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Are Poor Sleepers Afraid of the Dark? A Preliminary Investigation

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Abstract

No studies have investigated whether those with poor sleep are aware of being uncomfortable in the dark via subjective inquiry, and no study has evaluated whether poor sleepers have increased fear in the dark using objective indices (e.g., a validated startle paradigm). Good and poor sleepers (*N* = 108) completed questionnaires about their level of discomfort with the dark and were evaluated for an increased startle reflex by measuring eyeblink latency via electrooculogram in response to unexpected noise in the dark and the light. Participants listened to bursts of unexpected white noise, while in counterbalanced light/dark conditions. Relative to good sleepers, more poor sleepers reported increased discomfort in the dark. There was a significant lighting × time × sleeper status interaction for eyeblink latency. Relative to the first trial in the dark, eyeblink latency in good sleepers increased in the second dark exposure; suggesting habituation in the dark. Eyeblink latency in poor sleepers did not decrease. Thus, poor sleepers reported being uncomfortable in the dark and they remained more easily startled in the dark over the course of the study. It is unclear if the dark may predispose people to sleep problems, or if sleep problems sensitize poor sleepers to fear darkness.

Keywords: Fear, Phobia, Dark, Startle, Anxiety, Insomnia, Sleep

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Introduction

Individuals with insomnia, particularly those with psychophysiological insomnia, often experience heightened arousal when they turn off the lights and attempt to sleep. This phenomenon, which has been referred to as conditioned arousal, is purportedly linked to repeated pairings of the bed/bedtime routine with wakefulness and/or negative emotion (Perlis, Giles, Mendelson, Bootzin, & Wyatt, 1997). Whereas conditioned arousal is a well-documented process, it is unknown if the situation itself, that is turning off the lights to initiate sleep may lead to heightened arousal. This possibility is derived from studies demonstrating that in diurnal animals, including human beings, there is an enhanced arousal in response to dark lighting conditions. For example, using an experimental startle paradigm, Grillon, Pellowski, Merikangas, and Davis (1997) have shown that the human startle response is greater when in a dark, versus a lit, room. If one were to have an increased startle response in the dark, darkness at bedtime may provoke increased reactivity. Although fear of the dark is one of the most commonly reported fears among children (Muris, Merckelbach, Mayer, & Prins, 2000), this fear is expected to diminish as children age; however, the prevalence of fear of the dark in adults is unknown. The paucity of research in fear of the dark in adults may relate to the notion that such fears are associated with childhood, thus there may be a stigma associated with reporting such a fear as an adult. Thus it would be important in investigations of adult fear of the dark to employ validated objective methods, such as a startle paradigm (e.g., Davis, 1992; Grillon, Ameli, Woods, Merikangas, & Davis, 1991; Lang, Bradley, & Cuthbert, 1990), in addition to self-reported methods, to assess fear of the dark.

Since darkness facilitates physical reactivity to unexpected noise in everyone, a startle response may be exaggerated in those who are aroused by the experience of being in bed in darkness. With these possibilities in mind, we embarked on a pilot study to determine if: 1) self-reported fear of the dark is greater in those with poor sleep, relative to a good sleeper control group, and 2) if there were differing patterns of startle response in the dark in those with poor sleep, relative to those with good sleep, using objective methods. More specifically, if someone is not afraid of the dark, their startle response should diminish in the second exposure to the dark (i.e., relative to their first dark exposure, their eyeblink amplitude should decrease and their eyeblink latency should increase in the second exposure). Decreased responding to stimuli (e.g., increased eyeblink latency or decreased eyeblink amplitude) is consistent with habituation to previously startling stimuli (Davis & Sheard, 1974; Graham, 1975). In contrast, if someone is uncomfortable in the dark, their responses should increase because of the anticipatory anxiety created in the first dark exposure (Grillon et al., 1991; 1997); that is, the amplitude should increase and the latency to blink should decrease in the second dark exposure. We hypothesized that after the first exposure to the dark, there would be sensitization and thus, a potentiated startle reflex in the poor sleepers in the second exposure. To rule out the possibility that poor sleepers merely had more nonspecific hyperarousal (and thus startle more readily to any stimuli), we hypothesized that there would be no differences between good and poor sleepers in the latency to blink or size/amplitude of the eyeblink (i.e., startle) in lit conditions; that is, the differences between the groups would manifest in the dark only. To rule out increased attention in the poor sleeper group, we also included some pairings of the auditory fear stimuli with prepulse stimuli (i.e., a smaller 60 decibel signal presented before

the 102 decibel auditory burst of noise), and we hypothesized that there would be no group differences in processing/responding to the prepulse.

