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Sleep Quality and Temperament Among University Students: Differential Associations With Nighttime Sleep Duration and Sleep Disruptions

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Sleep-temperament associations have not yet been examined among university students, despite awareness of the high incidence of sleep problems in this population. The present study was conducted (a) to examine whether sleep quality was associated with temperament among university-attending young adults and (b) to determine whether particular components of sleep quality were differentially associated with temperament. University students completed questionnaires designed to assess sleep quality and temperament. Poor sleep quality was associated with increased negative affect and orienting sensitivity as well as decreased effortful control; regression analyses revealed differential associations between components of nighttime sleep quality and temperament ratings. The presented study reveals conceptual continuity in sleep-temperament relations from infancy to young adulthood and highlights important avenues for future research.

The sleep patterns of university students are more problematic than those of high school students and non-university-attending adults: in one report, university students obtained fewer hours of sleep at night on leisure days relative to high school students, and their nighttime mid-sleep time was later on school days relative to that of high school students (Urner, Tornic, & Bloch, 2009); in another study, a greater percentage of university students were identified as having poor-quality sleep relative to a large sample of "normative" Finnish adults ranging in age from 36 to 50 years (Buboltz, Brown, & Soper, 2001). Sleep problems in university students likely result from myriad influences, including biological factors such as changing sleep architecture and circadian rhythms as well as environmental factors such as increased involvement in academic and social activities (Colrain & Baker, 2011). An additional unexplored associate may be temperament. Sleep-temperament relations have been documented from infancy (Carey, 1974; Halpern, Anders, Coll, & Hua, 1994; Sadeh, Lavie, & Scher, 1994; Schaefer, 1990; Spruyt et al.,

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2008; Weissbluth, 1981, 1982; Weissbluth & Liu, 1983) to adolescence (Moore, Slane, Mindell, Burt, & Klump, 2011). Findings generally indicate that more disrupted or problematic sleep is positively associated with negative affect and sensitivity to stimuli in the environment, whereas sleep problems are negatively associated with effortful control or self-regulation. The goals of the present research were to (a) examine whether nighttime sleep quality was associated with these same dimensions of temperament among university-attending young adults and (b) to determine whether particular components of nighttime sleep quality, namely sleep duration and the frequency of sleep disruptions, were differentially associated with temperament ratings.

Temperament has been conceptualized as constitutionally based individual differences in reactivity and regulation. In this context, reactivity refers to arousability processes associated with affect, motor behavior, and attention, whereas regulation refers to inhibition or self-soothing processes that modulate reactivity. Individual differences in reactivity and regulation result from biological influences such as genetics and maturation but may be affected by experience-dependent processes as well (Rothbart & Derryberry, 1981). Temperament is commonly regarded as a subcomponent of personality, representing individual differences in unconscious habits or skills acquired through procedural learning (Cloninger, 1994).

Sleep-temperament associations have been reported in infant samples since the early 1970s. Carey (1974) documented that the frequency of parent-reported infant night wakings at 6 months was positively associated with reduced sensory threshold, such that increased night waking tended to co-occur with increased perception of low-intensity environmental stimuli. More recent research has confirmed associations between sleep and perceptual sensitivity (Sadeh, Lavie, & Scher, 1994) and has revealed additional associations between poor infant sleep habits and temperament profiles (see the following for empirical examples: Halpern, Anders, Coll, & Hua, 1994; Schaefer, 1990; Spruyt et al., 2008; Weissbluth, 1981, 1982; Weissbluth & Liu, 1983; see the following for a review: Ednick et al., 2009). To summarize, findings generally indicate that problematic sleep habits are associated with more "difficult" temperament profiles that are characterized by predominantly negative moods, irregular schedules, withdrawn tendencies, reduced adaptability, low approach, and intense reactions to novelty (Thomas, Chess, & Birch, 1968; Thomas, Chess, Birch, Hertzig, & Korn, 1963; Carey, 1970, 1974).

