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RESEARCH REPORT

Emerging adults' sleep patterns and attentional capture: the pivotal role of consistency

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Abstract College students face consistent cognitive demands and often get insufficient and/or irregular sleep. The current study investigated associations of sleep duration and sleep variability with attentional performance. Sleep duration variability was expected to moderate the association between duration and cognitive functioning. College students' ($n = 83$) natural sleep patterns were recorded via wristband actigraphy across three consecutive nights during an academic term. The association between sleep duration and attentional capture was strongest for those whose sleep was the most consistent across the three nights preceding the attentional task (i.e., low sleep duration variability). For those with low sleep duration variability, less sleep was associated ($B = -0.25$) with reduced ability to ignore irrelevant cues and redirect attention to target locations. In other words, *consistently* low sleep duration was associated with compromises in attention. Our results indicate the importance of consistent sleep routines as well as sufficient sleep duration in order to optimize attentional performance in college students.

Keywords Emerging adult · Attention · Sleep duration · Sleep variability

Introduction

Inadequate sleep is common in emerging adulthood (Lund et al. 2010; Orzech et al. 2011) and is significantly associated with multiple domains of psychological functioning, including mood (Galambos et al. 2009; Lev Ari and Shulman 2013) as well as cognitive and academic performance, likely due to its effect on attentional functioning (Frey et al. 2004; Gaultney 2010; Ratcliff and Van Dongen 2009). Experimental manipulations of sleep deprivation or restriction on attention have been inconsistent, with studies showing no effects (Blinks et al. 1999; Verstraeten et al. 2004), selective effects (Jugovac and Cavallero 2012; Martella et al. 2014; Roca et al. 2012; Versace et al. 2006) and systematic effects (Bratzke et al. 2009; Cote et al. 2008; Martella et al. 2011; McCarthy and Waters 1997; Sadeh et al. 2011) across attentional measures. Such inconsistencies may signal that the effects of sleep duration on cognitive performance are qualified by other aspects of emerging adults' sleep, such as variability in sleep patterns.

The construct of sleep variability

Sleep variability is one of the many qualitative aspects of sleep that may affect cognitive performance. In the small empirical literature examining this construct, sleep variability has been operationalized in a variety of ways. Some researchers have defined it as irregular sleep durations across several days (Lev Ari and Shulman 2012; Lemola et al. 2013; Moore et al. 2011) or from weekdays to weekends (Fuligni and Hardway 2006; Lemola et al. 2012). Others have operationalized variability in terms of bedtime and wake time shifts across school- and non-school nights (Biggs et al. 2011). Still others have defined it as irregularity in multiple aspects of sleep such as minutes of

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wakefulness after sleep onset, sleep latency, and sleep efficiency (Sanchez-Ortuno and Edinger 2012). Higher levels of sleep variability have been associated with greater body mass index (Moore et al. 2011), higher levels of aggressive behavior in children and adolescents (Biggs et al. 2011; Lemola et al. 2012), lower subjective well-being (Lemola et al. 2013), and greater incidence of depression (Doane et al. 2014).

Sleep variability may be a particularly important aspect of sleep for college students. There is evidence that wake time variability increases during the transition to college (Doane et al. 2014) and that sleep–wake cycles of college students are characterized by shorter sleep duration during the week and later bedtimes and rise times during the weekend (Forquer et al. 2008). Unfortunately, sleep variability does not appear to have been examined with respect to emerging adults' performance on cognitive tasks.

Quantity of sleep and cognitive functioning

Though a variety of cognitive tasks have been utilized in sleep deprivation studies, the majority of the research has focused on executive attention measures with Posner and Raichle's (1994) Attention Network Task (ANT) being one of the most popular. In its most basic form, this flanker task requires observers to respond to the direction of a central arrow flanked on both sides by arrows pointing in either the same (compatible) or opposite (incompatible) direction. Sleep deprivation has been shown to have more detrimental effects on incompatible trials (vs. compatible), which require observers to inhibit a contrary response produced by the flanker arrows in favor of the correct response indicated by the center arrow (Jugovac and Cavallero 2012; Martella et al. 2011).