Method

Participants

Participants included undergraduate students enrolled in an Introductory Psychology course at Ryerson University (*N* = 108) who volunteered in exchange for a one percent course credit inducement. Given that those with Posttraumatic Stress Disorder (PTSD) have demonstrated increased reactivity and vigilance in the dark (Grillon, Morgan, Davis, & Southwick, 1998), all participants completed the Primary Care Posttraumatic Stress Disorder Screen (PC- PTSD; Prins et al., 2003) online, prior to their participation in the study. The PC-PTSD is a well-validated, brief, four item measure developed to detect the presence of PTSD diagnosis in primary care settings. The four items were derived from factor analyses and correspond to the four underlying constructs specific to PTSD: re-experiencing, numbing, avoidance, and hyperarousal. Prins and colleagues (2003) used signal detection analyses to determine an optimally efficient cutoff score of three. A cutoff of three has excellent specificity (i.e., this measure correctly identifies the presence of a PTSD diagnosis with 87% accuracy) and sensitivity (i.e., it correctly identifies someone as not having a PTSD diagnosis when in fact there is not PTSD diagnosis present with 78% accuracy). Only those participants with a score of two or lower on this online measure (i.e., their scores are not typical of someone with PTSD) were permitted to sign-up for the experiment. Participants ranged in age from 18 to 37 years old (*M* = 22, *SD* = 4.7). No significant sex differences between sleeper status was observed (p = .63). Table 1 provides additional demographic information. Ryerson University's Research Ethics Board approved this study for use in a human population and written informed consent of the participants was obtained after the nature of the procedures had been fully explained. The recruitment posting stated that it was a study of "physical reactivity in the dark"; there was no mention about sleep or any study-specific hypotheses.

Table 1: Participant Demographics

Variable	Proportion (%)
Sex	
Female	79
Ethnicity	
Aboriginal	1.8
European	35.5
South Asian	11.8
East/Southeast Asian	17.3
African Canadian	3.6
Caribbean Canadian	11.8
Pacific Islander	1.8
West Asian/Middle Eastern	2.7
Latin/Central/South American	2.7
Other	10.9

Measures

The *Insomnia Severity Index* (ISI; Morin, 1993) is a seven item self-report questionnaire that provides an index of the global severity of insomnia by assessing the nature, severity, and impact of insomnia (Bastien, Vallieres, & Morin, 2001; Morin, Belleville, Belanger, & Ivers, 2011). Each item is rated on a 5-point Likert scale, ranging from "0 = no problem" to "4 = very severe problem," yielding a total score between 0 and 28. The ISI has been found to be a reliable and valid instrument to measure self-reported insomnia severity (Bastien et al., 2001; Morin et al., 2011).

For the purposes of this study, participants were categorized as a good sleeper if they scored below a clinical cutoff of 9, and a poor sleeper if they scored 10 or above (Morin et al., 2011).

The *Childhood Dark Discomfort Questionnaire* (CDDQ) is an 11-item measure, developed for this study to query how fearful participants were of a range of situations and experiences during childhood. Questions included in the CDDQ were adapted from established childhood fear questionnaires (Gullone & King, 1992; Ollendick, 1983). The main question of interest was the item pertaining to being in the dark. Responses were rated on a scale from "0 = not at all uncomfortable" to "4 = extremely uncomfortable." A response of two or above (i.e., at least "moderately uncomfortable" in the dark), was characterized as having a childhood fear of the dark. This score was chosen because we were interested in capturing at least moderate levels of discomfort rather than mild.

The *Dark Discomfort Questionnaire (DDQ)* is a 10-item measure that was developed specifically for this study to measure participants' self-reported fear of the dark. We used the Childhood Dark Discomfort Questionnaire described above to structure the items and responses but focused on a greater range of dark situations in which people would be more likely to report some degree of fear (e.g., dark room, movie theatres, dark parking lots). To mirror other fear inventories in the area, we adopted wording related to discomfort (e.g., "how uncomfortable would you feel" in a range of potentially aversive situations in the dark) rather than "fear", as there may be associated stigma with acknowledging fear in general. One question specifically queried about a fear of the dark. Participants provided a rating on a scale ranging from"0 = not at all uncomfortable" to "4 = extremely uncomfortable" for each given situation in the dark. Participants were characterized as having current fear of the dark if they endorsed a two or above on the question that asked about a comfort level in the dark (i.e., at least "moderately uncomfortable" in the dark). This score was chosen because we were interested in those who reported discomfort levels that were greater than mild.