Although the majority of the work on sleep-temperament relations has been conducted in infancy, there is remarkable consistency in the findings that have been obtained with older participants. Reports of work conducted with school-aged children indicate that behavioral sleep issues are positively associated with negative affect and the intensity of emotional responses among school-aged children (Owens-Stively et al., 1997). More recently, El-Sheikh and Buckhalt (2005) documented associations between increased sleep problems, reduced sleep duration, and increased nighttime activity with more intense emotional responses among 6- to 12-year-olds. In work conducted with adolescents, Monroe and Marks (1977) found that neurotic tendencies were three times more likely to occur among 12- to 18-year-olds with poor sleep habits relative to controls. Similarly, Gau (2000) reported that neuroticism (including constructs such as anxiety, complaining, nervousness, sadness, worry, and indecisiveness, among others) was associated with a variety of sleep behaviors among Taiwanese adolescents, including later bedtimes, reduced sleep duration, and other sleep problems; individuals in the high neuroticism group were also more likely to feel tired, moody, and sleepy during the day relative to those in the low neuroticism group. Most recently, Moore and colleagues (Moore, Slane, Mindell, Burt, & Klump, 2011) examined associations between sleep and temperament

among American adolescents. Sleep problems were positively associated with negative affect (such as frustration, depressive mood, and aggression), impulsivity (such as self-regulation of emotion and behavior), and sociability (such as emotional connectedness with others, including communication with and responsiveness to others) but were unrelated to extraversion (such as outgoing tendencies and novelty or sensation-seeking; see Ellis, 2002; Ellis & Rothbart, 2001). Interestingly, sociability was the strongest predictor of sleep problems in their sample, which they suggested was likely due to the increased amounts of time adolescents spend engaging with peers during the evening hours.

The work conducted to date indicates that sleep is associated with temperament from infancy to adolescence, but to our knowledge no work has been conducted examining these associations among young adults more generally or university students in particular. Such research is important given the prevalence of nighttime sleep problems in university students: recent reports indicate that between 20% (Buboltz et al., 2009) and 65% (Lund, Reider, Whiting, & Prichard, 2010) of university students experience poor-quality sleep, with as many as 65% of students reporting periodic sleep problems (Buboltz et al., 2009). To this end, the primary goals of the present research were to examine whether (a) the sleep-temperament associations that have been documented in younger samples were maintained among university-attending young adults and (b) to determine whether two components of nighttime sleep quality, namely nighttime sleep duration and the frequency of nighttime sleep disruptions, were differentially associated with temperament ratings on the short form of the Adult Temperament Questionnaire (ATQ; Evans & Rothbart, 2007; Mary Rothbart Temperament Lab, 2006). Based on previous research, we predicted that poor sleep quality would be associated with reduced effortful control as well as increased negative affect and orienting sensitivity; we did not expect significant associations between sleep quality and extraversion. To further explore associations between sleep and temperament among university students, we examined whether sleep quality was differentially related to the individual temperament scales that comprised each of the four aforementioned factor scores. Based on work conducted with infants, we predicted that poor sleep quality would be associated with increased sensitivity to low-intensity environmental stimuli (Carey, 1974); based on work conducted with adolescents, we predicted that poor sleep quality would also be associated with increased sociability (Moore et al., 2011). Finally, we examined whether nighttime sleep duration and the frequency of nighttime sleep disruptions differentially predicted ratings of effortful control, negative affect, orienting sensitivity, and extraversion. Because of the exploratory nature of this hypothesis, we did not make any specific predictions as to which components of sleep quality would be associated with various temperament dimensions. We did predict, however, that significant associations between components of sleep quality and temperament would be found for effortful control, negative affect, and orienting sensitivity, but not for extraversion.

