Better not to quarrel after a sleepless night: preliminary evidence of the negative impact of sleep deprivation on interpersonal conflict

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Abstract

Although poor sleep has been found to correlate with deteriorations in romantic relationships, its causal impact on interpersonal conflict has not previously been studied. Therefore, 30 couples were randomly assigned to either a single night of total sleep deprivation or a night of normal sleep to test the effects of sleep deprivation on couples' conflict. After the experimental night, all participants discussed a topic of recurrent conflict for 15 minutes. We collected pre- and post-conflict measures of cortisol, self-reports of feelings and satisfaction with the conflictual discussion. Multilevel analyses revealed higher cortisol levels during conflict and less positive affect prior to and after the conflict for sleep-deprived couples compared to couples in the control condition. Additionally, higher cortisol levels during the conflict predicted lower satisfaction about the content of the conflict among sleep-deprived couples. These findings provide initial evidence for a causal negative impact of sleep deprivation on couples' conflicts.

Introduction

During their lifetime, individuals face stressful situations in which the support of their romantic partner may be crucial. Even though a romantic partner may help to buffer external stress (Ditzen, Hoppmann, & Klumb, 2008), they can also be the source of tension (Kiecolt-Glaser, 2018). Indeed, marital strain has been reliably linked to higher cortisol levels as well as to other negative consequences for physical health, including immune dysregulation, endocrine changes, and elevations in cardiovascular activity (Kiecolt-Glaser, 2018; Kiecolt-Glaser & Newton, 2001; Miller, Dopp, Myers, Stevens, & Fahey, 1999; Robles & Kiecolt-Glaser, 2003). Even though an extensive body of research has focused on the influence that individual communication styles may have on conflict (Friedlander, Lee, & Escudero, 2019; Gottman & Notarius, 2002), it is also critical to test the causal influence of external factors. The present study aimed at testing whether sleep deprivation is impacting interpersonal conflict in romantic couples.

In line with this idea, a recent review has pointed out the role of sleep loss on diverse affective phenomena such as stress and emotions (Ben Simon, Vallat, Barnes, & Walker, 2020), which in turn may have an impact on social interactions (Deza-Araujo et al., 2021; Van Kleef, 2009). On the one hand, sleep deprivation has been shown to increase self-reported stress in participants (Minkel et al., 2012), higher skin conductance levels (Liu, Verhulst, Massar, & Chee, 2015), and increased cortisol levels (Leproult, Copinschi, Buxton, & Van Cauter, 1997). On the other hand, stress seems to worsen social relationships: elevated cortisol levels have been shown to increase punishment behavior (Deza-Araujo et al., 2021), and stress when commuting to work has been associated to subsequent acts of aggression at work (Hennessy, 2008).

Likewise, emotions affect conflicts and are affected by sleep loss. First, emotions are inherent to social situations (Van Kleef, 2009), and play a key role in the context of conflicts (Bodtker & Jameson, 2001; Klimecki, 2019). Importantly, the expression of more positive emotions *versus* negative emotions during interpersonal conflicts has been linked to successful marriages (Driver & Gottman, 2004; Gottman & Levenson, 1992). Second, evidence suggests that emotions are influenced by sleep loss: it has been

shown that acute sleep deprivation intensifies negative emotions and reduces positive affect in healthy adults compared to well-rested control participants (Paterson et al., 2011) and in medical residents after several nightshifts (Zohar, Tzischinsky, Epstein, & Lavie, 2005).

Furthermore, after a total sleep deprivation night, participants showed deficits in emotion recognition (van der Helm, Gujar, & Walker, 2010), a key process for successful social functioning (Schlegel & Scherer, 2016). In addition, previous research has suggested that sleep deprivation impairs decision-making (Killgore, Balkin, & Wesensten, 2006), leads to reduced trust in others, and promotes more aggressive interactions during a social game (Anderson & Dickinson, 2010).

Recent studies found links between shortened sleep or poor sleep quality and more conflictual interactions among romantic partners. More specifically, sleepless nights were correlated with more conflict the following day and a night with bad sleep was associated with reduced positive emotions and increased negative emotions during a conflictual discussion in romantic couples as well as a reduced empathic accuracy (Gordon & Chen, 2014). Moreover, couples reporting poor sleep showed greater inflammatory responses as measured by interleukin-6 during a conflict compared to couples who reported a better sleep (Wilson et al., 2017). Self-reported sleep problems have also been shown to correlate with more marital aggression (Keller, Haak, DeWall, & Renzetti, 2019). Interestingly, the relationship between sleep problems and marital aggression was mediated by lower levels of self-control (Keller et al., 2019).

Taken together, there is evidence for a correlation between poor sleep on the one hand and difficulties in social interactions and romantic relationships on the other hand (Gordon & Chen, 2014; Keller et al., 2019; Paterson et al., 2011; Wilson et al., 2017; Zohar et al., 2005). However, the causal link between sleep loss and interpersonal conflict has yet to be determined by testing the impact of sleep deprivation on social interactions (Gordon, Mendes, & Prather, 2019). Besides, scholars proposed that future studies in this domain will be enriched by combining subjective measures of sleep (e.g., sleep diaries) with objectives measures of sleep such as actigraphy, and by including behavioral measurements of the conflict (Gordon & Chen, 2014; Keller et al., 2019).