The *Anxiety Sensitivity Index* (ASI; Reiss, Peterson, Gursky, & McNally, 1986) is a 16-item measure on which respondents indicate the degree to which they are concerned about potential negative consequences of anxiety symptoms on a five-point Likert scale ranging from 0 = "very little" to 4 = "very much". The ASI has high levels of internal consistency (mean alpha coefficient = 0.84) and adequate test–retest reliability (r = .70; Peterson & Reiss, 1992). Anxiety sensitivity is a construct that refers to fear of anxiety and the feared outcome of anxiety (McNally, 1996; Reiss et al., 1986). Although there is limited research on anxiety sensitivity and sleep, the ASI has been used previously in an insomnia population. For example, using the ASI, anxiety sensitivity has been found to moderate the relationship between sleep anticipatory anxiety and sleep onset latency (Babson, Trainor, Bunaciu, & Feldner, 2008) and has been linked to overall sleep-related impairment (Vincent & Walker, 2001). Trait anxiety is not linked to startle response (Grillon, Ameli, Foot, & Davis, 1993), so this measure was instead of a trait measure of anxiety. The idea was that those who were more concerned about experiencing anxiety symptoms might show greater anticipatory anxiety in the dark (i.e., shorter eyeblink latency in the dark).

Stimuli and Apparatus

The startle stimuli and apparatus were based upon a fear of the dark paradigm used by Grillon and colleagues (1991; 1997). The startle response is a frequently used objective measure of increased fear in both animals and humans (Davis, 1992; Lang et al., 1990). The fear of the dark startle paradigm involves participants listening to bursts of sudden white noise stimuli (presented binaurally via stereo headphones) in counterbalanced light and dark conditions. The acoustic startle stimulus was a 40 millisecond (ms) burst of noise with a nearly instantaneous rise time. Background white noise was presented continuously during this experiment. The background white noise and startle stimulus were 60 decibels (dBA) and 102 dBA in intensity, respectively. The startle stimulus was presented either alone (S), or 120 ms after a 30 ms-long, 65 dBA white noise pre-pulse (PP). The prepulse stimuli were used as a measure of prepulse inhibition (PPI). PPI refers to the ability of a weaker, non-startling pre-stimulus (prepulse), presented prior to the startle stimulus, to reduce the amplitude of the startle response (Grillon et. al., 1997). As the startle response can be influenced by changes in attention, and as lighting can affect attention, we examined PPI in both the light and dark conditions.

The listening paradigm began with an adaptation period in the light, consisting of an initial 3-minute presentation of white background noise, followed by 6 startle stimuli presented 30 seconds apart (please see Figure 1 for a

pictorial representation of the listening paradigm). This adaptation period was designed to habituate participants to the unexpected noise, as excessively high amplitude blinks are often observed during exposure to the first startle stimuli. This adaptation period was followed by the presentation of four alternating light and dark phases, with the offset of one phase immediately followed by the onset of the other. The experiment was divided into two blocks, with each block containing two phases, one light and one dark. Participants were randomized into one of two groups prior to participation. Group A's adaptation period was in the light, followed by the following lighting phases: dark/light/dark/light. In contrast, Group B's adaptation period was in the dark, followed by the following lighting phases: light/dark/light/dark.. Each phase contained two sound (S) and two prepulse plus sound (PP-S) startle stimuli. Thus, a total of 16 acoustic stimuli were presented (twenty-two including the adaptation period). The stimuli in the listening paradigm were presented as follows for all participants, regardless of which group they were randomized to: Phase 1) S/PP-S/S/PP-S; Phase 2) PP-S/S/PP-S/S; Phase 3) S/PP-S/PP-S/S; Phase 4) PP-S/S/S/PP-S. The first startle stimuli in each phase was delivered 20 seconds following phase onset. The light was on for the duration of the adaptation phase in Group A and off for the adaptation phase in Group B. Illumination of the room was controlled by an external light switch, controlled by a trained research assistant, consistent with the timing of the listening paradigm audio file. The audio information was plugged into a head box, such that the audio stimuli could be seen on the electrooculogram (EOG) screen. The participants' room was completely dark when the lights were turned off (i.e., the luminance of the room was measured by the telephotometer at 0.06 ft L).

