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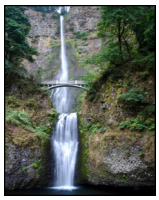

Disarming darkness: Effects of ambient lighting on approach motivation and state anger among people with varying trait anger

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ABSTRACT

The present research examined the influence of ambient lighting on approach-oriented motivation and emotion. Because darkness is associated with inactivity, the authors hypothesized that dark (vs. bright) environments would lower approach motivation. Consistent with this, participants in Experiment 1 (N = 80) reported less approach motivation in a dark (vs. bright) room. In Experiment 2 (N = 112), state anger –an approach-oriented emotion-was reduced among participants high (vs. low) on trait anger when participants were interviewed in a dark (vs. bright) environment. Subtle variations in ambient lighting may thus moderate approach-oriented motivations and emotions. These findings could have broad implications for understanding how environmental conditions may regulate human motivation and emotion.

1. Introduction

Ambient lighting influences virtually all aspects of human functioning, including 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 (Braver et al., 2014) and emotion (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.

1.1. Ambient lighting and motivation

People are diurnal animals. Indeed, research 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 indicators of alertness independent of time of the day (Rüger, Gordijn, Beersma, de Vries, & Daan, 2006; Smolders, De Kort, & Cluitmans, 2012), suggesting that the psychological effects of light are at least partly independent of endogenous circadian rhythms.

Ambient lighting may further influence people's motivations for approach and avoidance. Approach and avoidance systems are among the most basic structures that underlie motivation and emotion (Cacioppo, Priester, & Berntson, 1993; Russell, 2003). The approach system motivates people to go forward (Harmon-Jones, Harmon-Jones, & Price, 2013), typically with the goal to approach a reward or incentive. In contrast, the avoidance system motivates people to back away, in most cases with the goal to avoid a possible threat or punishment. Because well-lit environments make people more active, and allow for easier navigation than dark environments, we suggest that approach motivation becomes more potentiated in well-lit environments compared to dark environments.

Several lines of research support the idea that ambient lighting fosters approach motivation. First, ambient bright light improves cognitive task performance (Boyce, Beckstead, Eklund, Strobel, & Rea, 1997; Huiberts, Smolders, & de Kort, 2015; Smolders et al., 2012). Second, ambient bright light increases physiological arousal (Badia, Myers, Boecker, & Culpepper, 1991; Rüger et al., 2006). Third, ambient bright light promotes more active behavior, for instance, among consumers who are handling products (Areni & Kim, 1994; Summers & Hebert, 2001).

Conversely, darkness is associated with threat and caution, presumably because darkness renders potential environmental dangers harder to detect (Schaller, Park, & Mueller, 2003). Indeed, people display a stronger startle reflex in dark environments (Muhlberger, Wieser, & Pauli, 2008), a physiological indicator of avoidance motivation

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(Grillon et al., 1999). 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 effects of darkness on avoidance motivation may thus depend on additional 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).

1.2. Ambient lighting and emotion

If ambient bright light promotes approach motivation, then ambient bright light may also increase the occurrence of approach-oriented emotions. Consistent with this, people feel happier and more vital when they are exposed to brighter lighting conditions (Smolders & de Kort, 2014). Moreover, bright light has been used to treat clinical depression (Lam et al., 2016), a condition that is associated with low approach motivation (Dimidjian, Barrera Jr., Martell, Munoz, & Lewinsohn, 2011; though see Meedther, Pettersson, Berglund, & Ekselius, 2015, for a critical analysis).