METHOD

Participants

Seventy-one students were selected to participate after having been recruited through advertisements or through the use of the undergraduate participant pool maintained by a large public

university in the southwest. The data from one participant was excluded from analysis due to participant failure to comply with study instructions. Of the 70 participants (37 females) who completed the study, 1 was of graduate student standing; the remaining participants were undergraduates (mean age = 20 years; range = 18 to 25 years). Thirty-four of the participants were of Asian descent, 27 were of Caucasian descent, 5 were of mixed race, and 1 was of African American descent; 3 participants did not report race information. Eleven of the participants identified as Hispanic; 1 participant did not report ethnicity information. Participants were allowed to select either $25 in cash or 3 points of extra credit in a class of their choosing in appreciation for their participation.

Measures

Online screening questionnaire. Interested students completed an online screening questionnaire that was developed for this research based on the screening information described in Ellenbogen, Hulbert, Stickgold, Dinges, and Thompson-Schill (2006). The questionnaire inquired as to whether respondents were ever diagnosed with a sleep disorder (and if so, which one, the age at which the diagnosis was made, and how it was treated), whether respondents were being treated for a sleep disorder when they completed the questionnaire (and if so, which one and for how long has it been treated), if they thought they had any abnormal sleep patterns (and if so, to please describe them), whether they were taking any prescription or over-the-counter sleep aids when they completed the questionnaire (and if so, how many nights they were used during an average week), on how many nights they went to bed after 2:00 a.m. in an average week, how many hours of sleep they obtained on an average night, and if they were taking any psychoactive medications when they completed the questionnaire (and if so, which ones). Participants also completed the ESS (Johns, 1991) and were asked about their willingness to abstain from caffeine, alcohol, tobacco, and illegal substances during the 12-hour delay between the first and second sessions. Finally, they were asked whether they were native English speakers; students who were not were asked to indicate in which language they were most comfortable reading and speaking (English, their native language, or both languages equally). This questionnaire was used to identify students who met participation criteria similar to those reported by Ellenbogen and colleagues (2006) for the purposes of the cognitive component of the study, which is described in a separate report (Lukowski, Milojevich, & Phung, 2013).

Questionnaire battery. Participants completed a battery of questionnaires that included the Epworth Sleepiness Scale (ESS; Johns, 1991), the Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), the short form of the ATQ (Evans & Rothbart, 2007). The data from each questionnaire were reduced as described in the relevant data reduction manuals.

The ESS (Johns, 1991) is an 8-item questionnaire that assesses current sleepiness by asking participants to report how likely they would be to doze if they were in particular situations that are differentially soporific, including those in which most people would be expected to fall asleep (for example, lying down to rest during the afternoon when circumstances permit) and others in which only the sleepiest individuals would be expected to doze (for example, while sitting and talking with someone). Participants rated each item on a scale from 0 (would never

doze) to 3 (high chance of dozing); the clinical cutoff is a total score of 10. This measure has high internal consistency and test–retest reliability (Johns, 1992; $\alpha = .71$ in the current study).

The PSQI (Buysse et al., 1989) assesses participant sleep quality over the past month through the inclusion of 19 questions that inquire about quantitative and qualitative aspects of participant sleep habits. Quantitative questions inquire about factors such as the time participants usually go to bed at night, the time participants commonly wake up in the morning after sleep, the amount of time participants spend asleep during the night, and the frequency with which participants experience various nighttime sleep disruptions; qualitative questions include subjective assessments of perceived sleep quality and enthusiasm about completing daily activities. This inventory is commonly regarded as the gold standard for assessing subjective sleep quality in part because it has been validated on individuals with good and poor sleep habits; it has also shown acceptable levels of internal homogeneity and test–retest stability ($\alpha = .61$ in the current study).

