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Couples' Nighttime Sleep Efficiency and Concordance: Evidence for Bidirectional Associations with Daytime Relationship Functioning

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Abstract

Objective—Emerging evidence suggests the existence of bidirectional links between sleep and relational processes in dyads, but to date, this research has been primarily cross-sectional. The present analyses were undertaken to prospectively examine the directionality of the association between daily relationship functioning and nightly sleep quality and the association between couples' relationship functioning and concordance in sleep-wake rhythms.

Methods—Sleep was measured via both diaries and wrist actigraphy for 7 days in 29 heterosexual co-sleeping couples. Ecological momentary assessment methods were used to characterize daily relationship functioning. Dyadic, multilevel analyses were used to examine the degree to which nightly sleep efficiency or within-couple concordance in sleep timing predicted the next day's relational functioning and vice versa.

Results—In the first set of analyses, for males, higher diary-based sleep efficiency predicted less negative partner interaction the following day. For females, less negative partner interaction during the day predicted greater actigraphy-based sleep efficiency that night. Furthermore, if females reported more positive and less negative daytime partner interaction during the day, this also predicted higher diary-based sleep efficiency for their male partners that night. In the second set of analyses, among females only, lower diary- or actigraphy-based sleep onset concordance respectively predicted less positive and more negative partner interactions the next day.

Conclusions—Bidirectional associations appear to exist between sleep parameters and interpersonal interaction, and may represent a novel pathway linking close relationships with physical and mental health.

Keywords

sleep; couples; relationships; relationship quality

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INTRODUCTION

Although the majority of adults share a bed with a romantic partner (1), most sleep research has focused on the individual, thereby neglecting the impact of sharing a bed on the partners' respective sleep or on the functioning of the dyad. Three decades ago Aaronson and colleagues (2) wrote that "in contrast to our extensive knowledge of solo sleep, our understanding of interpersonal interaction during sleep is virtually non-existent." To date, only a handful of studies have attempted to advance this knowledge. The purpose of the current study is to present preliminary findings concerning the degree to which couples' nightly sleep affects and is affected by the couples' daily relationship functioning.

Considering sleep at the level of the dyad, rather than the individual, is important for multiple reasons. First, emerging evidence suggests that relationship problems and sleep problems co-occur (3). For instance, effective treatment of obstructive sleep apnea, a condition accompanied by significant sleep disturbance and daytime impairments, is associated with improvements in global marital satisfaction and reductions in marital disagreements (4) as well as improvement in the bedpartners' sleep (5). Likewise, studies have shown an association between higher rates of insomnia and lower marital satisfaction, even after controlling for other factors such as perceived physical health, sexual activity, and general social support (6,7). Other findings suggest that sleeping with a partner has objective effects on sleep, although the evidence is mixed on whether bed-sharing is beneficial or detrimental and may depend in part on qualitative elements of the relationship (8–10).

In addition, spouses may serve as important social "zeitgebers" that influence the timing of their partner's circadian sleep/-wake rhythms, and the degree to which couples are concordant in terms of sleep-wake rhythms may be linked to qualitative aspects of the relationship. For instance, couples who are concordant in either their sleep-wake preferences (i.e., larks versus owls) or their actual sleep times report higher marital adjustment and fewer conflicts (11,12). These findings suggest that a dynamic interdependence in bedpartners' sleep-wake rhythms exists that may influence, and be influenced by, contextual factors in the couple's relationship. However, past studies' predominant use of global measures of relationship satisfaction and sleep wake-parameters, as well as cross-sectional designs, preclude inferences regarding the dynamics and directionality of associations between couples' sleep and relationship functioning in their naturalistic context.