A second component of the ANT measures observers' ability to use spatial cues to orient their attention to the physical location in which a target is presented. When onset cues are not predictive of target location, attention toward a cue is thought to engage reflexive, attentional orienting, from which observers must disengage as they move their attention from the location of the cue to that of the target (Posner 1980; Posner and Raichle 1994; see Lupianez et al. 2006 for a review). The effects of sleep on attentional orienting have been mixed with some studies showing that sleep deprivation/restriction results in larger reaction time (RT) costs for invalid trials (cues presented at nontarget locations) versus valid trials where the cue and target are presented in the same location (Martella et al. 2011; Versace et al. 2006), while others have found no such difference between sleep deprivation groups (Jugovac and Cavallero 2012; Martella et al. 2014; Roca et al. 2012).

The current study

The aim of the present study was to investigate the direct and interactive associations of sleep duration and sleep variability with college students' deployment of attention to and away from irrelevant distractors. This study was designed to expand the literature on sleep and cognitive functioning in three primary ways.

First, we used Actigraph-2 wristbands to record college students' natural sleep cycles over the course of several days during academic terms. This is a departure from the typical sleep deprivation paradigms in which participants' attention has been assessed after 24–36 h of no sleep (e.g., Blinks et al. 1999; Bratzke et al. 2009; Roca et al. 2012), or their sleep has been consistently restricted to a smaller window over the course of several days (e.g., Cote et al. 2008; Sadeh et al. 2011; Versace et al. 2006). In the current study, participants' cognitive performance can be interpreted within the context of their normal day-to-day functioning, as opposed to experimentally induced conditions.

Second, we constructed an attentional task with the goal of mimicking students' ability to ignore task-irrelevant distractions encountered when studying. To this end, we used an attentional capture task (e.g., Posner 1980) in which participants attempted to ignore irrelevant spatial cues. To avoid potential conflicts between spatial cuing and flanker task demands, we chose a task that omitted the flanker portion of the ANT. In our study, cues preceded the 1 of 4 possible target locations at which the participant indicated whether an "+" or "=" sign was present in the display. The cues accurately predicted the location (valid trials) in only 25 % of trials and cued a non-target location (invalid trials) in the remaining 75 %. As reinforced with verbal instructions, it should be clear that participants ignore the cues, as they do not predict target locations. When such onset cues only predict target locations at chance levels, participants still are unable to resist attentional capture by the cues, leading researchers to propose that these attentional shifts are automatic and beyond voluntary control (e.g., Jonides 1981; Liao and Yeh 2011; Posner and Cohen 1984). The size of the cue validity effect (invalid–valid trial RT), thus reflects the speed at which participants can disengage attention from these reflexive attentional shifts toward cues and redeploy attention to another location, such that larger cuing effects reflect greater difficulty redeploying attention (Posner 1980; Posner and Raichle 1994). We also varied the cue-target interval (200 vs. 350 ms) in the event that sleep affected the time course of attentional deployment and disengagement.

Finally, in order to explore multiple dimensions of sleep variability, three indicators of sleep variability were assessed in the current study: sleep duration variability, sleep start time variability, and wake time variability. Three hypothetical models were tested to separately assess each of these indicators. In all models, it was hypothesized that shorter sleep duration and greater variability would be associated with higher levels of attentional capture (i.e., poorer attentional performance). Over and above the variance accounted for by these direct effects, it was expected that sleep variability would moderate the association of sleep duration with attentional capture, such that the combination of low sleep duration and high sleep variability would be associated with the highest levels of attentional capture.

Method

Participants

Participants included 83 undergraduate students (48 women, 35 men) enrolled in a small southeastern private college during the 2013–2014 academic year. They ranged in age from 18.08 to 22.58 years ($M = 20.54$, $\mathrm{SD} = 1.22$). Class membership was as follows: 24 % first year; 16 % sophomore; 19 % junior; and 40 % senior. Two percent of participants were of Hispanic origin and race was as follows: 87 % White; 2 % Black/African–American; 10 % Asian; and 1 % Hawaiian/Pacific Islander. Two participants' data were excluded from analyses: one participant used the incorrect response keys for a block of the attention task, and another participant had no actigraphy or sleep diary data for the three-night sleep period analyzed in this study.