To extend previous findings, the current study aimed at testing the causal impact of one night of sleep deprivation compared to normal sleep on interpersonal conflict in romantic couples. Based on previous studies (Gordon & Chen, 2014; Wilson et al., 2017) we expected that compared to couples with normal sleep, sleep-deprived couples will show difficulties reaching an agreement, worse emotion recognition, less satisfaction about the conflict discussion, more negative affect and less positive affect, and higher cortisol responses during a conflictual discussion.

Method

Participants

A total of 30 couples were recruited in Geneva and its surrounding areas through posters and flyers. Both members of each couple completed a demographic questionnaire as well as a series of questionnaires assessing inclusion criteria. Inclusion criteria were: no medical, psychiatric, or sleep-related disorder; no circadian preference assessed by Morningness-Eveningness Questionnaire (Horne & Ostberg, 1976); no medication or drug consumption. As the conflict discussions always took place in the morning, we wanted to ensure that no couple or participant was disadvantaged (e.g., less awake) because of their circadian preference. In addition, couples were recruited if they had been in a relationship between 1 and 5 years. On average, participants had a relationship length of 28.5 months (*SD* = 14.44 months). If both partners met all inclusion criteria, couples were randomly assigned (using a computer-generated list of random numbers) to either a total sleep deprivation condition (*mean age* = 22.9 years, *SD* = 5.01), or a control condition (*mean age* = 21.7 years, *SD* = 1.7). The current study was approved by the Ethics Commission of the Faculty of Psychology and Educational Sciences of the University of Geneva in February 2017. Written informed consent was obtained from every participant. Volunteers received a monetary compensation at the end of the experiment.

Measures

Questionnaires. Sleep hygiene was measured by a series of questionnaires: the Pittsburgh Sleep Quality Index (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), the Epworth Sleepiness Scale (Johns, 1993), and the Morningness-Eveningness Questionnaire (Horne & Ostberg, 1976). Scores on these questionnaires served to control that participants met inclusion criteria and are summarized in Supplementary Table 2. In addition, prior to the first visit to the laboratory, participants were required to complete online questionnaires related to personality traits as well as aspects of their relationship: the Relationship Assessment Scale (Hendrick, 1988), the Commitment in Close Relationship Scale (Bodenmann & Kessler, 2011), the Interpersonal Reactivity Index (Davis, 1983), and the State-Trait Anger Expression Inventory (Spielberger, 2010). These questionnaires were administered to test for potential differences in groups in relationship quality and emotions. Due to an error in sending the online link for these questionnaires to some participants, data from 14 participants are missing on the personality and relationship questionnaires. Thus, the sample size was reduced to 46 participants for the independent *t*-tests and Welch's *t*-tests (26 individuals in the sleep-deprivation and 20 participants in the control condition). These analyses revealed that groups only differed in relationship satisfaction, $t(44) = 4.04$, $p < .001$, all other $t_s(44) \leq .33$ and $p_s \geq .11$ (for details, see Supplementary Table 3). Because the relationship satisfaction scores were high ($M = 4.67$, $SD = 0.32$, scale range 1 to 5), we decided to compare them with the scores of the original sample of the Relationship Assessment Scale (Hendrick, 1988) and the ones of the sample used for its French validation (Saramago, Lemétayer, & Gana, 2021). Subsequent independent samples *t*-tests indicated that participants in the current study (N = 46) were more satisfied with their relationships, ps < .001 than participants of the Hendrick's study and participants of the French sample of Samarago et al. (means and standard deviations can be found in the Supplementary Material).

Stress measures. In order to measure the level of the stress hormone cortisol, saliva samples were collected using Salivette tubes (Salivette, Sarstedt, Nümbrecht, Germany). The first saliva sample was

collected on day 1 at 8:30 a.m. and the second one on the following day (day 2) at the same time (8:30 a.m.). The next saliva samples were collected throughout the experiment on day 2 (see Fig. 1). The saliva samples were then stored at -20°C and sent to the Clinical Psychology and Psychotherapy laboratory (University of Zürich) for analysis. Cortisol levels were calculated and expressed in nmol/l.

Emotion recognition. In order to assess whether sleep deprivation impacts dynamic emotion recognition, which in turn may breed conflict, the short version of the Geneva Emotion Recognition Test (GERT-S; Schlegel & Scherer, 2016) was administrated. This task includes 42 short video clips (3 seconds each) displaying 10 actors who express 14 different emotions (e.g., irritation, pride, interest). Importantly, the videoclips are multimodal: the participants were able to hear actors' voices as well as watch facial and body expressions. Clips were presented one by one and we instructed participants to determine after each clip the emotion that was expressed by the actor. Participants could choose among 14 different emotions. Each correct answer was scored 1 and incorrect answer was scored 0; leading to a total score from 0 (no emotion identified correctly) to 42 (all emotions correctly identified).

Emotions felt. Self-reports of affective states were collected at three time points using the Positive Affect Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). This questionnaire comprises 10 items assessing positive affect (e.g., enthusiastic) and 10 items assessing negative affect (e.g., hostile). Participants used a scale from 1 (*not at all*) to 5 (*very much*) to rate each item. In the present study, all participants filled in the PANAS pertaining to their current affect at that time on the morning of day 1, on the morning of day 2, and after the last discussion on day 2.