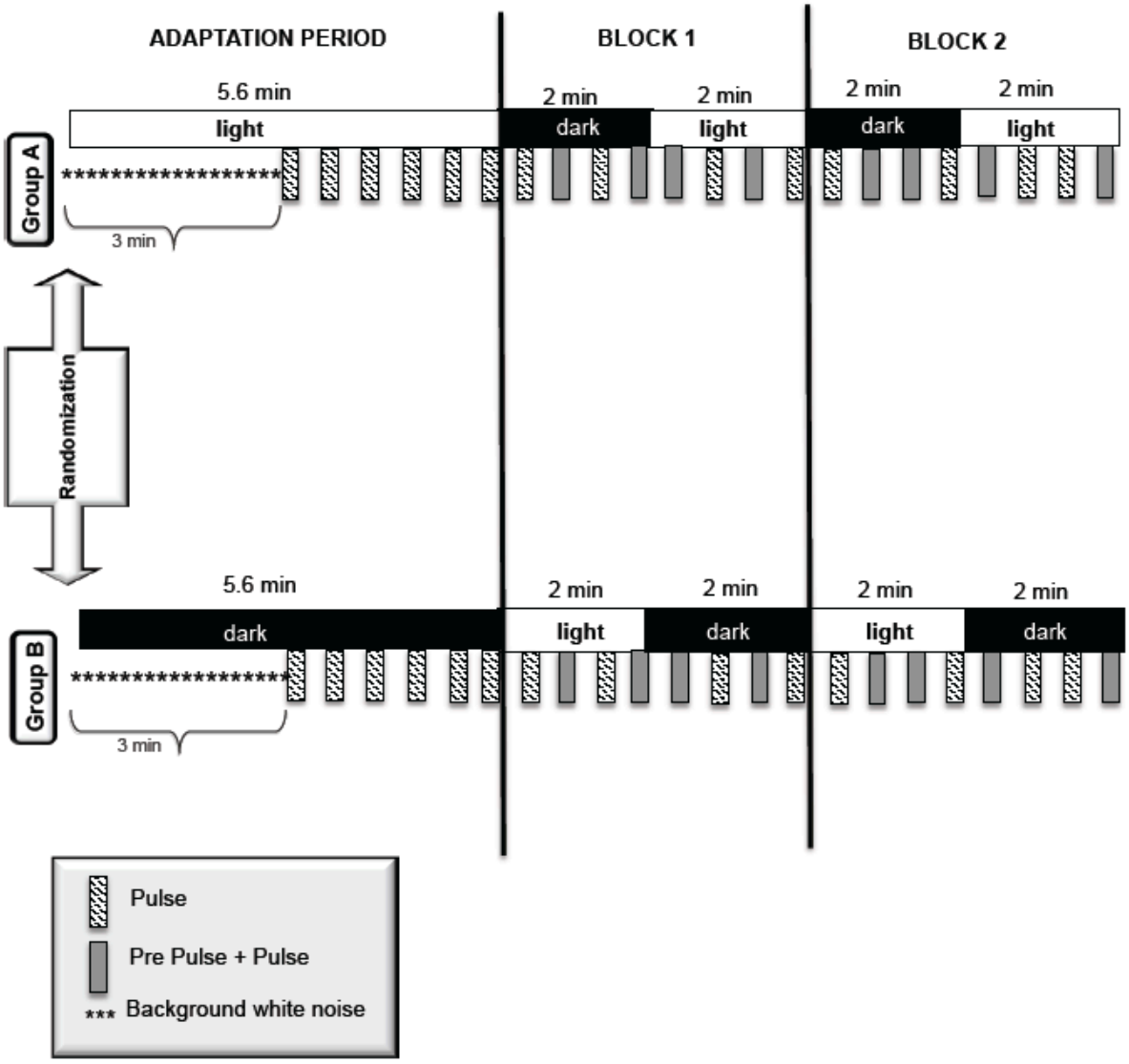

Figure 1: Visual representation of startle paradigm.

Procedure

This experiment was conducted during the day, between the hours of 9:00 am and 5:00 pm, at the Sleep and Depression Laboratory. Prior to arrival at the laboratory, participants were informed that the purpose of the study was to investigate physiological reactivity to unexpected noise while in dark and light conditions. They were also informed that reactivity would be monitored via sensors placed on the surface of the skin around the eyes, chest, and arm. Participants were unaware of the study hypotheses. Upon arrival at the laboratory, participants were asked to sign an informed consent agreement. Following the informed consent process, participants completed the self-report measures, which included a demographics form, the ISI, DDQ, and CDDQ. Questionnaire battery completion took approximately 20 minutes. Next, trained research assistants connected the psychophysiological equipment to the participant. Eyeblink latency was measured with an EOG. After cleaning the area around the eye, two sterilized disc electrodes filled with conductive paste were placed around the participant's eyes and adhered with surgical tape, one on the outer edge of the brow bone above the right eye (about 1 cm out and 1 cm up from the outer canthus of the eye) and the other on the bottom, outer edge of the left eye (about 1 cm out and 1 cm down from the outer canthus of the eye). Equipment connection took approximately 15 minutes to complete.