Participants were recruited through advertisements posted in university buildings for a 1-week study of technology use and sleep quality. Informed consent was obtained from all individual participants included in the study. Participation involved completing an initial 30-min online survey in a laboratory, wearing a wristband actigraphy monitor and keeping a sleep diary for 7 days and then completing a follow-up assessment involving a 20-min online survey and the computerized attention task in the laboratory. Participants earned $25.

Sleep monitoring protocol

Ambulatory actigraphy methods were utilized to assess sleep duration and variability. The Actiwatch-2 (Philips Respironics, Bend, OR) is a wristband device containing an accelerometer that provides continuous motion data used to code sleep characteristics. It also contains an ambient light sensor to aid in establishing when lighting sources are turned on or off in reference to a sleep period. At the end of the first assessment, participants were fitted with an Actiwatch-2 wristband and given instructions for its use. They were asked to wear the wristband continuously for 7 days and nights, removing it only for activities that could damage the device (e.g., contact sports, swimming). Participants completed daily morning and nighttime entries in a sleep diary. Morning entries included what time they went to sleep the night before and what time they awoke that morning. In order to maximize real-time entry of sleep diary data, participants were asked to keep the sleep diary on or beside their bed, and they received emailed sleep diary reminders on days one and three of the study.

The Actiware 6.0 software program was utilized to manage and score actigraphy data. Wristbands were configured to collect data in 60-s epochs. The wake threshold (i.e., activity level below which is an epoch is scored as sleep) was set at the default level of 40, or medium sensitivity. This software program uses an algorithm to automatically set sleep intervals based on 10 consecutive minutes of immobility at sleep start time and wake time.

Once automated intervals were set, each interval for each subject was examined to confirm convergence of the automatically generated intervals with four points of data: (1) sleep start and wake times entered by participants using the event marker button on the wristband; (2) sleep diary report of bedtime and wake time; (3) sleep diary report of activities in the hour before bed; and (4) light level. If such convergence was not present, the interval was corrected by applying the sleep interval criteria in a manner that was consistent with the preponderance of available data. Fully automated intervals were utilized for 28 participants. For an additional 21 participants, only one interval was adjusted within seven nights of data, and for the remainder of participants more than one interval was adjusted. The nature of discrepancies varied, but many stemmed from sedentary activities at bedtime (e.g., reading, watching TV, cell phone use), recorded in the sleep diary, that were miscoded by the automated application of the algorithm as the beginning of a sleep interval.

Three daily sleep statistics were automatically generated by the actigraphy software for sleep intervals in the 3 days immediately prior to the follow-up assessment: sleep duration, sleep start time, and wake time. Sleep duration was defined in minutes elapsed between the start and end of the sleep interval. Although we did collect data on sleep efficiency (sleep interval duration minus epochs coded as awake), this variable did not yield different results from that of duration. In five cases, sleep diary report data were substituted for one or more missing nights of actigraphy data.

Sleep duration

Cote et al. (2008) have shown that a single night of unrestricted sleep after sleep deprivation was enough to return attentional performance to baseline levels. To minimize such rebound effects we, therefore, calculated our sleep measures based on the three nights most proximal to the attention assessment—at least three nights were needed to obtain sleep variability measures.

Sleep variability

Following previous sleep studies (e.g., Sanchez-Ortuno and Edinger 2012), for each participant we computed the within-participant standard deviation of mean sleep across the three nights preceding the attention assessment. Similarly, we calculated the within-person standard deviation of sleep start time and wake time across the three nights (Doane et al. 2014). Because sleep start times often fell around the transition between 23:00 (11 p.m.) and 01:00 (1 a.m.), start and wake times were transformed such that 6 p.m. was coded as the 0 h (00:00) in military time. With this transformation, an 11 p.m. bedtime was coded as 05:00, while a subsequent 1 a.m. bedtime was coded as 07:00. This transformation ensured that bedtime variability would not be artificially inflated if times crossed the midnight mark across the three nights.