Conflict Discussion and Bonding Discussion. In order to induce a conflict, we used a well-established paradigm – the Conflict Discussion (Gottman, Markman, & Notarius, 1977; Levenson & Gottman, 1983, 1985). Each couple was first asked to find and list together three topics of recurrent conflict as well as three topics of regular agreement in their relationship (e.g., time spent together, food, housework, friends). Couple rated together (one for both partners) how severe each disagreement topic listed was from 0 (*not at all*) to 10 (*totally*). Then participants were asked to choose one of the topics of disagreement listed and discuss it for 15 minutes while trying to resolve it. We used the rating related to the topic that was actually discussed as pre-conflict measurement of conflict severity. After the 15 minutes of the discussion about the disagreement (conflict discussion), participants switched to the bonding discussion (i.e., discussing about a regular agreement). After the bonding discussion, we asked participants individually to complete a questionnaire using scales from 0 (*not at all*) to 10 (*totally*) to assess i) conflict severity (post-conflict measurement), ii) the satisfaction about the agreement (if they reached an agreement after the conflict discussion), and iii) the satisfaction about the content of the conflict discussion. Participants also indicated whether they succeeded in reaching an agreement during the conflict discussion (yes or no). We asked no questions related to the bonding discussion as the function of this discussion was to calm participants down after the conflict discussion.

Procedure

Participants interested in the study received an online link to the consent form via e-mail. Upon its completion, participants received an online link including a series of questionnaires to assess inclusion criteria (for details, see participant section above). Couples in which both members met all inclusion criteria, received a link to a second set of questionnaires to assess personality traits and relationship aspects. After the completion of these questionnaires, participants received sleep diaries and the sleep actigraphs to estimate the duration and quality of their sleep during the four consecutive nights preceding the experiment. Groups did not differ in terms of sleep duration and sleep quality before day 1 (more details are provided in the Supplementary Material). Before the experimental night, all participants were asked to arrive at 8.30 a.m. at the lab to complete the baseline measures (see Fig. 1). Experimenters first collected saliva samples. Next, participants completed the Positive Affect Negative Affect Schedule (Watson et al., 1988) and the Geneva Emotion Recognition Test (GERT-S; Schlegel & Scherer, 2016). Then, participants in the sleep deprivation condition left the laboratory. Participants in the control condition stayed for 3 hours of interaction with the experimenters to ensure that both groups were familiar with the experimenter. Participants in the control group were then asked to spend a normal night of sleep at home, under actigraphy control. Participants in the sleep deprivation condition came back to the lab at 10:30 p.m. to complete their sleep deprivation night under the continuous supervision of an experimenter (see Supplementary Material for further details on the sleep deprivation night procedure). The next morning, participants in the sleep deprivation and in the control conditions (after having spent a night of normal sleep at home) were invited for breakfast at 8.00 a.m. After breakfast, saliva samples were collected at 8.30 a.m., participants completed the Positive Affect Negative Affect Schedule (Watson et al., 1988) and Geneva Emotion Recognition Test (Schlegel & Scherer, 2016) again. Upon its completion, each couple was invited to sit in a soundproof room. Once both members of the couple were installed, a third saliva sample measure was collected. Before the conflict discussion started, participants were instructed to have a 5 minutes warm-up baseline discussion about the previous week. This discussion served to familiarize participants with the situation in the lab. Then, participants received instructions for the conflict discussion and the bonding discussion: they were asked to come up jointly with three topics for the conflict discussion and three topics for the bonding discussion, and to list them. In addition, for the three topics of disagreement couples evaluated together the degree of disagreement (conflict severity). Before starting the conflict discussion, saliva samples were collected for the fourth time. After 15 minutes, experimenters interrupted the discussion, entered in the room, and collected saliva samples again (fifth measure). They then asked couples to switch to the bonding discussion for 15 minutes. At the end of the allotted time, a sixth saliva sample was taken, and experimenters asked participants to fill in a self-report measure about the severity of the conflict, whether they found an agreement, the satisfaction about the agreement, and the satisfaction about the content of the conflict discussion. Couples also completed the Positive Affect Negative Affect Schedule (Watson et al., 1988) for the third time. At the end of the experiment, the aims of the study were revealed to the participants, they were paid for their participation, and the last saliva sample was collected.

Data Analysis

First, independent *t*-tests on demographical data, sleep-related questionnaires, personality and relationship questionnaires were conducted to test whether groups differ on any of these measures (details are summarized in Supplementary Tables 2 and 3). Independent *t*-tests indicated that groups only differed significantly on relationship satisfaction. More precisely, couples in the sleep deprivation condition reported lower levels of relationship satisfaction ($M = 4.52$, $SD = 0.32$), compared with couples in the control condition ($M = 4.86$, $SD = 0.22$). To ensure that the differences in relationship satisfaction did not impact the sleep-deprivation effect on the dependent variables, scores of relationship satisfaction were included as a covariate in each analysis. To test our hypotheses, data were analyzed using multilevel linear models (MLM), also known as random effects models or linear mixed models (Fitzmaurice, Laird, & Ware, 2011; Hoffman & Rovine, 2007). MLMs were chosen due to their ability to model multiple hierarchical levels of repeated data clustering (time points nested in subjects, and subjects themselves nested in dyads), as well as variables that vary continuously within repeated-measures. In addition, MLMs can handle missing data by not requiring that all repeated measures are fully observed at lower levels of the data hierarchy. Missing information in these levels is implicitly imputed using observed information pooled at higher levels, under a Missing at Random (MAR) assumption (Fitzmaurice et al., 2011). As such, missing time-level information does not lead to removal of an entire subject, and missing subject-level information does not lead to removal of an entire dyad. The latter was especially important for our covariate adjustment of relationship satisfaction, which was missing in 14 subjects but did not impact the available number of dyads for the final model.