Once the sensors were in place, the experimenter left the sleep laboratory room and used the microphone to ask participants to lie down on the bed and place adjustable headphones over their ears. Participants were asked to keep their eyes open for the duration of the study. Infrared cameras were used to visually verify that participants' eyes remained open during the experiment. At this time, the audio file was played over the headphones and the lights were turned on and off remotely. Following the listening paradigm, the experimenter returned to the room, the equipment was removed and participants were thanked and debriefed.

Data Reduction and Analysis

The data reduction procedures were adapted from Grillon et al. (1991). The location of each acoustic startle stimuli point was first determined from the audio file. The data were first filtered to minimize non-physiological phenomena (e.g., signal drift, environmental noise) using a low-pass filter at 0.3 Hz and high-pass filter at 35 Hz. The sampling rate was 200 Hz. At each stimulus point (i.e., burst of white noise), two features were extracted: latency of eye blink (EOG) response and amplitude of EOG response. These features were extracted for each of the 16 stimuli (both PP and PPI) for each participant, using custom MATLAB software on a PC computer.

Latency values were calculated as the length of time from the stimulus point to the point where the response signal (i.e., eyeblink) moved outside of a pair of amplitude thresholds. These thresholds were equal to the mean of the baseline amplitude, plus or minus twice its standard deviation. The baseline window was defined as the 50 ms pre-stimulus region [i.e., the period immediately preceding the presentation of the startle stimulus (Grillon et al, 1991; 1997)].

Peak values (i.e., amplitude of the blink response) were defined as the local maximum or local minimum with the largest absolute amplitude in the target window. Consistent with the startle paradigm (Grillon et al., 1991), the target window was defined as the region 21 ms to 120 ms after the startle stimulus.

Results were visually reviewed by a trained Research Assistant blinded to study hypotheses and random assignment, and erroneous latency or amplitude values caused by a non-physiological burst in activity were corrected, if possible, or discarded. Latency values greater than 1 s were not considered, as these far exceeded the expected startle response time (Grillon et al, 1991; 1997).

Results

On the basis of the ISI cutoff, participants were divided into good and poor sleepers (59% and 41%, respectively). A t-test assessed tested for differences between good and poor sleepers on the ASI; there was a statistically significant (p = .001) higher mean score in poor sleepers (M = 26; SD = 10) relative to good sleepers (M = 20; SD = 7). A Chi Square analysis between good and poor sleepers on self-reported childhood fear of the dark (CDDQ: Cronbach's alpha = .82) found no statistically significant group differences (p = .72). In the total sample, most participants (68%) reported this common childhood fear. However, Chi Square analyses revealed that relative to

good sleepers (26%), more poor sleepers (46%) reported a current adult fear of the dark (p = .05). An adult fear of the dark (DDQ; Cronbach's alpha = .83) was significantly correlated with a childhood fear of the dark (Pearson Product-Moment correlation coefficient r = .34, p = .01). The item-to-total correlation for the adult fear of the dark item with the other items on the DDQ was highly acceptable (.7). Likewise, item-to-total correlation for the childhood fear of the dark item with the other items on the CFI was highly acceptable (.64). To assess validity of the fear of the dark item, Pearson Product Moment Correlation Coefficients were calculated to determine if adult fear of the dark item significantly correlated with: 1) a summed score for the DDQ (r = .759, p < .001), 2) anxiety sensitivity (r =.25, p =.03), 3) summed score for the Childhood Fears Inventory (r = .233, p = .038) and 4) the childhood fear of the dark item (r = .343, p = .002). The summed score on the DDQ was correlated with summed score for the Childhood Fears Inventory (r = .479, p < .001), anxiety sensitivity (r = .303, p = .001), and the childhood fear of the dark item (r = .731, p < .001).

The magnitude of startle to the startle probe (S) data was analyzed using a three-way repeated measures an analysis of variance (ANOVA) with phase (dark, light) and block (1, 2) as within-subject factors and sleeper status (poor sleepers, good sleepers) as a between subject factor. The magnitude of startle (i.e., amplitude of eyeblink) to pulse-alone stimuli across the two sequential blocks of dark and light demonstrated that the magnitude of startle was increased in the dark condition, in comparison to the light condition [phase main effect: F(1, 52) = 4.05, p = .049), but there was no significant effect of block (p = 0.72)] and no significant interaction effect of group by block (p = 0.23). Thus, the magnitude of reaction was different in light versus dark conditions, regardless of the sleeper status and the results remained consistent regardless of whether the lights were kept on or turned off during the adaptation period. To evaluate whether the prepulse stimulus (PPI) reduced the amplitude of startle, the PPI scores were compared for the dark and the light phases. The prepulse inhibition scores did not differ significantly across the light and dark conditions, F(1, 52) = .11, p = .74.