There are a number of reasons to predict that the association between sleep and relationship functioning may be dynamic and bidirectional (13). Even isolated nights of sleep disturbance lead to daytime symptoms such as irritability and fatigue, while insomnia independently predicts the onset of depression (14); all of which may be detrimental for interpersonal functioning. Meanwhile, conflict with one's partner is plausibly linked with a variety of changes in sleep: difficulty falling asleep (e.g., due to increased post-conflict arousal or rumination), divergence from one's usual sleep schedule (e.g., one partner waits until the other falls asleep before retiring), or even changes in sleep setting (e.g., the bedpartner sleeps on the couch). In contrast, feelings of well-being and closeness to one's partner should facilitate the relaxation that is optimal for entering the sleep state (3). Given that both sleep and the presence and quality of close relationships have shown profound effects on health and well-being (15, 16) exploring possible bidirectional associations between sleep and relationship functioning may provide a stronger account of how relationships ultimately influence physical and mental health morbidity and mortality.

Thus, we undertook two separate sets of analyses to prospectively examine the directionality of the association between daily relationship functioning and two different parameters of nightly sleep. The first set of analyses investigated bidirectional effects between sleep and

relationship quality by using multilevel models to examine both within-person and cross-partner effects of nighttime sleep and daytime interpersonal interactions on a prospective basis (see Figure 1). We predicted that better sleep, as indicated by sleep efficiency, would predict more positive and less negative partner interactions the following day, and consistent with interdependence theory (17), we predicted that participants would be affected by both their own *and* their partner's sleep. We also hypothesized the reverse pathway; more positive and less negative daytime partner interactions would predict better sleep efficiency for both oneself and one's partner. Lastly, we explored whether gender moderates any observed effects, as previous research suggests that women may be relatively more affected by both the positive and negative aspects of relationship functioning than men (16).

The second set of analyses sought to prospectively investigate the associations between concordance in partner sleep-wake patterns and daytime relationship functioning. We predicted bidirectional effects between sleep-wake concordance and relationship functioning, hypothesizing that higher levels of concordance in sleep timing would predict better daily relationship outcomes, and conversely, that better daily relationship ratings would predict concordance in sleep timing that night. As in the first set of analyses, we also explored whether gender moderates the associations between concordance in sleep timing and daytime relationship ratings.

METHODS

Participants

A sample of 31 couples was recruited from the community. Participants were excluded if their age was outside the range of 18–45 or if they had been co-sleeping for less than 6 months or more than 10 years. Participants were also excluded if they had reported being diagnosed with any current sleep disorders, major psychiatric disorders, or current substance abuse. Female participants were excluded if they were currently pregnant or intended to become pregnant during the course of the study, or if they were post-menopausal or experiencing pre-menopausal symptoms. Although it was not a formal exclusion criterion, none of the couples had children. Finally, two same-sex couples were excluded from the present analyses due to hypotheses regarding gender effects in heterosexual couples, resulting in a final sample of 29 couples.

Study protocol

The current study hypotheses were tested in an observational, longitudinal design using ecological momentary assessment (EMA) methods, a technique uniquely suited to investigating dynamic processes in a naturalistic and thus ecological valid setting (18). Participants were assessed on a variety of self-report measures under naturalistic conditions up to 6 times a day over 7 days. Sleep was assessed via motion-sensitive wrist actigraphs and sleep diaries. In addition, couples completed global measures of depression and relationship satisfaction. Participants were compensated for their time. Data was collected between September 2006 and July 2007. All study procedures were approved by the Committee on the Use of Human Subjects and Internal Review Board at the University of Arizona.

Measures

Sleep measures—Each morning, participants completed a 7-item sleep diary including entries for naps, bedtime, sleep onset, sleep latency, number and duration of awakenings, and sleep offset, and out-of-bed time.

Wrist actigraphy (Actiwatch®; Mini Mitter, Sunriver, OR) provided a complementary behavioral measure of rest and activity. Participants were instructed to wear a wrist Actiwatch (Mini Mitter Co. Inc., Model AW64) continuously for 7 days, and to press an event marker

button on the face of the watch to record when they intended to fall asleep and when they had awakened for the final time at the end of their sleep period. These markers served as measures for calculating sleep onset and offset. Actigraphy-based measures were calculated using the standard medium-sensitivity scoring algorithm from the Actiware 5 software.