Attentional capture task

In the attentional capture task a cue was presented in one of four possible target locations before the onset of the target display (see Fig. 1). Cues, targets, and fixation points were displayed in white (RGB = 255, 255, 255; CIE: $x = .297$, $y = .311$, luminance = 60.6 cd/m^2) against a gray background (RGB = 81, 81, 81; CIE: $x = .298$, $y = .318$, luminance = 5.39 cd/m^2) as measured by a ColorVision (Lawrenceville, NJ) Spyder3PRO colorimeter. The targets and target display subtended 1.0° and 10.9° of visual angle, respectively. The experimental task was programmed in OpenSesame (Mathôt et al. 2012) and presented on an Asus 21″ high definition monitor controlled by a Macintosh computer.

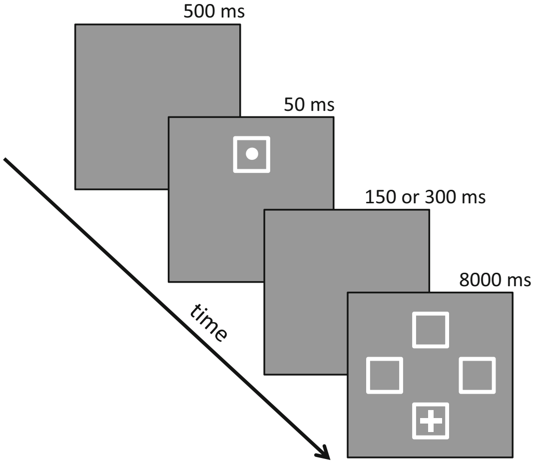

Fig. 1 Attention task trial sequence. A cue (*dot within bounding box*) either validly (25 % of trials) or invalidly (as shown, 75 % of trials) indicated the later location of the target item. Participants had to respond by button press as to whether the target was a "+" or "=" sign. The next trial began when either a response was given or 8000 ms elapsed

Participants performed two blocks of trials of 80 trials each. The first block was considered the practice block. On each trial a cue appeared for 50 ms followed by a blank screen for 150 or 300 ms (equally probable), creating a cue-target intervals (CTIs) totaling 200 and 350 ms, respectively. The target display then appeared and participants pressed the 'z' key if the target was an '=' sign or the '/' key if the target was a '+' sign. Participants had a maximum of 8 s to respond before the trial timed-out and the next trial began. Within each block 75 % of the trial sequences cued incorrect target locations (invalid trials) and 25 % of the trials validly cued the correct location in which the target would appear. Target and cue locations were counterbalanced so that cue and target locations were equally probable with respect to the four possible target locations. Both the sleep and attention task protocols were approved by the host institution's IRB.

Attentional capture

The degree to which the irrelevant cues captured subjects' attention was calculated by the following formula

$$\text{Attentional Capture} = \text{Invalid}_{\text{RT}} - \text{Valid}_{\text{RT}}$$

for both the 200 and 350 ms CTIs.

Data analysis

Our hypotheses required the use of moderational analyses that divided the pool of participants into three groups within a third variable (e.g., sleep duration variability). Power analyses were, therefore, based on the ability to detect large correlations within each of these groups. According to Cohen (1988), 23 participants per group were needed to detect large correlations at 80 % power, given a .05 alpha level. We tested an additional 14 participants to accommodate participant exclusion due to potential failures associated with adherence to the sleep assessment protocol.

Results

Reaction time ANOVA

Correct trial median RTs were submitted to a cue validity (invalid vs. valid cues) × CTI (200 vs. 350 ms) ANOVA with both variables being manipulated within subjects. The

Table 1 Descriptive statistics for sleep and attention parameters

Variable	Grand means			Three-night within-subject SD		
	n	*M*	SD	*n*	*M* (h)	SD (h)
Sleep duration	81	7.36 h	1.20 h	81	1.42	1.25
Sleep start time	80[a]	12:47 a.m.	1.21 h	80	1.02	0.81
Wake time	80[a]	8:06 a.m.	1.02 h	80	1.05	0.66
Attentional capture[b]	81	1.36 ms	39.1 ms	–	–	–