Modelling with MLMs proceeded in two steps, (1) random effects selection and (2) fixed effects selection. During random effects selection, a model was fitted with fixed effects for the time × condition design, adjusted for relationship satisfaction. Conditional on these effects, two random effects structures were compared for goodness-of-fit, one containing only a random subject intercept, versus one containing a random subject and a random dyad intercept. The structure that minimized the Akaike Information Criterion (AIC) was chosen as the final random effects structure. Following this, we proceeded to the fixed effects selection step, which consisted of a conventional Type II ANOVA breakdown of the MLM model with *F*-tests, testing the two-way interaction first (i.e., time × condition), followed by main effects. Relationship satisfaction scores were included as a covariate in each ANOVA. Planned contrasts of group comparisons at specific time points were conducted using *t*-tests within the MLM. As a measure of effect size, we report partial marginal R^2 for *F*-tests, and standardized regression coefficients for *t*-tests.

All analyses were conducted with R version 3.5.1. with the packages “psych” (Revelle, n.d.), “parameters”(Lüdecke, Ben-Shachar, Patil, & Makowski, 2020), “effectsize”(Ben-Shachar, Lüdecke, & Makowski, 2020), “r2glmm”(Jaeger, 2017), “lme4” (Bates, Mächler, Bolker, & Walker, 2015) and “lmerTest”(Kuznetsova, Brockhoff, & Christensen, 2017) for multilevel modelling.

Results

Sleep deprivation increases cortisol levels during the conflict discussion

To test whether sleep-deprived couples were more stressed by the conflict discussion than couples with normal sleep, planned contrasts were conducted. The time (T1, T2, T3, T4, T5, T6, T7) × condition (control vs sleep deprivation) ANOVA showed no evidence for an interaction of time × condition, $F(6, 262.144) = 1.05$, $p = .40$, partial marginal $R^2 = .007$. As depicted in Fig. 2, a planned contrast did not reveal any group difference at baseline (T1 day 1), $t(57.27) = -0.57$, $p = .57$, $\beta_z = .18$, (95% CI [-0.44, 0.81]). Likewise, a planned contrast did not indicate any difference in salivary cortisol level between rested couples and sleep-deprived couples at T2, after the night of sleep deprivation, $t(57.27) = -0.99$, $p = .33$, $\beta_z = .32$, (95% CI [-0.31, 0.95]). Importantly and in line with our hypotheses, sleep-deprived couples experienced significantly higher cortisol levels during the conflict phase (T5) compared to couples who rested, $t(57.27) = -2.25$, $p = .028$, $\beta_z = 0.72$, (95% CI [0.09, 1.35]). Further details of the ANOVA can be found in the Supplementary Material.

Sleep deprivation decreases positive affect

We next analyzed whether couples experienced less positive affect as measured by the PANAS after a sleep deprivation night compared to couples who slept at home. A time (T1, T2, T3) × condition (control vs sleep deprivation) ANOVA breakdown of fixed effects and planned contrasts were calculated (details are in the Supplementary Material). As shown in Fig. 3, a planned contrast did not show that both groups differed on their self-reported positive affect on day 1 (i.e., prior to the sleep deprivation), $t(83.65) = 1.39$, $p = .17$, $\beta_z = -0.36$, (95% CI [-0.86, 0.15]). Subsequent planned contrasts revealed that sleep-deprived couples reported less positive affect than control couples prior to, $t(83.65) = 5$, $p < .001$, $\beta_z = -1.29$, (95% CI [-1.79, -0.78]), and after the conflict discussion, $t(83.65) = 3.85$, $p < .001$, $\beta_z = - .99$, (95% CI [-1.5,-0.49]). The same analyses were conducted on negative affect. Whereas these analyses confirmed that there were no differences between groups before the experimental manipulation, $t(88.51) = -0.79$, $p = .43$, $\beta_z = 0.26$, (95% CI [-0.38, 0.91]), groups did not differ in negative affect after the sleep deprivation (all $t_s(88.51) \leq .0.11$, all $p_s \geq .24$; details are in the Supplementary Material).

Sleep deprivation effect on conflict-related measures

The sample size for the subsequent analyses was reduced to 58 participants, due to missing data of one couple in the control condition. We tested whether sleep-deprived participants had more difficulties in finding an agreement during the conflict discussion compared to the participants who slept at home. To this end, a chi-square test was calculated. It accounted for no differences among conditions, $p = .63$. Indeed, among the 18 couples who reached an agreement at the end of the conflict discussion, 10 were in the sleep-deprivation condition while 8 were in the control condition. For those who did not find any agreement, 6 couples were in the control condition and 5 in the sleep-deprivation condition.

Regarding the satisfaction about the agreement and about the content of the conflict discussion, we used two conventional one-way ANOVAs with the factor condition (control vs sleep-deprivation). These analyses did not reveal any main effect of condition (both *p*s ≥ .21). Finally, a time (T1, T2) × condition (control vs sleep deprivation) ANOVA and planned contrasts were calculated to measure whether sleep-deprived participants and participants who slept at home differed in their post-conflict ratings related to the severity of the conflict. *T*-tests did not reveal any difference between sleep-deprived couples and rested couples on their ratings related to the severity of the conflict, at pre-conflict (baseline), $t(39.10) = 0.67$, $p = .50$, $\beta_z = -.19$, (95% CI [-0.74, 0.36]), and post-conflict, $t(38.62) = 1.60$, $p = .12$, $\beta_z = -.44$, (95% CI [-0.99, 0.01]).