Although positive emotions tend to be approach-oriented, they are confounded with positive valence. It is therefore important to consider negative approach-oriented emotions. A prime example of a negative approach-oriented emotion is anger, a basic human emotion that arises from the obstruction of one human e, and typically involves a sense of being offended or intentionally hurt by another person (Frijda, 1986; Ortony, Clore, & Collins, 1988). Extensive research has show that anger, even thought it is experienced as negative, is accompanied by heightened approach motivation (for a review, see Carver & Harmon-Jones, 2009). For instance, state anger is positively associated with reward sensitivity, and people high in approach motivation respond with more anger to provocations. Also, anger activates the left anterior cortex (e.g., Hortensius, Schutter, & Harmon-Jones, 2012) 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 help to down-regulate anger. Moreover, because this environmental regulation 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, a personality disposition that relates to the frequency, intensity, and duration with which people experience angry feelings (for a review, see Veenstra, Bushman, & Koole, 2018). Blocking approach motivation may thus help especially people with high trait anger to respond with less anger to provoking situations. The latter notion may seem counter-intuitive, given that dark environments are often experienced as unsafe (Schaller et al., 2003) and thus potentially more violent. Nevertheless, we suggest that feelings of reduced safety may not just affect potential targets of aggression, but also potential aggressors. The danger associated with darkness may thus lead normally anger-prone people to exert more caution, and thereby inhibit approach-oriented emotions like anger.

1.3. The present research and hypotheses

In the present research, we empirically examined 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 the link between anger and approach motivation is strongest among people high (rather than low) in trait anger (Veenstra, Schneider, Bushman, & Koole, 2017). We thus predicted that people high (rather than low) in trait anger would be more inhibited in their arousal of anger by exposure to a dark (compared to a bright) environment.

2. Experiment 1

Experiment 1 examined the influence of ambient darkness compared to ambient bright light on self-reported approach motivation, using the well-established behavioral activation and behavioral inhibition scales (Carver & White, 1994; Franken, Muris, & Rassin, 2005). Based on the idea that dark environments lower approach motivation, we hypothesized that behavioral activation ratings would be lower in a dark room than in a bright room. Because the level of threat in our laboratory was relatively low compared to less familiar, or outdoor surroundings, we expected smaller, if any, effects of ambient darkness on behavioral inhibition ratings.

2.1. Method

2.1.1. Participants and design

Participants were 80 paid volunteers (46 females, M_{age} = 20.36, SD_{age} = 2.48, *range* = 17–29) at the Vrije Universiteit Amsterdam. Participants were randomly assigned to a bright cubicle (n = 39) vs. dark cubicle (n = 41). The main dependent variable was participants' self-reported approach motivation. The experiment was conducted along with another study on the effects of arm movements on the relation between trait and state anger. To prevent the studies from influencing each other, study order was counterbalanced.

2.1.1.1. Sampling plan. Due to a lack of previous research, we did not have information on the expected 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_{bright} = 39 versus N_{dark} = 41 resulted in an estimated power of 67%.

2.1.2. Procedure and materials

Participants were seated in separate cubicles behind a computer screen. A picture of the cubicle is displayed in Fig. 1. The cubicle was fully closed by a door, and measured 190 by 107 cm. The computer display (HP Compaq LA2205wg; 1680 × 1050; 60 Hz) was set to full (100%) brightness, 80% contrast, and 6500 K color temperature. The cubicle was lit with two fluorescent lights (28 W/830HE). The illuminance levels of the bright versus dark cubicles were measured with the Lacie Blue Eye Pro received at participants' eyes, approximately 70 cm from the computer screen. In the bright condition (lights on) illuminance level was 197 Lux when the Lacie Blue Eye Pro was directed to the computer screen, and 2526 Lux when it was directed to the ceiling. In the dark condition (lights off) illuminance level was 188 Lux when the Lacie Blue Eye Pro was directed to the computer screen, and 2 Lux when it was directed to the ceiling.

After providing informed consent, participants in the dark condition were instructed to call the experimenter, who turned off the light in the cubicle. Participants then answered the behavioral activation and inhibition questionnaires on the computer. Participants in the bright condition started with the questionnaires immediately.