An ANOVA tested for differences in eyeblink latency (i.e., the time from the white noise stimuli onset to the eyeblink onset) in good versus poor sleepers, light versus dark, and first versus second time-block, and found a statistically significant 3-way interaction (p = .04). To follow-up the statistically significant interaction and determine if our hypotheses were supported, we conducted a t-test and found that good sleepers showed increased eyeblink latency in block 2 relative to block 1 in the dark (p = .04, d = .49; see Figure 2). Using Cohen's (1992) criteria, this was a medium effect size (.5). Similarly, we conducted a t-test to determine whether poor sleepers had decreased eyeblink latency in block 2 relative to block 1 in the dark; there was no statistically significant difference (p = .40, d =.30; see Figure 3). The effect size was small. After exposure to the first dark phase, good sleepers had a mean increase in eyeblink latency of 11 ms in the second exposure to the dark and poor sleepers had a mean decrease of 45.5 ms, but the difference in the poor sleepers was not statistically significant. A t-test compared good and poor sleepers' eyeblink response in the dark on block 2 and did not find a statistically significant difference (p = .17, d = .40). This effect is in the upper end of the small range. We conducted a linear regression analysis to determine if anxiety sensitivity predicted the eyeblink latency in the second dark block. ASI was not a significant predictor of blink latency in the first step (ß = .07, p = .60). In the second step, the interaction term (ISI × ASI) for insomnia severity and anxiety sensitivity (ß = −.22, p = .25) also did not predict the eyeblink latency in the second dark block.

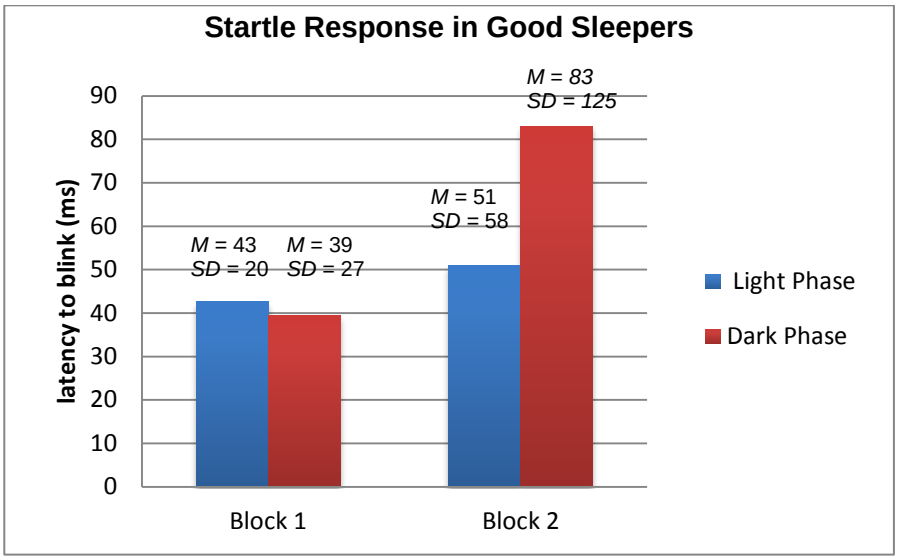

Figure 2: Good sleeper's latency to blink milliseconds (ms) in response to the unexpected noise bursts in light and dark condition in Block 1 and Block 2.