Pearson correlations were calculated to test whether cortisol levels during the conflict (T5) were related to conflict-related measures in both conditions. We hypothesized that higher levels of cortisol were linked with higher conflict severity and lower levels of satisfaction about the content and agreement of the conflict discussion. Confirming our hypothesis, we found a significant negative correlation among sleep-deprived couples, $r = -.36$, $p = .047$, (95% CI [-0.64, -0.01]), but not for couples who slept at home, $r = -.03$, $p = .87$, (95% CI [-.40, .35]): higher cortisol levels during the conflict (T5) predicted lower satisfaction about the conflict's content in sleep-deprived participants. Figure 4 shows the significant correlation found among sleep-deprived couples. Neither the correlation between cortisol at T5 and satisfaction about the conflict's agreement, $r = -.22$, $p = .25$, (95% CI [-0.53, .16]), nor the correlation between post-conflict severity ratings and cortisol levels, $r = -.06$, $p = .75$, (95% CI [-0.31, .41]) were significant in sleep-deprived couples. None of these correlations among couples in the control condition was significant, all *p*s ≥ .45.

No sleep deprivation effect was found on emotion recognition

Finally, we tested whether sleep-deprived couples presented lower scores on emotion recognition (assessed by the GERT-S) after a sleepless night compared to couples who slept at home. MLMs indicated that the optimal random effects structure was the one including a random subject intercept and random dyad intercept. Consequently, a time (T1, T2) × condition (control vs sleep deprivation) ANOVA and a planned contrast testing whether groups differed on emotion recognition after the experimental night were performed. This latter did not show any difference between sleep-deprived participants and participants who slept at home, $t(28.56) = 0.70$, $p = .49$, $\beta_z = -.27$, (95% CI [-1.03, 0.49]).

Discussion

The current study aimed to test the causal impact of one night of sleep deprivation on interpersonal conflicts in romantic partners. The present findings show increased cortisol levels and less positive emotions related to a conflict discussion in sleep-deprived couples. Interestingly, increased cortisol levels in sleep-deprived couples predicted lower satisfaction with the content of a conflict discussion. Taken together, our findings provide first preliminary evidence for the deleterious impact of sleep loss on conflicts in romantic relationships.

Previous studies have reported both lower and higher levels of cortisol in general after sleep deprivation (Meerlo, Sgoifo, & Suchecki, 2008). The present results did not reveal any difference in cortisol levels between sleep-deprived couples and couples who slept at home after the experimental night. However and importantly, sleep-deprived couples showed higher cortisol levels during the conflict discussion than couples who slept at home. Moreover, the cortisol level during the conflict discussion in sleep-deprived couples predicted lower satisfaction with the content of the conflict discussion. This finding dovetails with the observation that elevated cortisol levels by an external stressor worsen social interactions by increasing antisocial behavior (Deza-Araujo et al., 2021), and research showing an association between a stressor (commuter stress) and subsequent aggression behaviors in another context such as the workplace (Hennessy, 2008).

With regard to self-reported emotions, sleep-deprived couples reported fewer positive emotions compared to couples who slept at home, providing further support to the growing body of research establishing a link between sleep loss and a reduction in positive affect (Finan et al., 2017; Zohar et al., 2005). In the present study, sleep-deprived participants also indicated less positive feelings after the conflict discussion compared to participants in the control condition. This is consistent with previous findings linking self-reported poor sleep with reduced positive emotions observed by coders in relationship conflicts (Gordon & Chen, 2014). Regarding negative feelings, previous evidence points to increased negative affect after one night of sleep deprivation (Yoo, Gujar, Hu, Jolesz, & Walker, 2007) or after accumulated disrupted sleep in medical residents (Zohar et al., 2005). Furthermore, previous correlational studies suggest that poor sleep was associated to less conflict resolution, reduced emotion recognition, and increased aggression (Gordon & Chen, 2014; Keller et al., 2019; van der Helm et al., 2010). The present study did not corroborate any of these findings. This might be due to i) the relatively small sample size in our study, ii) the relatively short conflict discussion, iii) the timing of data collection for conflict measures (i.e., after the bonding discussion), iv) the use of self-reports to assess negative feelings, and v) the overrepresentation of satisfied couples in our research, which is a common issue in the field (Wilson et al., 2017). Nevertheless, our paradigm demonstrated that sleep deprivation affects both objective (i.e., cortisol) and subjective measures of emotion (i.e., positive affect) and that the increase in cortisol decreases satisfaction with a conflict discussion. These alterations could be related to an overactivation of the amygdala and a decreased functional connectivity with the prefrontal cortex, a phenomenon already described after a total sleep deprivation (Yoo et al., 2007).