We measured variations in approach and avoidance motivation using the behavioral activation scale (BAS, 13 items, M = 70.95, SD = 9.32, Cronbach's α = 0.77) and the behavioral inhibition scale (BIS, 7-items, M = 64.53, SD = 17.87, Cronbach's α = 0.88, e.g., "I feel pretty worried or upset when I think or know somebody is angry at me."). The BIS/BAS scales were originally developed to tap into chronic personality differences (Carver & White, 1994). However, the BIS/BAS scales are also sensitive to situational variations in BIS/BAS activation

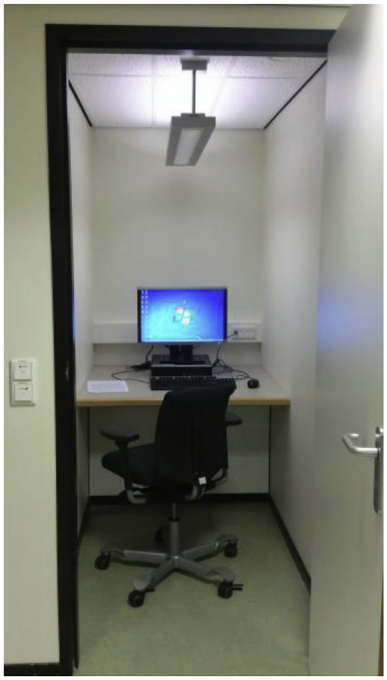

Fig. 1. One of the cubicles used in Experiment 1.

(e.g., Schmeichel, Harmon-Jones, & Harmon-Jones, 2010; Yan, Dillard, & Shen, 2012). We therefore used the BIS/BAS scales to capture situational variations in approach and avoidance motivation.

The BAS has three subscales (BAS- reward, 5 items, $M = 79.21$, $SD = 9.56$, Cronbach's $\alpha = 0.67$, 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 $\alpha = 0.76$, 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 $\alpha = 0.67$, e.g., "I will often do things for no other reason than that they might be fun." (Carver & White, 1994; Franken et al., 2005). The items were answered on a computerized slider (1 = *very strongly,* 100 = *not at all*), and were recoded by the researchers before data analysis such that higher scores indicate a higher level of behavioral activation or behavioral inhibition.

2.2. Results

To examine whether lighting (bright 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 relevant scales and test results. Participants reported more behavioral activation when they were sitting in a bright 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]. Follow-up tests of the separate BAS subscales showed that lighting mainly affected participants' self-reported behavioral drive. The effect of lighting on participants' level of reported behavioral inhibition was not statistically significant, $M_{bright} = 67.38$, $SD_{bright} = 16.90$, $M_{dark} = 61.82$, $SD_{dark} = 18.56$, $t(78) = 1.40$, $p = .166$, *Cohen's* $d = 0.31$, 95%CI [-0.12, 0.75].

As can be seen in Table 2, all BAS subscales were positively related ($ps < .031$), except for behavioral drive and behavioral fun, $r = 0.03$, $p = .805$. Higher levels of behavioral inhibition were related to higher levels of behavioral reward, $r = 0.33$, $p = .003$, but lower levels of fun, $r = -0.26$, $p = .021$, and unrelated with behavioral drive, $r = 0.17$, $p = .124$. Overall, behavioral inhibition and behavioral activation were unrelated, $r = 0.09$, $p = .454$, consistent with the idea that these are discrete psychological systems (Carver & White, 1994).

Table 1
Effects of lighting condition (dark vs. bright cubicle) on behavioral activation and inhibition (BAS/BIS) scores and their different subscales.

		M (*SD*)	*t*-value	*p*-value	Cohen's *d*; 95% *CI*
BAS	Light	73.13 (8.18)	−2.08	.040	0.47; 0.02, 0,91
	Dark	68.87 (9.94)			
	Overall	70.95 (9.32)			
BAS-drive	Light	74.46 (14.24)	−1.98	.051	0.44; −0.002, 0.89
	Dark	67.90 (15.34)			
	Overall	71.10 (15.09)			
BAS-fun	Light	61.87 (15.29)	−0.86	.391	0.19; −0.25, 0.63
	Dark	58.76 (16.94)			
	Overall	60.28 (16.13)			
BAS-reward	Light	80.89 (8.05)	−1.54	.127	0.34; −0,10, 0.79
	Dark	77.61 (10.65)			
	Overall	79.21 (9.56)			
BIS	Light	67.38 (16.90)	−1.40	.166	0.31; −0.12, 0.75
	Dark	61.82 (18.56)			
	Overall	64.53 (17.87)			

Note: $N_{total} = 80$, $N_{dark} = 41$, $N_{bright} = 39$.

