) and originated from Dutch abbreviated
version of the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971/1981/1992; Wald & Mellenbergh, 1990).

Participants subsequently read a vignette describing an anger-arousing situation and were asked to imagine experiencing this situation. The vignette methodology has been widely used in emotion research. People’s responses to emotional vignettes generally show a great deal of correspondence with their responses to actual emotion-arousing stimuli (Robinson & Clore, 2001). The vignette was modeled after similar vignettes used in anger research (e.g., Rusting & Nolen-Hoeksema, 1998) and read:

“You want to apply for a job opening at your work. To compete with the other colleagues in your department, you each have to write a renewal plan for the department. You have been working hard, and when you’re almost finished, one of your colleagues stands at your desk. He says he is short in time, and asks if he can use your notes to get an idea of how to approach the assignment. You reluctantly agree, and one week later you find out that your colleague has re-typed your notes literally, and handed it in as if it were his ideas. Your boss calls the two of you in: he is very angry, and threatens to dismiss you both. Your colleague puts the blame on you, and claims that you copied his work. When you walk away from the office, your colleague says you’re a naive loser and it’s easy to use you.”

After reading the vignette, participants’ state anger was assessed with five items asking them how angry they would be towards their colleague, how stupid they thought his behavior was, and to what extent they would be inclined to take revenge, punish, and forgive their colleague on 11-point Likert scales (1 = definitely not, 11 = very much) (M = 8.54, SD = 1.40, Cronbach α = .65).

Individual differences in trait anger were measured using the Trait Anger Scale (TAS; Spielberger, 1988; Spielberger et al., 1983) that contains 10 items (M = 3.88, SD = 1.24, Cronbach’s α = .84, e.g. “I have a fiery temper”) and could be answered on a 7-point Likert scale (1 = definitely not, 7 = very much). An overall trait anger score was obtained by averaging the items. Finally, a debriefing followed, and participants were thanked.

Results

Recall that we expected that ambient lighting would moderate the relation between trait anger and state anger, such that there was a positive relation between trait and state anger in the daytime condition, but no relation in the nighttime condition. We performed a multiple linear regression analysis, and tested whether the relationship between trait and state anger was moderated by differences in lighting, i.e., daytime and nighttime. We coded lighting (time of day) condition (daytime = +1, nighttime = -1), standardized trait anger (Z scores), computed an interaction term between these variables, and simultaneously entered these factors into a multiple linear regression analysis predicting self-reported state anger (R²model = .199, R(3, 108) = 8.96, p < .0001).
First, the analysis revealed a main effect of trait anger, $\beta = .37$, $t(108) = 4.22$, $p < .0001$, $r = .36$, $R^2 = .142$, such that people with higher levels of trait anger reported more anger in response to the provocative situation than people with lower levels of trait anger. There was no main effect of lighting condition, $\beta = -.07$, $t(108) = -0.81$, $p = .418$, $R^2 = .006$. Most importantly, the regression showed the predicted interaction effect between lighting condition and trait anger, $\beta = .26$, $t(108) = 3.03$, $p = .003$, $R^2 = .078$. Correlations between trait anger and state anger in the two different lighting condition groups revealed that higher levels of trait anger predicted higher levels of state anger during daytime, $\beta = .52$, $t(59) = 4.72$, $p < .0001$, $r = .52$, $R^2 = .275$, but not during nighttime, $\beta = .13$, $t(49) = 0.94$, $p = .353$, $r = .13$, $R^2 = .018$. This interaction is graphically displayed in Figure 2. Differences in pre-existing mood could not account for the effects, because participants in the daytime and nighttime groups did not differ on the initial anger subscale measure of the POMS, or any of the single mood items (all $p$s > .10).