The short form of the ATQ (Evans & Rothbart, 2007) was included to assess adult temperament. The 77-item questionnaire asks participants to rate how representative each statement is of their usual behavior on a 7-point scale ranging from 1 (extremely untrue) to 7 (extremely true); participants could also indicate if a particular question was not applicable to them. The data obtained from individual questions are reduced to yield information on 4 distinct factors that were previously identified by Evans and Rothbart (2007) using exploratory factor analysis. The factor scores include effortful control (including the subscales activation control, attentional control, and inhibitory control), extraversion (including the subscales sociability, high-intensity pleasure, and positive affect), negative affect (including the subscales fear, frustration, sadness, and discomfort), and orienting sensitivity (including the subscales neutral perceptual sensitivity, affective perceptual sensitivity, and associative sensitivity; $\alpha = .65$ in the current study).

Procedure

The described study was approved by the relevant university institutional review board.

Recruitment. The online screening questionnaire was used to identify students who went to bed before 2:00 a.m. at least 3 nights per week, obtained 6 or more hours of sleep per night, and scored less than 10 on the ESS (Johns, 1991). Eligible students also reported that they were native English speakers or were as comfortable conversing and reading in English as they were in their native language. Additionally, eligible students did not have a history of diagnosed sleep disorders, they were not being treated for a sleep disorder when the questionnaire was completed, they did not report any abnormal sleep patterns or their reported abnormal sleep habits were not deemed abnormal by the researchers (e.g., having trouble sleeping during final exam week), they did not take nighttime sleep aids, and they were not taking any psychoactive medications. Eligible students also indicated their willingness to abstain from caffeine, alcohol, tobacco, and illegal substances during the 12-hour delay between the first and second sessions. Five hundred fifty-eight students completed the online screening questionnaire but were ineligible to participate for the following reasons: 38 went to bed before 2:00 a.m. fewer than 3 nights per week, 12 routinely obtained less than 6 hours of sleep per night, 129 scored 10 or greater on the ESS (Johns, 1991), 11 were not native English speakers or were more comfortable speaking and/or reading in their native language than in

English, 1 was diagnosed with a sleep disorder, 3 reported abnormal sleep patterns that were unspecified or verified as abnormal by the researchers, 6 used nighttime sleep aids, 5 were using psychoactive medications, and 59 were unwilling to abstain from caffeine, alcohol, tobacco, and illegal substances during the delay between the sessions; 294 students were ineligible for multiple reasons.

Enrollment. Eligible students were contacted by phone or e-mail about continuing their participation in the study. Students who agreed to participate were randomly assigned to arrive at the laboratory for their first session at either 9:00 a.m. or 9:00 p.m., a manipulation that was necessary for the cognitive component of the study.

Questionnaire battery. After informed consent was obtained, each participant completed the questionnaire battery in the order listed in Materials. Each participant was also provided with a brochure from the university counseling center due to the sensitive nature of some items on the inventories; participants were instructed to contact their office with any mental health questions or concerns.

RESULTS

Preliminary analyses were conducted to determine whether participant sleepiness at the first session and participant sleep quality over the past month differed by group assignment (testing at 9:00 a.m. or 9:00 p.m.). Between-subjects analyses of variance (ANOVAs) indicated that testing time was not associated with differential sleepiness on the ESS at the first session (testing at 9:00 a.m.: 6.69 $\pm$ .62, testing at 9:00 p.m.: 6.74 $\pm$ .64) or global sleep quality on the PSQI (testing at 9:00 a.m.: 4.56 $\pm$ .39, testing at 9:00 p.m.: 5.06 $\pm$ .40). We also conducted correlations to examine whether month of testing (coded continuously from 1 = January to 12 = December) and week of the quarter (coded continuously from 1 to 10) in which participants were tested were associated with participant sleep quality and temperament factor scores. Month of testing was not associated with measures of sleep or temperament; associations involving test week were not found when considering the 62 participants who were tested during the usual academic year (additional information on the resulting correlations can be obtained from the first author). We also considered whether participants were tested during vacations as a potential covariate. None of the participants were tested on weekends or university holidays; we also believe that the 8 students tested during the summer months were enrolled in classes at the university when they participated, given that the study was only advertised using the undergraduate human subjects pool through which students commonly receive extra course credit for participating in research. As such, we do not believe that any of the students were tested during vacation periods.