The present results are only a first step in providing causal evidence for the negative impact of sleep deprivation on couple conflict. Future studies with larger sample sizes are needed to replicate these results and to explore the role of cortisol as a biological mediator of situational stressors (including sleep deprivation) on conflict processes in more depth. Furthermore, studies on couple conflict could also adopt paradigms in which the conflict discussion is longer (e.g., 60 min.) and complement self-reports by including more biological measures, such as functional magnetic resonance imaging (Rafi, Bogacz, Sander, & Klimecki, 2020). In addition, there is also the need to explore psychological mechanisms underlying the adverse effects of sleep loss on social interactions. In line with this idea, scholars have started to explore many processes such as impaired empathic accuracy (Gordon & Chen, 2014),

attentional biases (Finan et al., 2017; Nota & Coles, 2018), reduced ability to regulate one's own emotion (Mauss, Troy, & LeBourgeois, 2013), or lower self-control (Keller et al., 2019). Even though we did not find any difference in emotion recognition abilities between sleep-deprived couples and couples who slept at home, more studies are needed to understand this issue in more depth. Additionally, further work should adopt strategies to recruit dissatisfied couples in order to measure the impact of sleep loss in unhappy couples. Indeed, it remains unanswered whether the negative impact of sleep loss on relationship conflict found here would be more severe in less satisfied couples. Given the present results and previous evidence linking poor sleep to difficulties in romantic relationships and marital quality (Gordon & Chen, 2014; Keller et al., 2019; Wilson et al., 2017;Troxel, Robles, Hall, & Buysse, 2007), it would be interesting to evaluate the clinical effectiveness of interventions aiming to restore restful sleep in couple therapy (Gunn & Eberhardt, 2019).

Whereas it was already demonstrated that sleep is important for emotion regulation (Mauss et al., 2013), our study shows that sleep is also affecting feelings, cortisol levels, and couple's relations. The current findings align with a recent review article establishing that an appropriate sleep (duration and quality) is crucial for having an adaptive social and emotional functioning (Ben Simon et al., 2020). In the future, more causal studies using randomized controlled trials should be carried out in order to replicate these results with larger samples. Additionally, our results may extend to other interpersonal interactions such as the ones happening at workplace. For instance, it remains unknown whether highlighting the importance of a good sleep hygiene prior to negotiation may favor successful conflict resolution. Encouraging evidence has been already reported in the context of an intervention aiming to reduce insomnia and showing its beneficial effects on work-related outcomes, such as showing concern and courtesy towards coworkers (Barnes, Miller, & Bostock, 2017). Consequently, there is an urge to bring together disciplines (sleep research, affective sciences, and social psychology) to account for the effects of sleep loss, delineate the role of sleep, and finally, to contribute to a better understanding of social and affective processes (Gordon, Mendes, & Prather, 2017).

Declarations

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Conflict of Interest

The authors declare that they have no conflict of interest.

Disclaimer

Sources of financial support had no influence over the design, analysis, interpretation, or choice of submission outlet for this research.

Data Availability

Data are publicly available at https://osf.io/dgrj3/?view_only=b50343d0f84246b1a91aad517b403a95.

Informed Consent

All participants provided informed consent prior to participation.

References

Anderson, C., & Dickinson, D. L. (2010). Bargaining and trust: the effects of 36-h total sleep deprivation on socially interactive decisions. *Journal of Sleep Research*, *19*(1-Part-I), 54–63. https://doi.org/10.1111/j.1365-2869.2009.00767.x

Barnes, C. M., Miller, J. A., & Bostock, S. (2017). Helping employees sleep well: Effects of cognitive behavioral therapy for insomnia on work outcomes. *Journal of Applied Psychology*, *102*(1), 104–113. https://doi.org/10.1037/apl0000154

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, *67*(1). https://doi.org/10.18637/jss.v067.i01

Ben-Shachar, M., Lüdecke, D., & Makowski, D. (2020). effectsize: Estimation of Effect Size Indices and Standardized Parameters. *Journal of Open Source Software*, *5*(56), 1–7. https://doi.org/10.21105/joss.02815

Ben Simon, E., Vallat, R., Barnes, C. M., & Walker, M. P. (2020). Sleep Loss and the Socio-Emotional Brain. *Trends in Cognitive Sciences*, *24*(6), 435–450. https://doi.org/10.1016/j.tics.2020.02.003

Bodenmann, G., & Kessler, M. (2011). Commitment in close relationships (Comsec). Unpublished Manuscript.

Bodtker, A. M., & Jameson, J. K. (2001). Emotion in conflict formation and its transformation: Application to organizational conflict management. *International Journal of Conflict Management*, *12*(3), 259–275. https://doi.org/10.1108/eb022858

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). Pittsburgh Sleep Quality Index (PSQI). *Psychiatry Research*, *28*(2), 193–213. https://doi.org/10.1007/978-1-4419-9893-4

Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology*, *44*(1), 113–126. https://doi.org/10.1037/0022-

3514.44.1.113

Deza-Araujo, Y. I., Rimmele, U., Gyger, L., Aguirre, C., Sander, D., & Klimecki, O. M. (2021). A social and physical stressor increases later punishment in healthy males.

Ditzen, B., Hoppmann, C., & Klumb, P. (2008). Positive couple interactions and daily cortisol: On the stress-protecting role of intimacy. *Psychosomatic Medicine*, *70*(8), 883–889. https://doi.org/10.1097/PSY.0b013e318185c4fc

Driver, J. L., & Gottman, J. M. (2004). Daily marital interactions and positive affect during marital conflict among newlywed couples. *Family Process*, *43*(3), 301–314. https://doi.org/10.1111/j.1545-5300.2004.00024.x

Finan, P. H., Quartana, P. J., Remeniuk, B., Garland, E. L., Rhudy, J. L., Hand, M., … Smith, M. T. (2017). Partial Sleep Deprivation Attenuates the Positive Affective System: Effects Across Multiple Measurement Modalities. *Sleep*, *40*(1). https://doi.org/10.1093/sleep/zsw017