Several sleep parameters were calculated from both diary and actigraphy data. These measures included: sleep onset latency (SOL), the length of time between goodnight time (GNT; the time the participant closed their eyes with the intention of initiating sleep) and sleep onset; wake after sleep onset (WASO), the total time spent awake after sleep onset and before the final awakening (sleep offset); and sleep efficiency (SE), the percentage of time spent asleep between GNT and sleep offset (which served as the primary outcome for the first set of analyses). Actigraphy-based sleep onset was defined as the first 10 minutes of immobility, per the default setting.

Ecological Momentary Assessment (EMA) of daily partner interactions: Participants responded to EMA items regarding interpersonal interactions on personal digital assistants (PDA; Palm Z22 Color PDA HandHeld Organizer) installed with free EMA software, the Purdue Momentary Assessment Tool (PMAT; Military Family Research Institute at Purdue University).

EMA relationship measures—Relationship functioning was assessed up to six times per day on two different visual analogue scale (VAS) items (ranging from ‘not at all’ to ‘extremely’) via the PDAs. The two items assessed the valence of the most recent partner interaction (at the same 3-hour intervals as other ratings), asking respectively about positive interactions (i.e., ‘If in contact (in person, phone, or e-mail) with your partner within the last three hours, to what extent was your interaction of a positive nature?’) and negative interactions. To obtain a reliable measure of the overall daily interaction patterns, we averaged the Positive and Negative Interaction scales across the day for each participant.

Global relationship and depression measures—At both the beginning and end of the study, participants completed the Relationship Assessment Scale (RAS; (19), a 7-item Likert scale designed to provide a global measure of relationship satisfaction. The RAS has moderate-to-high correlations with other measures of marital satisfaction, has good test-retest reliability, and displays consistent psychometric properties across ethnically diverse and age-diverse samples of couples (20).

Given that depressive symptoms covary with both relationship functioning and sleep, depressive symptomatology, assessed using the widely-used and well-validated Beck Depression Inventory-2nd edition (BDI-II; (21)), was included as a potential covariate in all statistical models.

Data analysis

Descriptive statistics—The age and sleep parameters of males and females were compared using two-tailed tests.

Correlational analyses—Preliminary Pearson’s correlational analyses were used to examine mean-level associations between relational and individual-dispositional variables and the sleep measures using SPSS 14.0 (SPSS Inc.). For these analyses, male and females were run separately, to avoid potential inflation of correlation coefficients due to nesting within couples.

Dyadic multilevel analyses—We selected Kashy and Kenny’s Actor-Partner Interdependence Model (APIM, (22) as our primary analytic tool for two critical reasons. First, as a dyadic variant of multilevel modeling, APIM uses the dyad as the unit of analysis and thus provides a means to both account for and directly investigate the statistical nonindependence (i.e., nesting) between the two individuals in the dyad. Second, the APIM allows the simultaneous analysis of within-person (i.e., actor) and cross-partner (i.e., partner) effects. The actor effect consists of the association between an individual’s independent variable score (e.g., sleep efficiency) and his or her own score on the dependent variable (e.g., Positive Interaction).. The partner effect consists of the association of an individual’s independent variable score and his or her partner’s score on the dependent variable. Specifically, in the first set of analyses, we employed the APIM to investigate the daily bidirectional associations between sleep efficiency and relationship functioning within individuals, within couples, and between couples. The second set of analyses used a similar dyadic multilevel model to investigate the daily bidirectional associations between concordance in sleep timing and relationship functioning, but omitted the cross-partner effects (as the sleep concordance variable was the same for both partners). The multilevel analyses were conducted in SAS version 9 using Proc Mixed.

Per standard recommendations for multilevel modeling (18,23) all within-person time-varying covariate predictor variables were group-centered (centered around each participant’s own mean).

In both studies, we explored potential gender differences by simultaneously modeling outcome variables for both male and female partners and directly comparing the specific coefficients for males and females. The coefficients of all significant predictors of interest were tested using the ESTIMATE function of SAS Proc Mixed.