[a] One participant was excluded from this analysis as they did not sleep in one of the 24 hour periods, thus their sleep start/wake variability could not be mathematically calculated

[b] Data for the cue validity effect at the 200 ms CTI

effect of cue validity was minimal, $F(1, 80) = 1.91$, $p = .170$, indicating that there were no generalized attentional capture effects. RTs were, however slightly faster at the 350 ms ($M = 498$ ms, SD = 69.9 ms) versus the 200 ms ($M = 505$ ms, SD = 69.0 ms) CTI, $F(1, 80) = 4.73$, $p = .033$, $\eta^2 = .056$. The cue validity × CTI interaction was not significant, $F(1, 80) = 1.81$, $p = .183$.

Associations between sleep variables and attentional capture

Descriptive statistics and bivariate correlations among primary study variables are presented in Tables 1 and 2. Independent samples *t* tests were conducted to examine gender differences in primary study variables. Significant differences emerged only for wake time variability (in mins), such that men ($n = 33$, $M = 74.35$, SD = 47.78) had higher variability than women ($n = 47$, $M = 55.14$, SD = 31.28), $t(78) = 2.18$, $p = .03$, $d = .49$.

Preliminary analyses revealed that attentional capture effects at the 200 ms (vs. 350 ms) CTI were more highly correlated with sleep measures, indicating that changes in sleep patterns may exert their effects in processes earlier in the attentional time course. Thus, all of the correlational analyses below exclusively used data from the 200 ms CTI in the 2nd block of trials (i.e., test block).

Three separate hierarchical regression analyses were conducted to test direct and interactive associations of sleep duration and indicators of sleep variability with attentional capture at the 200 ms CTI. Variables were entered as follows: (1) mean three-night sleep duration; (2) three-night sleep variability; and (3) the sleep duration × sleep variability interaction term. Predictor variables were centered at their means.

Table 2 Inter-correlations of primary study variables

Variable	1.	2.	3.	4.
1. Sleep duration[a]	–			
2. Sleep duration variability[a, c]	.16	–		
3. Sleep start time variability[b, c]	.21	.50**	–	
4. Wake time variability[b, c]	.09	.35**	.35**	–
5. Attentional capture[a]	−.18	−.32	−.03	−.14

** $p < .01$

[a] $n = 81$

[b] $n = 80$

[c] Within-subject standard deviation across three nights

Regression results for the first model, testing sleep duration variability, are presented in Table 3. In the first block sleep duration was not a significant predictor of attentional capture ($\Delta R^2 = .03$), but in the second block sleep duration *variability* was a significant predictor ($B = -11.79$, $p = .006$, $\Delta R^2 = .09$). In the third block, a significant increment of variance (6 %) was accounted for by the interaction of sleep duration × sleep duration variability ($p = .026$). Given these interactive effects, we conducted simple slope analyses (Hayes and Matthes 2009) and found sleep duration to be significantly negatively associated with attentional capture at low levels of sleep duration variability (one SD below the mean; $B = -0.25$, SE $B = 0.10$, $t = 2.55$, $p = .013$), but not at average ($B = -0.06$, SE $B = 0.06$, $t = 0.97$, $p > .250$) or high levels of sleep duration variability (one SD above the mean; $B = 0.14$, SE $B = 0.11$, $t = 1.30$, $p = .199$). In other words in this linear relationship, consistently fewer hours of sleep were associated with poorer ability to ignore distracting cues, whereas consistently more hours of sleep were associated with a greater ability to redirect attention away from distractors. The scatterplot in Fig. 2 illustrates the relationship between these three variables with sleep variability represented by the relative size of the bubble/data points.

The regression model testing sleep start time variability was not statistically significant ($R^2 = .03$). No significant variance was accounted for in attentional capture by sleep start time variability in the second block ($B = 0.12$, SE $B = 4.44$, $\beta = .00$, $t = 0.03$, $p > .250$, $\Delta R^2 = .00$) or the sleep duration × start time variability interaction in the third block ($B = 2.84$, SE $B = 4.66$, $\beta = .07$, $t = 0.61$, $p > .250$, $\Delta R^2 = .01$).