Determination of Potential Covariates

Correlations were conducted to determine whether participant age (coded continuously from 18 to 25 years), sex (0 = male, 1 = female), and ethnicity (0 = Hispanic and 1 = non-Hispanic) were associated with responses on the PSQI (Buysse et al., 1989) and the ATQ

TABLE 1
Correlations between Potential Covariates, Sleep Quality, and Temperament

Questionnaire Measures	*Age*	*Sex*	*Ethnicity*	*Group Assignment*
Sleep quality information				
Sleep duration	.09	−.12	.00	−.02
Sleep disruptions	.14	.04	.06	.19
Global sleep quality	−.09	.02	.17	.11
Temperament factor scores				
Effortful control	.18	.02	.38*	−.11
Negative affect	−.21	.13	−.14	.21^{+}
Orienting sensitivity	−.03	.00	.09	.12
Extraversion	−.20^{+}	.19	−.03	.10

Note. Significant findings are noted (*) when $p \leq .05$; marginal findings are noted ($^{+}$) when $p \leq .10$.

(Evans & Rothbart, 2007). These data are shown in Table 1. As shown, demographic factors were not related to participant sleep quality but were significantly and marginally associated with temperament. Because of these relations and because participant age and sex have been included as covariates in recent work on sleep-temperament relations among adolescents (Moore et al., 2011), we included these variables as covariates in the present report as well. We also included group assignment (0 = testing at 9:00 a.m., 1 = testing at 9:00 p.m.) as an additional categorical covariate given that the imposed difference in testing times could have influenced participant responses. Significant results are presented when $p < .05$.

Descriptive Information on Participant Sleep Quality

Information on participant sleep quality is presented in Table 2 for the complete sample and separately for participants with good and poor sleep quality.[1] Between-subjects ANOVAs were conducted controlling for the aforementioned variables to determine whether components of sleep quality varied by participant sleep quality; chi-square analyses were conducted on dichotomized scores without any covariate control. Results indicated that participants with good sleep quality based on the composite score obtained from the PSQI (Buysse et al., 1989) reported earlier bedtimes, shorter sleep latencies, longer nighttime sleep durations, less frequent nighttime sleep disruptions, more efficient nighttime sleep, and a greater proportion of good-quality sleep overall relative to participants identified as having poor sleep quality.

Correlations

Partial correlations between global sleep quality and temperament are shown in Table 3. Poor sleep quality was related to lower ratings on the effortful control factor score and on all

[1] One participant with poor sleep quality did not report ethnicity information. As such, this participant was excluded from analysis given the use of ethnicity as a categorical covariate.

TABLE 2
Overall Descriptive Statistics and Group Differences in Components of Sleep Quality

	Overall Sample (n = 69)	*Good Sleep Quality (n = 49)*	*Poor Sleep Quality (n = 20)*	*Statistic*	*p-value*	*Effect Size*
General descriptive information						
Rise time	8:30 ± :12	8:22 ± :13	8:38 ± :20	.47	.50	.01
Bed time*	12:38 ± :07	12:10 ± :08	1:05 ± :13	13.89	.0001	.18
Sleep latency (minutes)*	19.11 ± 1.38	13.18 ± 1.49	25.03 ± 2.35	17.86	.0001	.22
Sleep efficiency*	.87 ± .01	.91 ± .01	.83 ± .02	16.29	.0001	.21
Reported sleep quality (percent reporting fairly good or very good sleep quality over the past month)*	84%	96%	55%	17.75	.0001	.51
Sleep medication (percent reporting no use during the past month)	94%	94%	95%	.03	.86	−.02
Staying awake (percent reporting no problems during the past month)	67%	74%	50%	3.52	.06	.23
Enthusiasm (percent reporting no problems during the past month)	41%	45%	30%	1.31	.25	.14
Descriptive information for variables included in correlation and regression analyses						
Sleep duration*	6.79 ± .12	7.45 ± .13	6.13 ± .21	28.41	.0001	.31
Sleep disruptions*	5.33 ± .44	4.44 ± .48	6.22 ± .76	3.88	.05	.06
Global sleep quality*	5.49 ± .18	3.40 ± .20	7.58 ± .31	126.79	.0001	.67