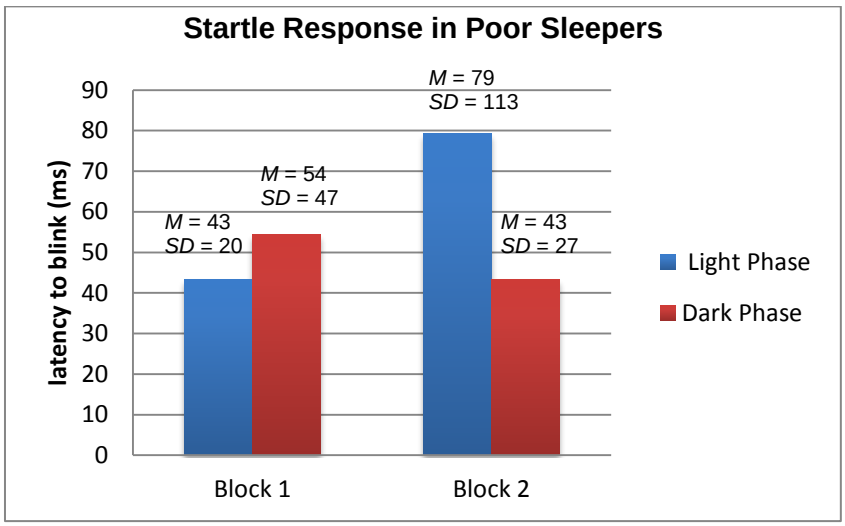

Figure 3: Poor sleepers' latency to blink milliseconds (ms) in response to the unexpected noise bursts in light and dark condition in Block 1 and Block 2.

Discussion

Relative to good sleepers, poor sleepers had a higher rate of self-reported discomfort in the dark; in fact, almost half of poor sleepers acknowledged feeling at least moderately uncomfortable in the dark. This was interesting because initially we were concerned that there would be stigma associated with endorsing a fear or discomfort associated with childhood, and that there would be under-reporting of this fear. This study suggests that adults may readily report feeling discomfort in this situation when asked. There were no differences in self-reported childhood fear of the dark between good and poor sleepers. It remains unknown as to whether the increased fear of the dark in poor sleepers is due to unsuccessfully resolved childhood fear of the dark or whether having poor sleep increases a fear of the dark that was previously resolved in the developmental process. It is also important to note that fear of the dark was assessed with a single question, which assessed fear in terms of levels of discomfort, and it is unknown whether this single item would reflect a clinically significant level of fear, for example characteristic of a phobia. There was some evidence that the reliability and validity of the two developed measures for this project was good. Nonetheless, the finding of increased self-reported fear in poor sleepers was a surprising and a potentially important finding because it means we should be able to ask our patients with sleep problems about this concern, and assess the significance of the fear in the clinical picture.

There were differing patterns of response to the dark after the first exposure amongst good sleepers. Our hypothesis about habituation in good sleepers and no evidence of habituation in poor sleepers was supported. In the second dark exposure, good sleepers had longer eyeblink latencies in response to stimuli. Poor sleepers did not change in their startle response in the second dark exposure, which is supportive of the hypothesis that habituation would not occur; however, this finding is also contrary to our sensitization hypothesis in the poor sleeper group. Although there was a mean 45 ms decrease in blink latency (i.e., greater startle) from the first exposure to the dark to the second exposure, this decrease was not statistically significant and the effect was small. This finding should be interpreted cautiously as it may be due to inadequate power. Previous studies have suggested that potentiation of the eyeblink by fear is not due to actual increase in the startle reflex (i.e., shorter latency to blink) but, rather, to a lack of habituation (Ross, 1961; Spence & Runquist, 1958). The good sleepers in this study demonstrated habituation, as they had a statistically significant mean increase in eyeblink latency from the first to second exposures to the dark. The poor sleepers did not exhibit an increase in eyeblink latency, thus there was no evidence of habituation, and the increase, although small in effect may be suggestive of sensitization. Now that we know it is a somewhat small effect, future studies could follow-up on the sensitization hypothesis with a greater sample size.

The prepulse stimuli was part of the paradigm to test whether there were attentional changes to the auditory stimuli; that is, to test if effects were merely due to attention. There were no differences found between the light and the dark on prepulse stimuli events, which does not support an attentional explanation. In other words, the prepulse was not processed differently in the light versus the dark; only the pulse alone showed a lighting condition effect. There was no evidence that the size of the blink (amplitude) was greater in poor sleepers relative to good sleepers in the dark since both groups showed greater amplitude in the dark. This supports other studies showing that there is a greater degree of startle in the dark than the light (Grillon et al., 1997). Unlike eyeblink latency, the amplitude index was not sensitive to sleeper differences perhaps because the eyeblink latency index is considered a more robust index of startle (Landis et al., 1939).

These findings must be considered in light of possible limitations. It is unknown whether these results will generalize beyond this sample. It is a young adult, predominantly female University sample, and it may not generalize to those who are older, with a greater representation of males, and with greater levels of clinically significant sleep disturbance. There was a relatively high (> 40%) degree of sleep disturbance in this sample, although this is commensurate with other studies recruiting young adults (e.g., Barclay & Ellis, 2013; Schmidt, Richter, Gendolla, & Van der Linden, 2010).