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

	BAS	BAS-drive	BAS-fun	BAS-reward	BIS
BAS	–	.72*	.64***	.76***	.09
BAS-drive		–	.03	.51***	.17
BAS-fun			–	.24*	-.26*
BAS-reward				–	.33**
BIS					–

Note: $*p < .05$, $**p < .01$, $***p < .001$, N = 80.

2.3. Discussion

As expected, participants in Experiment 1 reported less approach motivation in a dark environment than a bright environment, as indicated by the behavioral activation scale (Carver & White, 1994). These findings support the idea that ambient darkness lowers approach motivation (e.g., Huiberts, et al., 2015; Mehrabian, 1976; Rüger et al., 2006; Smolders & de Kort, 2014; Summers & Hebert, 2001).

Notably, the effect of ambient lighting on self-reports of behavioral inhibition did not reach statistical significance. This could be due to lack of statistical power, given that Experiment 1 only had a sample size sufficient to detect a medium to large effect size. Close inspection of Table 1 shows that the standard deviations on the BIS scale were almost twice as high as those on the BAS, which created much statistical noise in the BIS scores. However, the pattern of findings for self-reported behavioral inhibition went into the opposite direction, as would be expected if the dark room evoked feelings of threat, and thereby the avoidance system. Thus, the dark (vs. bright) room did not seem to trigger increased avoidance motivation.

3. Experiment 2

Angry feelings are especially driven by approach motivation among people high in trait anger (Veenstra, Schneider, Bushman et al., 2017; Veenstra, Schneider, & Koole, 2017). 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 when it was dark outside, this would prevent the development of approach-motivated states in participants with high (vs. low) trait anger, and thereby would keep high trait-anger participants from becoming angrier than their low trait-anger

counterparts. By contrast, when it was light outside, we expected to find the usual pattern, such that participants with high trait anger would be more easily aroused to anger than participants with low trait anger.

3.1. Method

3.1.1. Participants and design

Participants were 112 Dutch adults in the city of Utrecht (58 females, M_{age} = 22.46, SD_{age} = 2.49, *range* = 17–33), approached either during the daytime (n = 61) or 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.

3.1.1.1. Sampling plan. We determined the required sample size using G*Power (Faul et al., 2007). We assumed a small to medium effect size (f^2 = 0.10; corresponding with R^2 = 0.091). 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. The recruited sample fell two participants short of this desired sample size, due to time constraints.

3.1.2. Procedure and materials

Participants were recruited outdoors, in front of a 12-storey student-housing complex in the city of Utrecht, the Netherlands (see Fig. 2 for a picture of the location). Participants who arrived or left the building were asked to fill out a short survey of the Vrije Universiteit Amsterdam. We approached participants in the daytime group between 1 PM and 4 PM, whereas participants from the nighttime group were approached between 9 PM and 11 PM. The sun in the Netherlands sets at 9.00 pm in the beginning of August, and 7.15 PM in the end of September. During nighttime, there was just enough lighting to read and fill out the questionnaires. Perceived threat was unlikely to be high, given that people were interviewed in front of their own house, a familiar habitat. We ensured that the weather circumstances were approximately the same during the day- and night: clear/partly cloudy, no rain, not too hot or cold, not too windy. Participants who reported having consumed alcohol that evening were not included, because alcohol may increase approach motivation (e.g., Steele & Josephs, 1990).

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 types of adjectives were averaged into two single indices (Cronbach α = 0.75/.62, *Ms* = 1.29/3.14, *SDs* = 0.50/1.28) and originated from the Dutch abbreviated version of the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971/1981/1992; Wald & Mellenbergh, 1990).

Fig. 2. Location of Experiment 2: Student-housing complex (daytime) in the city of Utrecht, the Netherlands.

Participants subsequently read a vignette describing an anger-arousing situation and were asked to imagine experiencing this situation. The vignette methodology is 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 rated on 11-point Likert scales (1 = *definitely not*, 11 = *very much*) 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 (M = 8.54, SD = 1.40, Cronbach α = 0.65).

Individual differences in trait anger were measured using the Trait Anger Scale (TAS; Spielberger, 1988; Spielberger, Jacobs, Russell, & Crane, 1983) that contains 10 items (M = 3.88, SD = 1.24, *Cronbach's* α = 0.84, 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, participants were debriefed and thanked.