RESULTS

Sample characteristics

As a whole, the sample was comprised of young adults who were good sleepers as based on the diary-based parameters of sleep continuity (Table 1), with sleep representative of healthy individuals in this age-group (1). The mean actigraphy-based sleep parameters reflected somewhat poorer sleep than the diary measures, and other than the female partners’ diary- and actigraphy-based sleep onset latency ($r=0.47$, $p=0.10$), the diary- and actigraphy-based sleep parameters were uncorrelated (r ’s ranged from 0.11–0.30, all p ’s > 0.10)

The BDI and RAS scores did not differ between baseline and end-of-study (analyses not shown here); therefore, the mean values are reported to improve reliability. No significant differences existed in the means for female and male partners. Mean RAS scores were high (maximum score of 35), consistent with stable, healthy relationships among the participating couples. Likewise, the mean BDIs were in the nondepressed range (<10) for both sexes. The weekly means of the prospective relationship measures also reflected healthy relationships among the sample, with high levels of Positive Interaction (~80 out of 100) and low levels of Negative Interaction (~9 out of 100).

Lastly, couples reported co-sleeping (operationally defined as sharing a bed for at least 4 nights per week) for a mean duration of 2.7 years (range=6 months-10 years).

Missing data

Average compliance for completing EMA measures was 93.27 % ($SD = 0.14$) with a majority of participants missing 2 or fewer time points. No extra procedures (e.g., imputation of missing

time points) were undertaken as the multilevel modeling approach is robust against the effects of missing data.

Mean correlations between depression, relationship, and sleep measures—

Significant associations were observed between the weekly means of the sleep parameters and those of depression and/or relationship that varied by gender (see Table 2). In male participants, significant associations were confined to diary-based WASO, which correlated with global measures of relationship quality and depression, while in female participants, actigraphy-based measures of sleep continuity (SOL, WASO, and SE) were associated with the global relationship and depression measures, as well as the weekly means of the daily relationship functioning measures.

Daily actor-partner interdependence between sleep and relationship quality—

In order to reduce the chance of Type I errors due to multiple comparisons, and in the interest of parsimony, we selected sleep efficiency as the primary outcome for the daily analyses. Sleep efficiency is a commonly used measure in clinical sleep research because it accounts for both SOL and WASO in its calculation. Higher values of sleep efficiency indicate more consolidated sleep. Also, because of well-established effects of depression on both relationship processes and sleep, we initially included participants' mean BDI scores as covariates in all statistical models. However, given that BDI did not significantly contribute to any of the outcomes, and its inclusion reduced model fits (based on the deviance statistic), it was omitted from all models.

The first series of multilevel models investigated the effect of sleep efficiency on the following day's relationship functioning. There were no effects of the female partner's diary-based sleep efficiency on her mean Positive or Negative Interaction ratings the following day. In contrast, the male partner's diary-based sleep efficiency predicted his rating of Negative Interaction the following day (actor effect; $B = -21.84$, $t(259) = -2.33$, $p = 0.02$), but did not predict his Positive Interaction rating. No cross-partner associations existed between diary-based sleep efficiency and the next day's partner interaction ratings. Finally, actigraphy-based sleep efficiency did not predict next day's Positive or Negative Interaction in either gender (neither actor nor partner effects).

Examining the reverse association (daily relationship functioning predicting that night's sleep), for female partners only, daily Positive Interaction ratings predicted her own diary-based sleep efficiency that night, but this "actor" effect did not reach statistical significance ($B = 0.0006$, $t(251) = -1.76$, $p = 0.08$). There was, however, evidence of a significant "partner" effect; both the female partners' mean Positive Interaction ratings and her mean Negative Interaction ratings predicted the male partners' diary-based sleep efficiency ($B = 0.001$, $t(132) = 2.41$, $p = .02$; and $B = -0.002$, $t(178) = -2.53$, $p = 0.01$; see Figures 2A and 2B). For both males and females, their own Negative Interaction ratings did not predict their own diary-assessed sleep efficiency that night. For actigraphy-based sleep efficiency, the female partner's mean Negative Interaction rating predicted her own actigraphy-based sleep efficiency that night ($B = -0.12$, $t(139) = -2.33$, $p = .02$). No other actor or partner effects existed on actigraphy-based sleep efficiency.