Fitzmaurice, G. M., Laird, N. M., & Ware, J. H. (2011). *Applied Longitudinal Analysis*. *Wiley Series in probability and statistics*. Hoboken, NJ, USA: John Wiley & Sons, Inc. https://doi.org/10.1002/9781119513469

Friedlander, M. L., Lee, M., & Escudero, V. (2019). What we do and do not know about the nature and analysis of couple interaction. *Couple and Family Psychology: Research and Practice*, *8*(1), 24–44. https://doi.org/10.1037/cfp0000114

Gordon, A. M., & Chen, S. (2014). The Role of Sleep in Interpersonal Conflict: Do Sleepless Nights Mean Worse Fights? *Social Psychological and Personality Science*, *5*(2), 168–175. https://doi.org/10.1177/1948550613488952

Gordon, A. M., Mendes, W. B., & Prather, A. A. (2017). The Social Side of Sleep: Elucidating the Links Between Sleep and Social Processes. *Current Directions in Psychological Science*, *26*(5), 470–475. https://doi.org/10.1177/0963721417712269

Gordon, A. M., Mendes, W. B., & Prather, A. A. (2019). Sleep and Social Processes. In Z. Krizan (Ed.), *Sleep, Personality, and Social Behavior* (pp. 3–12). Springer. https://doi.org/10.1007/978-3-030-30628-1

Gottman, J. M., & Levenson, R. W. (1992). Marital processes predictive of later dissolution: Behavior, physiology, and health. *Journal of Personality and Social Psychology*, *63*(2), 221–233. https://doi.org/10.1037/0022-3514.63.2.221

Gottman, J. M., Markman, H., & Notarius, C. (1977). The Topography of Marital Conflict: A Sequential Analysis of Verbal and Nonverbal Behavior. *Journal of Marriage and the Family*, *39*(3), 461–477. https://doi.org/10.2307/350902

Gottman, J. M., & Notarius, C. I. (2002). Marital Research in the 20th Century and a Research Agenda for the 21st Century. *Family Process*, *41*(2), 159–197. https://doi.org/10.1111/j.1545-5300.2002.41203.x

Gunn, H. E., & Eberhardt, K. R. (2019). Sleep in the Context of Close Relationships. In Z. Krizan (Ed.), *Sleep, Personality, and Social Behavior* (pp. 135–152). Springer.

Hendrick, S. S. (1988). A generic measure of relationship satisfaction. *Marriage and the Family*, *50*(1), 93–98.

Hennessy, D. A. (2008). The Impact of Commuter Stress on Workplace Aggression. *Journal of Applied Social Psychology*, *38*(9), 2315–2335. https://doi.org/10.1111/j.1559-1816.2008.00393.x

Hoffman, L., & Rovine, M. J. (2007). Multilevel models for the experimental psychologist: Foundations and illustrative examples. *Behavior Research Methods*, *39*(1), 101–117. https://doi.org/10.3758/BF03192848

Horne, J. A., & Ostberg, O. (1976). A self assessment questionnaire to determine Morningness Eveningness in human circadian rhythms. *International Journal of Chronobiology*, *4*(2), 97–110.

Jaeger, B. C. (2017). *Package 'r2glmm.' R Found Stat Comput Vienna available CRAN R- project org= R2glmm*.

Johns, M. W. (1993). Daytime Sleepiness, Snoring, and Obstructive Sleep Apnea. *Chest*, *103*(1), 30–36. https://doi.org/10.1378/chest.103.1.30

Keller, P. S., Haak, E. A., DeWall, C. N., & Renzetti, C. (2019). Poor Sleep Is Associated With Greater Marital Aggression: The Role of Self Control. *Behavioral Sleep Medicine*, *17*(2), 174–180. https://doi.org/10.1080/15402002.2017.1312404

Kiecolt-Glaser, J. K. (2018). Marriage, divorce, and the immune system. *American Psychologist*, *73*(9), 1098–1108. https://doi.org/10.1037/amp0000388

Kiecolt-Glaser, J. K., & Newton, T. L. (2001). Marriage and health: His and hers. *Psychological Bulletin*, *127*(4), 472–503. https://doi.org/10.1037/0033-2909.127.4.472

Killgore, W. D. S., Balkin, T. J., & Wesensten, N. J. (2006). Impaired decision making following 49 h of sleep deprivation. *Journal of Sleep Research*, *15*(1), 7–13. https://doi.org/10.1111/j.1365-2869.2006.00487.x

Klimecki, O. M. (2019). The Role of Empathy and Compassion in Conflict Resolution. *Emotion Review*, *11*(4), 310–325.

Kuznetsova, A., Brockhoff, P. B., & Christensen, R. H. B. (2017). lmerTest Package: Tests in Linear Mixed Effects Models. *Journal of Statistical Software*, *82*(13). https://doi.org/10.18637/jss.v082.i13

Leproult, R., Copinschi, G., Buxton, O., & Van Cauter, E. (1997). Sleep Loss Results in an Elevation of Cortisol Levels the Next Evening. *Sleep*, *20*(10), 865–870. https://doi.org/10.1093/sleep/20.10.865

Levenson, R. W., & Gottman, J. M. (1983). Marital interaction: Physiological linkage and affective exchange. *Journal of Personality and Social Psychology*, *45*(3), 587–597. https://doi.org/10.1037/0022-3514.45.3.587