3.2. Results

We performed a multiple linear regression analysis to determine 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 the product of these variables as the interaction term, and simultaneously entered these factors into a multiple linear regression analysis predicting self-reported state anger, R^2_{model} = 0.199, $F(3, 108)$ = 8.96, $p < .0001$.

There was a main effect of trait anger, β = 0.37, $t(108)$ = 4.22, $p < .0001$, r = 0.36, R^2 = 0.142, 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, β = −0.07, $t(108)$ = −0.81, p = .418, R^2 = 0.006. Importantly, the predicted interaction effect emerged between lighting condition and trait anger, β = 0.26, $t(108)$ = 3.03, p = .003, R^2 = 0.078. Follow-up analyses showed that trait anger predicted higher levels of state anger during the daytime, β = .52, $t(59)$ = 4.72, $p < .0001$, r = 0.52, R^2 = 0.275, but not during the nighttime, β = 0.13, $t(49)$ = 0.94, p = .353, r = 0.13, R^2 = 0.018. This interaction is graphically displayed in Fig. 3. Differences in pre-existing mood could not account for the effects, because participants in the daytime versus nighttime did not differ on the initial anger subscale measure of the POMS, or any of the mood items (all *ps* > .10).

3.3. Discussion

Experiment 2 extended the effects of ambient lighting outside the laboratory in a quasi-experimental setting. 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,

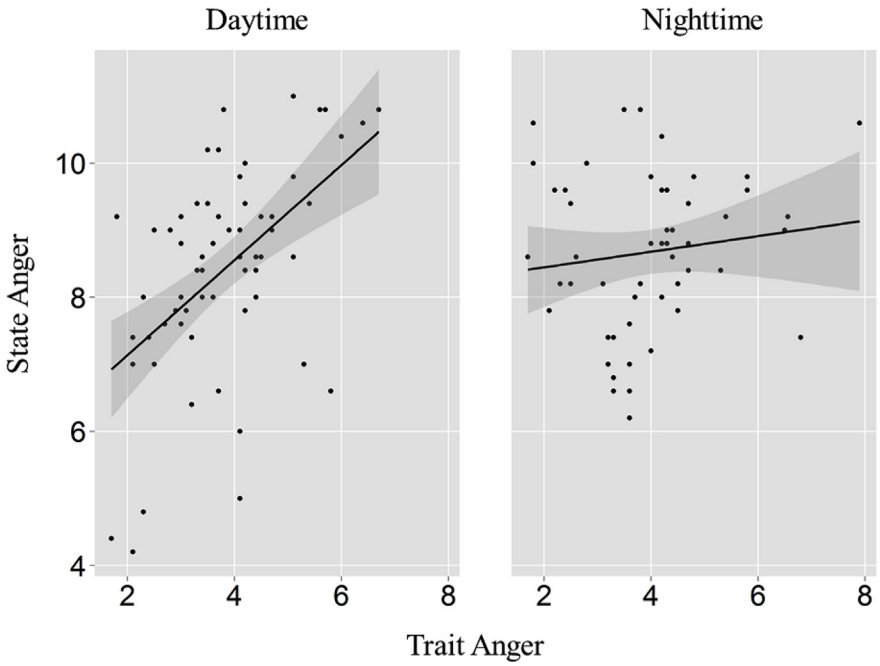

Fig. 3. Relation between trait and state anger at daytime (left) and nighttime (right).

there was no association between trait anger and state anger. These findings are consistent with the idea that ambient lighting conditions regulate the approach-oriented emotion of anger among people with varying levels of trait anger.

In the absence of a provocation, state anger was unrelated to time of day and other forms of negative mood. This set of findings renders it less likely that we interviewed different groups of people during different times of the day. Moreover, it appears that the effects of time of day were specific to reactive anger, an emotional state that is closely associated with heightened approach motivation (Carver & Harmon-Jones, 2009).