Significant gender differences were found for each of the above significant effects. The effect of diary-based sleep efficiency on one's own next day's Negative Interaction rating was significantly stronger among males (actor effect, $B = 37.63$, $t(229) = 2.18$, $p = 0.03$). Likewise, the cross-partner effects of daily relationship functioning on that night's diary based sleep efficiency interpersonal functioning were stronger among the males. That is, both the female's Positive and Negative Interaction ratings predicted the male's sleep efficiency more strongly than the male's Positive or Negative Interaction ratings predicted the female's sleep efficiency ($B = -0.002$, $t(196) = -2.65$, $p = 0.001$; and $B = 0.002$, $t(236) = 2.66$, $p = 0.008$, respectively).

Mean correlations between sleep concordance, mood, and relationship functioning

—No significant associations were observed between any of the sleep concordance measures and the paper-and-pencil relationship or depressive symptoms measure. In female partners only, there was a non-significant correlation between larger mean within-couple differences in sleep onset and lower mean global relationship satisfaction (RAS) scores ($r=-0.34$, $p=0.07$).

The sleep concordance measures showed relatively stronger associations with weekly means of the prospective relationship functioning measures. In female partners, larger within-couple differences in sleep onset (diary and actigraphy-based) correlated with lower mean Positive Interaction ratings ($r=-0.41$, $p=0.03$, and $r=-0.37$, $p=0.06$, respectively) and higher mean Negative Interaction ratings ($r=0.39$, $p=0.04$, and $r=0.42$, $p=0.03$, respectively). In male partners, larger within-couple differences in sleep onset (diary and actigraphy-based) were unrelated to the weekly means of prospective relationship functioning. No correlations emerged using within-couple differences in sleep offset as the measure of sleep concordance.

Bidirectional effects of sleep timing concordance and relationship functioning

—Next, we investigated the daily associations between sleep timing concordance and relationship measures. For all participants, the unconditional means and growth models indicated that significant variability existed at both the within- and between-individual levels and no significant linear trend existed over the week in the daily mean Positive Interaction or Negative Interaction ratings. For each model, the frequency of partner interaction and the outcome variable's value during the previous evening were included as covariates.

For female partners, lower concordance with their male partner's sleep onset predicted less positive and more negative partner interactions the next day. That is, greater within-couple diary-based sleep onset differences (i.e., greater discordance) predicted lower Positive Interaction ratings the next day (see Table 3 and Figure 3) and greater within-couple actigraphy-based sleep onset differences predicted higher mean Negative Interaction ratings the next day (see Table 3 and Figure 4). In contrast to findings for the female partners, concordance in sleep timing (as measured by both actigraphy and diary) was unrelated to the male partner's Positive and Negative Interaction ratings. Diary- and actigraphy-based sleep offset differences were unrelated to either Positive or Negative Interaction ratings for males or females.

Again comparing the specific coefficients for each of the significant effects above, a trend towards a significant gender difference emerged for the association between diary-based sleep onset concordance and the next day's Positive Interaction ratings (greater for females; $B=-1.91$, $t(153)=1.71$, $p=0.09$) but no significant gender difference existed in the association between sleep onset concordance and mean Negative Interaction.

In order to address the possibility that the quality of daily partner interactions led to changes in the degree of concordance in couple sleep timing (e.g., a conflict during the evening leads one partner to go to bed early while the other waits to retire until the first falls asleep), we next examined whether the daily mean partner interaction ratings predicted the corresponding nights' sleep timing differences (i.e., predictors and outcomes were reversed from previous analyses). However, no significant effects emerged for the predictors of interest in these models.

DISCUSSION

In a sample of 29 co-sleeping couples, we conducted a preliminary investigation of the bidirectional associations between nighttime sleep and daytime relationship functioning. This is the first such report to prospectively examine these associations, focusing on the couple as

the unit of analysis, and incorporating both subjective and objective measures of sleep, as well as utilizing EMA methods to assess the quality of daily interactions in the couples' naturalistic setting. Consistent with recent theoretical models linking close relationships with sleep (3, 13), our preliminary study (given the small sample size) is the first to prospectively demonstrate that sleep and relationship functioning are dynamically and reciprocally related in couples.