Note. Analyses of variance were conducted controlling for the group assignment and participant age, sex, and ethnicity; chi-square analyses did not include any covariate control. The Statistic column presents the *F*-value for analyses of variance and the χ^2 value for chi-square analyses; the Effect size column presents η_p^2 values for analyses of variance and φ for chi-square analyses. Significant group differences are noted (*) when $p \leq .05$.

three associated scales (activation, attentional, and inhibitory control). Poor sleep quality was associated with higher ratings on the negative affect factor score, particularly when considering the scales of fear and sadness but not discomfort or frustration. Poor sleep quality was also related to higher scores on the orienting sensitivity factor scale, but only when considering associative sensitivity (significant relations were not observed for affective or neutral perceptual sensitivity). Sleep quality was not related to the extraversion factor score or any of its associated scales, including high-intensity pleasure, positive affect, and sociability.

Regressions

Four separate regression analyses were conducted to determine whether nighttime sleep duration and the frequency of nighttime sleep disruptions predicted effortful control, negative affect, orienting sensitivity, and extraversion. The aforementioned covariates were entered as the first step for each of the conducted regression models, followed by the sleep variables on the second step; the regression output is shown in Table 4. The results indicated that the frequency

TABLE 3
Correlations Between Sleep Quality and Temperament

Temperament Scales and Factors	*Sleep Quality*
Effortful control	−.45*
Activation control	−.35*
Attentional control	−.45*
Inhibitory control	−.29*
Negative affect	.42*
Discomfort	.19
Fear	.41*
Frustration	.21
Sadness	.30*
Orienting sensitivity	.26*
Affective perceptual sensitivity	.15
Associative sensitivity	.28*
Neutral perceptual sensitivity	.14
Extraversion	−.11
High-intensity pleasure	.11
Positive affect	−.21
Sociability	−.16

Note. Correlations were conducted controlling for the group assignment and participant age, sex, and ethnicity. Significant findings are noted (*) when $p \leq .05$. Higher global sleep quality scores are indicative of poorer sleep quality.

TABLE 4
Associations Between Components of Sleep Quality and Temperament

	Effortful Control			*Negative Affect*			*Orienting*			*Extraversion*		
	b	*SE(b)*	*Beta*	*b*	*SE(b)*	*Beta*	*b*	*SE(b)*	*Beta*	*b*	*SE(b)*	*Beta*
Age	.13*	.05	.27	−.11*	.05	−.27	−.02	.06	−.04	−.07	.06	−.17
Sex	.14	.16	.10	.02	.14	.02	−.08	.17	−.06	.20	.16	.15
Ethnicity	.79*	.22	.41	−.30	.19	−.18	.16	.23	.09	−.05	.21	−.03
Group assignment	−.13	.16	−.09	.19	.14	.16	.13	.17	.09	.19	.16	.15
Sleep duration	.13	.07	.19	−.10	.06	−.18	−.19*	.08	−.29	−.08	.07	−.14
Sleep disruptions	−.02	.02	−.09	.05*	.02	.29	.04	.03	.18	−.02	.02	−.10
		.26			.23			.14			.12	
		.04			.11			.11			.03	

Note. Regression analyses were conducted controlling for group assignment and participant age, sex, and ethnicity. ΔR^2 reflects the increase in R^2 when the two predictor variables were added to the model. Significant findings are noted (*) when $p \leq .05$.

of nighttime sleep disruptions was positively associated with negative affect and the duration of nighttime sleep was negatively associated with orienting sensitivity; significant relations were not observed between the duration of nighttime sleep or the frequency of nighttime sleep disruptions and effortful control or extraversion.