Because Experiment 2 was conducted in the field, it is conceivable that the observed effects were due to differences in time of day instead of differences in intensity of light. However, research on circadian rhythms has typically observed increases agitation and aggression in the early evening (especially among people with impaired impulse control, such as dementia patients, Todd et al., 2018). This so-called 'sun-downing' effect goes in the opposite direction as our hypotheses, and thus cannot explain our findings in Experiment 2. Moreover, circadian rhythms cannot explain the results of Experiment 1, in which lighting was varied within a controlled setting during the day. Our results in Experiment 1 are thus most parsimoniously explained in terms of variations in approach motivation. Still, it would be desirable in future work to replicate Experiment 2 while assessing a broader range of motivations and emotions.

4. General discussion

The present research investigated the motivational and emotional consequences of ambient lighting conditions. Ambient darkness was found to attenuate approach motivation, such that people reported less behavioral activation in a dark rather than a well-lit laboratory cubicle (Experiment 1). Moreover, ambient darkness regulated the approach-oriented emotion of anger (Experiment 2), such that participants with high (rather than low) trait anger displayed less state anger in response to an anger-arousing situation when they were interviewed at night, when it was dark, rather than in the daylight. These findings suggest that ambient lighting conditions exert a systematic influence on motivations and emotions that are associated with the approach system.

The present research fits well with previous findings that bright ambient lighting fosters approach-related states, such as increased physiological arousal and alertness (Rüger et al., 2006; Cajochen, Zeitzer, Czeisler, & Dijk, 2000), active behavior (Summers & Hebert, 2001), and positive emotion (Smolders & de Kort, 2014). This broad pattern of effects may signify that people are biologically prepared to move forward when the environment is brightly illuminated, because this allows people to satisfy their needs (e.g., for food) while potential threats can be easily detected. Conversely, people may be biologically prepared to become less approach-motivated when it turns dark, because darkness renders potential threats less visible, while simultaneously making it harder to identify need-satisfying stimuli (e.g., food sources).

The effects of ambient lighting are also consistent with theories of situated emotion regulation (Koole & Veenstra, 2015). According to these theories, affordances from the body and the environment play a key role in shaping people's motivations and emotions. In line with these ideas, body postures has been shown to influence motivated attention, approach behavior, and neurological and neuroendocrine correlates of approach motivation (Price, Peterson, & Harmon-Jones, 2012). The current effects of ambient lighting suggest that motivational processes are not only influenced by the affordances of the body, but also by broader perceptual affordances such as lighting.

The present research inevitably 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 postural changes (e.g., Eerland, Guadalupe, Franken, & Zwaan, 2012), or neurological measures, such as relative left prefrontal activation (e.g., Hortensius, et al., 2012). Second, the present research did not explicitly address circadian rhythms in motivation. Prior work indicates that the behavioral and physiological effects of ambient lighting often interact with day-night rhythms (e.g., Rüger et al., 2006; Smolder et al., 2012). Such interactions represent an important topic for future research. Third, the present experiments involved relatively mild variations in ambient lighting. For instance, the 'dark' condition in Experiment 1 had luminance levels of around 188 Lux, which are generally not considered darkness in lighting research. It is perhaps for this reason that the effects of ambient lighting that we observed were statistically small.

Caution is hence warranted in interpreting our findings, and in generalizing our findings to real-life settings.

Still, even statistically small effects of environmental cues might serve as 'nudges' that subtly guide behavior in a more desirable direction (Thaler & Sunstein, 2008). Targeted changes in ambient lighting may be part of an environmental design that creates optimal ecological conditions for certain kinds of behavior. For instance, brighter lighting in work settings may make somewhat easier for employees to step up their efforts. At places where reactive aggression is a concern, for instance, around soccer stadiums, it may be helpful to create darker environments (though see Cozens, Neale, Whitaker, Hillier, & Graham, 2003, on the complex effects of street lighting).

Ironically, dark environments tend to be subjectivelt experienced as unsafe, given that darkness is associated with threat (Schaller et al., 2003). The present findings suggest, however, that dark environments may often be objectivelt safer, by lowering approach motivation and anger, especially among people who are normally hot-tempered. Darkness may thus be disarming, gently nudging people to maintain more peaceful relations with another.

Author note

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jenvp.2018.07.005.

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