**Figure 2.** The relation between trait and state anger during daytime and nighttime.

**Discussion**

The results of Experiment 2 extend the effects of ambient lighting to anger management processes outside the laboratory. As predicted, during the daytime, higher trait anger was associated with more state anger in response to a provocative situation. By contrast, during the nighttime, there was no association between trait anger and state anger. These findings are consistent with the idea that ambient lighting conditions influence anger management processes among people with varying levels of trait anger.
General Discussion

In the present article, we investigated the motivational and emotional consequences of ambient lighting conditions. We found that ambient darkness attenuated people's approach motivation, such that people reported less behavioral activation in a dark laboratory cubicle than in a well-lit laboratory cubicle (Experiment 1). Moreover, we found evidence that ambient darkness may regulate the approach-oriented emotion of anger (Experiment 2). When participants were interviewed in the light of day, higher trait anger was associated with more state anger in response to an anger-arousing situation. By contrast, when participants were interviewed in the dark of the night, there was no association between trait anger and state anger. These findings suggest that ambient lighting conditions exert a systematic influence on the motivations and emotions that are associated with the approach system.

The present research fits well with previous findings that ambient lighting fosters processes that typically accompany high approach motivation, such as improved cognitive processing (Huiberts, et al., 2015; Smolders, et al., 2012), increased physiological arousal and alertness (Rüger, et al., 2006; Cajochen, et al., 2000), active behavior (Summers & Hebert, 2001), and more active and positive emotion (Smolders & de Kort, 2014). The current research adds to this literature, by providing more direct evidence that ambient light fosters approach motivation. This motivational effect may signify that people are biologically prepared to move forward when the environment is well-lit, because this allows people to explore their surroundings to find food while potential predators can be easily detected. Likewise, people may be biologically prepared to become less approach motivated when the lights go out, because darkness hides them from potential predators while they rest.

The effects of ambient lighting on motivation and emotion can be explained from a situated social cognition perspective (Koole & Veenstra, 2015, Chapter 8; Smith & Semin, 2007; see also Veenstra et al., in press, Chapter 2). This means that people's experiences are dependent on situational affordances, that is, the tendency to become approach motivated manifests itself primarily in interactions that promote motivational and emotional reactions. Several prior lines of research showed that manipulating body postures influence neurological correlates of approach motivation, motivated attention, neuroendocrine levels, as well as approach behavior (for an extended review see Price, Peterson, & Harmon-Jones, 2012). The effects of ambient lighting on motivation suggest that motivational processes are not only influenced by the affordances of the body, but also by broader perceptual affordances such as lighting.

Inevitably, the present research has limitations. First, we used only self-report measures to assess motivational and emotional states. Future research could examine the effects of ambient lighting on behavioral measures of approach motivation such as leaning forward or backward by measuring subtle changes in people’s center of pressure (e.g. Schneider et al., 2013; Eerland, Guadalupe, Franken, & Zwaan, 2012), and neurological measures, such as relative left prefrontal activation (Hortensius, et al., 2012; Kelley, Hortensius, & Harmon-Jones, 2013). Second, the effects of Experiment 2 could be explained by differences in time of day instead of differences in intensity of light.
However, this alternative explanation becomes less parsimonious when the observed effects are considered together with results of Experiment 1, in which lighting was varied within a controlled setting during the day. Third, participants’ level of approach motivation was not measured in Experiment 2. Future research could include motivation to test whether the inhibiting effect of darkness on the trait and state anger relation is mediated by decreases in self-reported approach motivation. Fourth and last, Experiment 2 only assessed the effects on ambient lighting on an approach-oriented emotion. Future work may examine how darkness compared to light influences avoidance-related emotions like anxiety in more threatening environments.

Despite these caveats, the present research opens up possibilities for new kinds of motivational interventions that use ecological conditions such as ambient lighting. For instance, managers may be advised to use plenty of lighting at the workplace, because the resulting approach motivation may stimulate employees to work harder. Conversely, at places where anger management is an issue, for instance, around soccer stadiums, it may be better to create darker environments. Ironically, the latter dark environments may be subjectively experienced as less safe, given that darkness is associated with threat (Schaller et al., 2003). The present findings suggest, however, that dark environments may be safer in objective terms, by lowering approach motivation and anger, especially among people who are normally ill-tempered. A dark place may thus be a peaceful place.
Ambient lighting affects motivation and anger