Specifically, for males only, poor sleep (as indicated by diary-based sleep efficiency) predicted more negative ratings of partner interactions the next day. Sleep disruption or loss have well-documented effects on a variety of cognitive (e.g., poor concentration), affective (e.g., irritability), and relational (e.g., sociability) processes that could influence one's capacity to manage complex interpersonal interactions (e.g., (24,25)). Thus, poor sleep efficiency may deplete males' interpersonal-relevant resources to the point where partner interactions become more conflictual. The lack of a similar effect for women may imply greater interpersonal capacity, or greater resilience in interpersonal-relevant processes. Alternatively, the sole finding for males may reflect a gender-specific effect exclusively on the *perception* of the partner interactions, rather than an effect on the interactions themselves. One possibility is that sleep-disturbed males are more negatively biased due to a mood-based mechanism, given previous reports of mood disturbance (i.e., depression) driving marital distress in males (26).

In contrast, however, among females, there was a stronger relationship for the reverse association—daytime interactions affecting nighttime sleep. The females' reported positive interactions predicted their own diary-based sleep efficiency (albeit only reaching marginal significance), while their reported negative interactions predicted their actigraphy-based sleep efficiency. This is in line with evidence suggesting that women are more sensitive to both the "highs" and "lows" of relationships (27). Notably, the females' perception of daytime interaction also predicted their male partners' sleep. The absence of an effect of the males' partner interaction ratings on their own sleep makes this finding particularly intriguing, as it suggests that the males may have been influenced by relational processes through some pathway that was unbeknownst to them.

We also found evidence that subjective and objective concordance in sleep timing, as measured by within-couple differences in diary- or actigraphy-based sleep onset respectively, predicted the perceived quality of daytime interactions. However, these effects were confined to the female partners, for whom greater diary-based concordance in sleep onsets predicted higher ratings of positive daily partner interactions and greater actigraphy-based concordance in sleep onsets predicted lower ratings of negative daily partner interactions. That is, for women, it was the interdependence between the couple's sleep/wake rhythms, rather than their own sleep, that predicted their perceptions of the relationship functioning. In contrast, for men, it was the perturbations in their own sleep that appeared to influence their partner interactions.

Questions remain regarding the nature of the mechanisms linking bedpartners' sleep timing concordance and their daily interpersonal experience. Theorists have posited a bidirectional relationship between circadian and interpersonal processes, hypothesizing that romantic partners serve as social zeitgebers that contribute to the stability, and thus the strength, of their physiological circadian rhythms (e.g., (28)). However, given that sleep offset is more tightly correlated to underlying circadian timing than is sleep onset (29), the lack of significant association between concordance in bed partners' sleep offsets and their interpersonal functioning indicates a behavioral explanation is more likely. For example, discordance in sleep onsets could reflect relational conflict that leads one partner to require longer to fall asleep on a given night, or to one partner waiting to retire until the other falls asleep. However, inconsistent with these explanations, we did not find that daytime interactions predicted concordance in sleep timing that night. One possibility is that our broad measures of partner

interactions are not capturing subtler relational changes, such as emotional distancing, that may be influencing sleep concordance.

A number of the analyses showed disparate associations between diary- versus actigraphy-based measures of sleep efficiency or concordance with the global and prospective measures of relationship functioning. Previous studies have also noted such disparities; it may be that diary-based sleep data demonstrate more consistent associations with self-reports of other aspects of functioning (e.g., (30)). However, in the correlational analyses, which aggregated sleep data across the week, there were stronger correlations between relationship functioning measures and actigraphy-based sleep parameters. This suggests that, on average, relational measures covary with both subjective and objective sleep domains. On a day-to-day basis, however, diary-based sleep measures may track more closely with daily reports of interpersonal functioning. Taken together, these findings underscore the importance of examining prospective dynamics in addition to retrospective impressions.