Similar nonsignificant results were found for the wake time variability model ($R^2 = .06$). No significant variance was accounted for in attentional capture by wake time variability ($B = -4.74$, SE $B = 4.33$, $\beta = -.12$, $t = 1.10$,

Table 3 Hierarchical multiple regression analyses of sleep duration and duration variability predicting attentional capture ($n = 81$)

Predictors	ΔR^2	R^2	Adj R^2	B	SE B	β	t	p
Block 1	.03	.03	.02					
Sleep duration				−6.87	4.33	−.18	1.59	.117
Block 2	.09**	.12**	.10					
Sleep duration				−4.94	4.21	−.13	1.17	.244
Sleep duration variability				−11.79	4.21	−.30	2.80	.006
Block 3	.06*	.17*	.14					
Sleep duration				−3.99	4.13	−.10	0.97	.336
Sleep duration variability				−19.45	5.31	−.50	3.66	.000
Sleep duration × sleep duration variability				14.34	6.27	.30	2.27	.026

* $p < .05$; ** $p < .01$

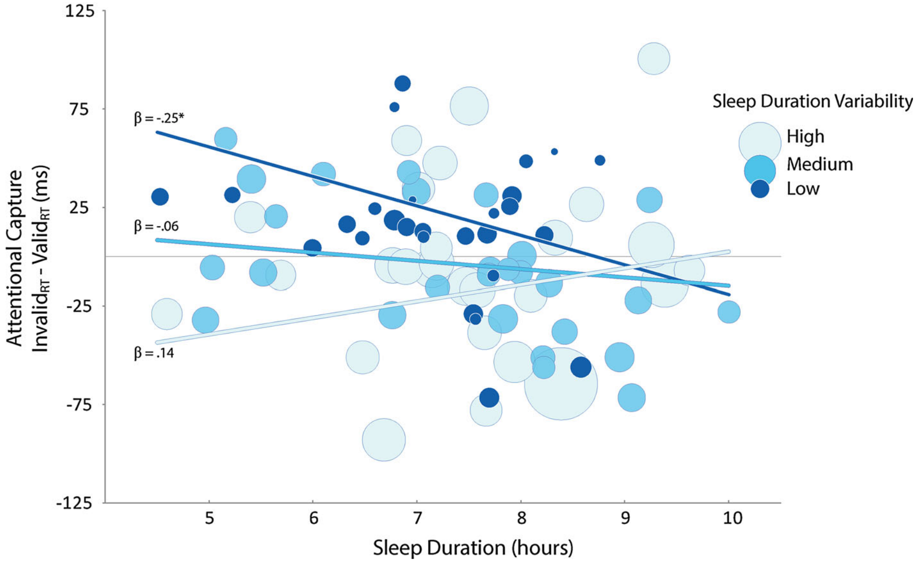

Fig. 2 Attentional capture as a function of sleep duration across the three nights preceding the attention task. The bubble diameter for each point represents the three-night within-subject standard deviation for that participant. Bubble shading and trend lines correspond to the simple slope analyses that segmented the data around 1 standard deviation above (*light bubbles*), below (*dark bubbles*, and at the mean (*medium dark bubbles*) of sleep duration variability. *$p < .05$

$p > .250$, $\Delta R^2 = .015$) or by the sleep duration × wake time variability interaction ($B = 5.55$, SE $B = 5.06$, $\beta = .13$, $t = 1.10$, $p > .250$, $\Delta R^2 = .015$).

Regression equations were recalculated excluding one outlier with high sleep duration variability. The pattern of significant results remained consistent but effect sizes were attenuated. In the regression model examining sleep duration variability, 3 % of the variance was accounted for in the first block, an additional 6 % in the second block, and a unique 5 % in the third block. As in the full sample, no significant results emerged for regression models examining sleep start time or wake time variability.

Discussion

The results from the current study reinforce a growing literature documenting the adverse effects of impoverished sleep on attentional functioning. We show that such effects are not restricted to laboratory-based sleep deprivation studies, but are also present when documenting college students' natural sleep cycles. Based on previous studies of sleep and attentional performance (Bratzke et al. 2009; Cote et al. 2008; Martella et al. 2011; McCarthy and Waters 1997; Sadeh et al. 2011), we expected that lower average sleep duration across 3 days would be associated with greater attentional capture. Though the trend was present, sleep duration by itself was not significantly associated with attentional capture, but this relationship was instead moderated by sleep variability.