DISCUSSION

Remarkable consistency has been obtained in findings of sleep-temperament associations from infancy to adolescence. The goal of the present work was to extend this literature into young adulthood by examining associations between participant sleep quality and temperament among university students. An additional goal was to determine whether particular components of sleep quality, namely nighttime sleep duration and the frequency of nighttime sleep disruptions, were differentially associated with temperament ratings. Our hypotheses were supported: poor sleep quality was associated with increased negative affect and orienting sensitivity as well as reduced effortful control; sleep quality was unrelated to participant-reported extraversion. Findings from regression analyses revealed that nighttime sleep duration and the frequency of nighttime sleep disruptions were differentially associated with negative affect and orienting sensitivity but were unrelated to effortful control or extraversion.

The reported associations between sleep quality and temperament are reminiscent of those that have been obtained with younger samples. Sleep problems have been reliably associated with increased negative affect from infancy to adolescence; our data confirm this association in a young adult sample and extend the findings by indicating that poor sleep quality is primarily associated with increased fear and sadness but not discomfort or frustration. These findings are similar to those from the psychopathology literature, which routinely indicates associations between sleep problems and depression (for examples, see Buysse et al., 2008; Gregory et al., 2011; Milojevich & Lukowski, 2013). Moreover, results from regression analyses suggest that variability in the frequency of nighttime sleep disruptions selectively contributed to ratings of negative affect relative to nighttime sleep duration.

Previous research has also demonstrated associations between night waking and orienting sensitivity. Carey (1974) reported that night waking was positively related to orienting sensitivity among 6-month-olds, suggesting that infants with lower sensory thresholds might be more attuned to low-intensity stimuli in the environment, ultimately resulting in increased night waking. Our findings also revealed an association between sleep quality and orienting sensitivity. Analyses of the scale scores that comprised the orienting sensitivity scale, however, revealed that poor sleep quality was not associated with the perception of low-intensity stimuli in the environment (neutral perceptual sensitivity) but was instead related to increased associative sensitivity, or the occurrence of spontaneous cognitions unassociated with the environment. Given this divergence from the results reported by Carey (1974), it is not surprising that we also did not replicate his finding that increased night wakings were associated with orienting sensitivity; instead, regression analyses revealed that reduced nighttime sleep duration was preferentially associated with orienting sensitivity.

Our work is also in agreement with that conducted among adolescents, such that our analyses and those reported by Moore and colleagues (2011) revealed associations between sleep problems and effortful control; sleep problems were identified in their sample using

four sleep-related questions from the parent-report form of the Child Behavior Checklist (Achenbach, 1991a) and the Youth Self Report form (Achenbach, 1991b). We expanded upon these findings as well by indicating that poor sleep quality was associated with all measured components of effortful control, including activation, attentional, and inhibitory control. These findings differ from those obtained in behavioral studies, such that few associations have been demonstrated between sleep loss and inhibitory control among participants without clinically relevant sleep problems (see Binks, Waters, & Hurry, 1999; Pace-Schott et al., 2009, both of which tested university students on a version of the Color-Word Stroop test either after a period of sleep deprivation or after typical sleep). As suggested by Pace-Schott and colleagues (2009), university-attending young adults may not experience performance deficits on cognitive tasks after a period of sleep deprivation because they have adapted to the sleep restriction they usually experience; another possibility they mentioned is that performance deficits may not be observed on behavioral tasks because participants may already be functioning at such reduced levels due to naturalistic sleep deprivation that further decrements in performance are not observed after additional experimental sleep restriction. Our data lend some support for their second hypothesis, such that poor sleep quality was associated with reduced effortful control. Future work is needed, however, to determine whether consistency is apparent in participant-reported effortful control and performance on behavioral tasks in laboratory settings.