Strengths and limitations

This study had a number of strengths. Most notably, to our knowledge it is the first to use a prospective design to investigate cross-partner and bidirectional associations between nighttime sleep and daytime relationship functioning in an ecologically valid context. Furthermore, unlike much of the previous literature, the study utilized both subjective (diaries) and behavioral (actigraphy) measures of sleep/wake patterns, as well as EMA measures of relationship functioning. The study also capitalized on recent advances in statistical approaches to dyadic data, allowing examination of dynamic within-person and cross-partner effects while appropriately addressing the within-couple interdependence.

Despite these strengths, the study also had some significant limitations, perhaps most notably that we had a relatively small sample comprised of primarily young, happy couples and good sleepers. Future studies should include a larger sample with broader range of relationship functioning and sleep quality in order to have sufficient statistical power to detect significant differences, as well as to address potential moderators of the association between relationship functioning and sleep quality. Next, although actigraphy provides a more objective measure of sleep/wake patterns, it is not a physiological measure of sleep. Another limitation is the open-ended nature of the VAS measures of partner interactions, which while less burdensome for repeated daily assessments, may lead to some uncertainty regarding what the measures are capturing. (Although in support of the validity of the VAS measures, their weekly means were moderately correlated with the RAS scores.) Future studies should consider including measures with more specific items regarding the different spheres of partner interaction (e.g., physical closeness, verbal versus nonverbal communication, etc.) in order to better elucidate which aspects of daytime interaction are most strongly related to nighttime sleep. Future studies are also needed that incorporate potential biological mediators (e.g., oxytocin) that may explain these associations as well as contribute to downstream influences on health. Finally, our study did not assess sexual intimacy, a prominent yet under-studied aspect of the co-sleeping arrangement and one that correlates highly with marital satisfaction; however, surprisingly little is known about sexual activity and sleep.

Conclusion

Psychological and physiological co-regulation in the context of adult attachment relationships is an important, yet understudied, pathway linking close relationships and health (31). These findings suggest that sleep is a pathway implicated in such co-regulation. These results offer a glimpse into the apparent mutual interdependence of sleep and relational processes both between and within co-sleeping partners. Although methodological limitations preclude establishing a causal link, this preliminary data is consistent with recent theoretical models

linking sleep and relationship functioning in a reciprocal and dynamic fashion. Further elucidation of this mutual interdependence between couples' sleep and relationship functioning may have important clinical implications for bed-partners looking to reduce or avoid conflicts with one another, or to diminish their own distress. Understanding how sleep affects and is affected by couples' relationship functioning may elucidate a key biobehavioral pathway through which close relationships influence health during both night and day.

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List of abbreviations

APIM	Actor-Partner Interdependence Model
BDI	Beck Depression Inventory (2 nd ed.)
EMA	Ecological Momentary Assessment
GNT	Good night time
RAS	Relationship Assessment Scale
SE	Sleep efficiency
SOL	Sleep onset latency
VAS	Visual analogue scale
WASO	Wake after sleep onset

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Figure 1.

Theoretical model of bidirectional relationships between sleep and daily interpersonal interactions in couples, accounting for actor and partner effects. The symbols (♀ and ♂) indicate female and male partners, respectively.

Figure 2.

Figure 2A & B. Female's partner interaction ratings predict male's diary-based sleep efficiency

Figure 3. Within-couple concordance in diary-based sleep onsets predict female's positive interaction ratings

Figure 4. Within-couple concordance in actigraphy-based sleep onset predicts female's negative interaction ratings