Because previous findings have shown higher levels of sleep variability to be associated with compromises in health and well-being (Biggs et al. 2011; Lemola et al. 2012, 2013; Moore et al. 2011), in the current study higher sleep variability was expected to be associated with poorer attentional performance. Only one indicator of sleep variability, sleep duration variability, was significantly directly associated with attentional capture, and this correlation was unexpectedly negative rather than positive. That is, *lower* sleep duration variability was associated with greater attentional capture. However, this main effect was qualified by a significant interaction indicating that sleep duration was negatively associated with attentional capture only when sleep duration variability was low (i.e., consistent sleep duration across multiple days prior to the attention task). For these participants, consistently little sleep was associated with poorer ability to quickly disengage from irrelevant distractors (i.e., more attentional capture), whereas participants who consistently obtained more sleep tended to more efficiently disengage from distracting cues and redeployed attention to potential target locations.

These findings should be interpreted with respect to the specific population being studied. For example, in the current population too little sleep may be the norm. The mean sleep duration across three nights was 7.36 h, which is consistent with previous studies of emerging adults (Lund et al. 2010; Maslowsky and Ozer 2014) and less than the recommended nightly duration for late adolescence/early adults (NCCDPHP 2014). It is also telling that the mean three-night within-subject standard deviation for sleep duration was 1.42 h, suggesting that students' sleep periods tended to vary by at least an hour and a half across the three nights sampled.

Previous research has found that two nights of little sleep followed by a rebound night of longer sleep results in both a higher sleep variability score and the ability to compensate on the third night for attentional losses incurred during the two previous nights' sleep (Cote et al. 2008). Given college students' tendency toward sleep durations that are lower than ideal and variable across nights, future studies should investigate the implications of rebound sleep for attentional performance.

It bears noting that these attentional capture effects were only observed at the 200 ms CTI and had disappeared for the 350 ms CTI. This time course effect suggests that the negative effects of consistently deprived sleep on attentional capture occur during early attentional orienting processes and that the extra time provided by the 350 ms CTI may have given sleep-deprived individuals enough time to redeploy attention away from irrelevant cues so that their performance was on par with those participants getting consistently more sleep. Further, many of those participants who consistently obtained more sleep exhibited negative attentional capture scores. This phenomenon, also known as *inhibition of return*, reflects healthy/adaptive inhibition of locations where targets are not likely to appear (Posner 1980; see Klein 2000 for a review). Our findings thus support those of Martella et al. (2014) who found diminishing inhibition of return effects in participants undergoing sleep deprivation.

One potential limitation with the current study was that we were limited to one assessment of attentional functioning. That said, our attentional capture task is well-tested paradigm designed to assess the magnitude of attentional capture by task-irrelevant onsets. Nonetheless, a number of our participants' attention was not captured by the onset cues. It may be that the high ability of our college students (combined verbal and math Scholastic Aptitude Test [SAT] scores are approximately 1400) potentially modulated this effect. Previous work has shown positive correlations between working memory capacity and the ability to resist attentional capture (Kane et al. 2001), and working memory capacity has been correlated with SAT scores (Daneman and Carpenter 1980). The population used in our study was also limited to college students assessed during an academic term. Though this may be a homogenous population in terms of race and age, using a cohort known for its highly variable sleep patterns (Wolfson 2010) allowed us to adequately assess naturally occurring sleep variability, compared to working adult populations that may obtain more consistent sleep.

In sum, the results from this study suggest that the effects of sleep on attention are limited to consistently low duration sleepers who consequently tend to have difficulty ignoring distractors, and consistently well-rested sleepers who excel at redirecting attention away from these distractors. Neither sleep start time nor wake time were significant predictors of attention, suggesting that sleep duration is more important to attentional health, rather than disruptions in circadian rhythms associated with variable bed and wake times (Biggs et al. 2011).

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standards All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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