Although no sex differences were found, future studies should attempt to sample more broadly. We purposely selected a naïve sample to control for extensive, longstanding anxiety or sleep histories; future studies should replicate this finding in a sample with a wider range of clinical histories, age, and sex. Also related to generalizability is the issue of trauma. Those with a significant trauma score were unable to sign up for this experiment. Thus, although we excluded those with significant trauma to control for the increased startle found in those with PTSD, we did not assess for trauma histories without diagnostic-levels of PTSD or general levels of anxiety. It may be reasonable to suspect that those with trauma histories may be more likely to be poor sleepers, and we cannot exclude the possible role of trauma in the current findings. It is less likely that anxiety played a role because there were no differences in the two groups during the light. Although there was higher anxiety sensitivity in the poor sleepers, it did not predict eyeblink latency in the dark. This is perhaps not surprising, given that other startle paradigm studies have not found that trait anxiety relates to differences in fear potentiated startle (for a review, see Grillon et al., 1993).

Although the measures appeared to have good psychometric properties, further work needs to be done to ensure they are valid and reliable. The use of the term discomfort, as opposed to fear may have inflated the apparent rate of fear of the dark. Discomfort and fear are highly related constructs in investigations of emotion and arousal, presumably because of their shared loading on negative emotion but also their shared loading on the behavioral inhibition system (Derryberry & Rothbart, 1988). Nonetheless, the choice of wording for the scale or the inclusion of other fear-related items in the questionnaires may have affected the reporting of discomfort in the dark in unforeseen ways. Future studies interested in subjective reporting of fear of the dark in adults could develop a measure for the construct of fear of the dark and test it in a more systematic way.

We specifically tested participants outside of the bedtime situation (i.e., not at night) to minimize the possibility that poor sleepers would be feeling more anxious about the pre-sleep period and their startle response would have increased because of this anxiety. The fact that these findings occurred so far removed from the sleep situation (i.e., during the day) under such artificial, controlled conditions is even more remarkable. It would be interesting to see if the time of day would affect the results, and future studies could assess whether fear of the dark is potentiated at night. It is interesting to speculate about whether there may be a subset of those with sleep problems who experience increased arousal when turning off the light to go to sleep. This is a testable hypothesis worth further investigation.

With the above possible caveats in mind, there are several implications of the findings. As suggested above, the design of this study precludes any causal statements, so it may be that a feeling uncomfortable in the dark predisposes people to poor sleep or it could be that protracted poor sleep creates a negative association with the dark. If someone has a fear of the dark, they are at greater risk for sleep disturbance because of the increased arousal associated with the lights being turned-off. In a poll of over 1000 American adults (National Sleep Foundation, 2012), 10% of adults reported leaving their televisions on the entire night while they slept. Although this habit may be due to falling asleep before turning off the television, sleeping with a nightlight (46% of adults reported this habit in the same poll) or other lit devices could be for some, a safety behavior to mitigate anxiety about the dark. If they attempt to compensate for this fear by leaving devices on throughout the night, they continue to be at risk for poor sleep because of the sleep-interfering properties of light and/or noise from devices. Moreover, fears are strengthened through avoidance so leaving devices on, or always having to have a bed-partner present while sleeping, should have the unintended effect of maintaining the fear. It is unknown as to whether the fear reported in this study is worthy of a phobia diagnosis, but the good news is that phobias are readily treated via exposure therapy (Chambless & Woody, 1990; Marks, 1987). If these preliminary results are replicated in clinical samples, it would mean that included in sleep assessment should be queries into dark-related phobias, and when appropriate, the phobia could be treated via exposure therapy. One further implication is that we may have to adapt existing treatments for insomnia. For example, stimulus control (Bootzin, 1972) is included as a frontline treatment for chronic insomnia (National Institutes of, 2005). Stimulus control is an effective treatment for insomnia (Morin, 2010) and one recommendation within stimulus control is to leave the bedroom when anxious or alert. If these results are replicated in a clinical sample, we would have to consider whether this recommendation in a person with a fear of the dark may actually reinforce the dark phobia. That is, avoiding the feared stimuli (i.e., the dark) by going into another (i.e., lit) room would result in a decrease in anxiety, thus, strengthening the association of anxiety symptoms and the dark. The sleepiness generated by stimulus control may eventually override the phobia and make sleep more easy, but the residual phobia may remain. However, treating a dark phobia via systematic dark exposures first, may enhance treatment outcomes for Cognitive Behavioral Therapy for insomnia. Treating fear of the dark in people with sleep problems may also enhance their quality of life. These are empirical questions that can be answered in future studies.

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