Finally, we also replicated findings by Moore and colleagues (2011) indicating that sleep problems were not associated with extraversion. We also attempted to replicate their finding that sleep problems were associated with increased sociability, but our data revealed no association between sleep quality and sociability. One possibility for this discrepancy may be that the sociability scale on the ATQ (Evans & Rothbart, 2007) used in this research includes questions only associated with this construct, whereas the affiliativeness or sociability measure on the Early Adult Temperament Questionnaire-Revised (EAT-R; Ellis, 2002; see also Capaldi & Rothbart, 1992) used by Moore and colleagues (2011) is a factor score that includes the scales of affiliation, perceptual sensitivity, and pleasure sensitivity. Because Moore and colleagues (2011) did not analyze the individual scale scores that comprise the affiliativeness factor score in their research, one does not know to what extent the obtained findings are due to associations with the affiliativeness scale or result from associations with perceptual sensitivity or pleasure sensitivity. Another possible reason for the discrepant findings may be that the affiliativeness score on the EAT-R assesses "the desire for warmth and closeness with others, independent of shyness or extraversion" (Mary Rothbart Temperament Lab, 2006) whereas the sociability scale on the ATQ loads on the extraversion factor score. Future work is required to clarify the association between sleep and sociability, particularly because other work has suggested that sleep problems do not co-occur with increased sociability (Carney, Edinger, Meyer, Lindman, & Istre, 2006; Galambos, Howard, & Maggs, 2011; Galambos, Vargas Lascano, Howard, & Maggs, 2011). On the contrary, findings suggest that increased sociability may serve as a protective factor that buffers against the negative effects of sleep problems or other stressors (Cohen, 2004).

In addition, future research should also attempt to account for some of the limitations of the present study. It is noteworthy that the obtained sleep-temperament associations were obtained among university students who were recruited due to their generally good sleep habits: as indicated, participants went to bed before 2:00 a.m. at least 3 nights per week, obtained 6 or more hours of sleep per night, did not have a history of diagnosed sleep disorders, were

not being treated for a sleep disorder, did not have any abnormal sleep patterns, and did not take nighttime sleep aids; as further evidence of this, only 30% of the complete sample ($n = 21$) were determined to have poor sleep quality on the PSQI (Buysse et al., 1989). As a result, these findings likely underestimate associations between sleep and temperament among university students and may not generalize to the university-attending population at large, who likely experience worse sleep habits than those reported herein. Future research is needed to determine whether the reported relations differ when considering the full range of sleep habits reported by university students. Work should also be conducted directly examining sleep-temperament associations among university students compared to same-age peers not attending university, as associations between sleep and temperament may vary relative to those reported herein.

Experimental or longitudinal studies are also needed to determine the direction of effects between sleep problems and temperament. There are no data to our knowledge to inform the question of whether variability in temperament profiles precedes sleep problems or whether sleep problems contribute to variability in temperament; as such, the mechanism underlying these pattern of effects is as of yet unidentified. Finally, additional work would be strengthened by the use of actigraphy or other objective measures of sleep quantity and quality as well as multi-informant (participant-, parent-, roommate-, and teacher-report as well as laboratory-based) measures of temperament to determine consistency in findings across various reporting techniques.

Although sleep-temperament associations have been studied for almost half a century, important questions about these relations and their contribution to other aspects of functioning remain unanswered. The presented research reveals conceptual continuity in sleep-temperament relations from infancy to young adulthood and also highlights important avenues for future research. Given the prevalence of sleep problems among university-attending young adults, longitudinal and experimental research identifying causal links between sleep and temperament is warranted. With approximately 20 million students attending 2- or 4-year U.S. undergraduate institutions in fall 2009 (U.S. Department of Education, National Center for Education Statistics, 2012), such research could significantly impact the development of prevention and intervention efforts for numerous students who experience sleep problems that may hinder their academic progress or mental health.

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