Table 1

Sample characteristics

	Females (n=29)		Males (n=29)		p
	Mean ± SD	Range	Mean ± SD	Range	
Age	25.59±4.44	18–36	26.66±5.61	18–40	0.43
Diary-based sleep data					
Sleep onset	0:13±1:32	22:21–05:19	0:17±1:27	22:48–4:58	0.84
Sleep onset latency (minutes)	13.2±0.18	0:02–0:90	0:26±0:24	0:04–1:00	0.56
Wake after sleep onset (minutes)	9:32±9:23	0–32:86	10:17±14:45	0–58:57	0.79
Sleep offset	7:53±1:32	5:59–13:48	7:25±1:25	5:16–11:31	0.23
Sleep efficiency (%)	94.91±3.49	84.63–98.88	93.77±5.35	80.02–99.23	0.34
Total sleep time (hours)	7.50±0.82	5.66–9.13	6.94±0.87	5.17–8.39	0.02
Actigraphy-based sleep data					
Sleep onset	0:10±1:31	22:25–5:03	0:14±1:26	22:26–5:02	0.86
Sleep onset latency (minutes)	11.26±7.18	2:58–29:21	13.40±8.61	1:64–36:64	0.31
Wake after sleep onset (minutes)	42.33±19.41	19.86–81:21	40.17±14.35	21.64–70:64	0.63
Sleep offset	7:46±1:37	5:58–13:37	7:16±1:23	5:10–11:16	0.22
Sleep efficiency (%)	85.62±4.92	76.47–94.75	84.02±4.55	73.25–92.06	0.20
Total sleep time (hours)	6.89±0.88	4.07–9.05	6.36±0.81	5.03–7.68	0.02
Relationship Assessment Scale (RAS)	32.19±2.38	27–35	31.71±2.94	23–35	0.50
Beck Depression Inventory (BDI)	4.31±3.04	0–11	5.33±1.07	0–24.5	0.40
Positive interaction, weekly mean	79.67±13.52	46.4–99.5	76.31±13.70	52.0–98.3	0.36
Negative interaction, weekly mean	9.50±10.42	0–43.6	9.28±9.10	0–32.7	0.93

Table 2
Correlations of diary- and actigraphy-based sleep parameters with measures of relationship functioning and depression

	Female partners					Male partners				
	Global relationship functioning	Prospective relationship functioning	Negative Interaction	BDI	Global depression	Global relationship functioning	Prospective relationship functioning	Negative Interaction	BDI	Global depression
	RAS	Positive Interaction	Negative Interaction	BDI	RAS	Positive Interaction	Negative Interaction	BDI	RAS	Global depression
Diary-based										
Sleep onset latency	-0.14	-0.29	0.02	0.11	-0.01	0.27	0.05	0.09		
Wake after sleep onset	0.11	0.15	-0.21	-0.13	-0.39*	-0.15	0.28	0.37*		
Sleep efficiency	0.05	0.12	0.09	0.02	0.25	-0.06	-0.27	-0.22		
Actigraphy-based										
Sleep onset latency	-0.50**	-0.36 [†]	0.49**	0.18	-0.18	0.08	0.23	0.30		
Wake after sleep onset	-0.15	-0.16	0.27	0.31 [†]	-0.07	0.02	0.05	-0.09		
Sleep efficiency	0.31	0.20	-0.41*	-0.36 [†]	-0.03	0.01	-0.25	0.09		

Note.

[†] $p < 0.10$.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

Table 3

Unstandardized parameter estimates of the prediction of daytime partner interaction ratings from previous night's sleep onset concordance

Variables	Next day's partner interaction rating			
	Positive partner interaction		Negative partner interaction	
	Female (B)	Male (B)	Female (B)	Male (B)
<i>Diary-based predictor of interest</i>				
Sleep onset concordance on previous evening ^a	-2.23*	-0.33	1.05	0.54
<i>Covariates</i>				
Number of interactions that day	0.93	1.63**	-0.08	-0.23
Positive interaction at previous evening's bedtime	0.15*	0.04*		
Negative interaction at previous evening's bedtime			0.12**	-0.01
<i>Actigraphy-based predictor of interest</i>				
Sleep onset concordance on previous evening ^a	-1.38	-0.82	1.63*	1.05
<i>Covariates</i>				
Number of interactions that day	0.95	1.69**	-0.07	-0.31
Positive interaction at previous evening's bedtime	0.17***	0.05		
Negative interaction at previous evening's bedtime			0.14**	0.02

Note:

^a Sleep onset concordance is operationalized as the difference in hours between the partners' respective sleep onsets (i.e., higher values indicate greater differences)

[†] $p < 0.10$.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.