Levenson, R. W., & Gottman, J. M. (1985). Physiological and Affective Predictors of Change in Relationship Satisfaction. *Journal of Personality and Social Psychology*, *49*(1), 85–94. https://doi.org/10.1037/0022-3514.49.1.85

Liu, J. C. J., Verhulst, S., Massar, S. A. A., & Chee, M. W. L. (2015). Sleep Deprived and Sweating It Out : The Effects of Total Sleep Deprivation on Skin Conductance Reactivity to Psychosocial Stress. *Sleep*, *38*(1), 155–159. https://doi.org/10.5665/sleep.4346

Lüdecke, D., Ben-Shachar, M., Patil, I., & Makowski, D. (2020). Extracting, Computing and Exploring the Parameters of Statistical Models using R. *Journal of Open Source Software*, *5*(53), 1–5. https://doi.org/10.21105/joss.02445

Mauss, I. B., Troy, A. S., & LeBourgeois, M. K. (2013). Poorer sleep quality is associated with lower emotion-regulation ability in a laboratory paradigm. *Cognition and Emotion*, *27*(3), 567–576. https://doi.org/10.1080/02699931.2012.727783

Meerlo, P., Sgoifo, A., & Suchecki, D. (2008). Restricted and disrupted sleep: Effects on autonomic function, neuroendocrine stress systems and stress responsivity. *Sleep Medicine Reviews*, *12*(3), 197–210. https://doi.org/10.1016/j.smrv.2007.07.007

Miller, G. E., Dopp, J. M., Myers, H. F., Stevens, S. Y., & Fahey, J. L. (1999). Psychosocial predictors of natural killer cell mobilization during marital conflict. *Health Psychology*, *18*(3), 262–271. https://doi.org/10.1037/0278-6133.18.3.262

Minkel, J. D., Banks, S., Htaik, O., Moreta, M. C., Jones, C. W., McGlinchey, E. L., … Dinges, D. F. (2012). Sleep deprivation and stressors: Evidence for elevated negative affect in response to mild stressors when sleep deprived. *Emotion*, *12*(5), 1015–1020. https://doi.org/10.1037/a0026871

Nota, J. A., & Coles, M. E. (2018). Shorter sleep duration and longer sleep onset latency are related to difficulty disengaging attention from negative emotional images in individuals with elevated transdiagnostic repetitive negative thinking. *Journal of Behavior Therapy and Experimental Psychiatry*, *58*, 114–122. https://doi.org/10.1016/j.jbtep.2017.10.003

Paterson, J. L., Dorrian, J., Ferguson, S. A., Jay, S. M., Lamond, N., Murphy, P. J., … Dawson, D. (2011). Changes in structural aspects of mood during 39-66h of sleep loss using matched controls. *Applied Ergonomics*, *42*(2), 196–201. https://doi.org/10.1016/j.apergo.2010.06.014

Rafi, H., Bogacz, F., Sander, D., & Klimecki, O. (2020). Impact of couple conflict and mediation on how romantic partners are seen: An fMRI study. *Cortex*, *130*, 302–317. https://doi.org/10.1016/j.cortex.2020.04.036

Revelle, W. (n.d.). *An introduction to psychometric theory with applications in R*. Springer.

Robles, T. F., & Kiecolt-Glaser, J. K. (2003). The physiology of marriage: pathways to health. *Physiology & Behavior*, *79*(3), 409–416. https://doi.org/10.1016/S0031-9384(03)00160-4

Saramago, M., Lemétayer, F., & Gana, K. (2021). Adaptation et validation de la version française de l'échelle d'évaluation de la relation. *Psychologie Française*. https://doi.org/10.1016/j.psfr.2020.09.004

Schlegel, K., & Scherer, K. R. (2016). Introducing a short version of the Geneva Emotion Recognition Test (GERT-S): Psychometric properties and construct validation. *Behavior Research Methods*, *48*(4), 1383–1392. https://doi.org/10.3758/s13428-015-0646-4

Spielberger, C. D. (2010). State-Trait Anxiety Inventory. In *The Corsini Encyclopedia of Psychology*. Hoboken, NJ, USA: John Wiley & Sons, Inc. https://doi.org/10.1002/9780470479216.corpsy0943

Troxel, W. M., Robles, T. F., Hall, M., & Buysse, D. J. (2007). Marital quality and the marital bed: Examining the covariation between relationship quality and sleep. *Sleep Medicine Reviews*, *11*(5), 389–404. https://doi.org/10.1016/j.smrv.2007.05.002

van der Helm, E., Gujar, N., & Walker, M. P. (2010). Sleep Deprivation Impairs the Accurate Recognition of Human Emotions. *Sleep*, *33*(3), 335–342. https://doi.org/10.1093/sleep/33.3.335

Van Kleef, G. A. (2009). How emotions regulate social life: The emotions as social information (EASI) model. *Current Directions in Psychological Science*, *18*(3), 184–188. https://doi.org/10.1111/j.1467-8721.2009.01633.x

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070. https://doi.org/10.1037/0022-3514.54.6.1063

Wilson, S. J., Jaremka, L. M., Fagundes, C. P., Andridge, R., Peng, J., Malarkey, W. B., … Kiecolt-Glaser, J. K. (2017). Shortened sleep fuels inflammatory responses to marital conflict: Emotion regulation matters. *Psychoneuroendocrinology*, *79*, 74–83. https://doi.org/10.1016/j.psyneuen.2017.02.015

Yoo, S.-S., Gujar, N., Hu, P., Jolesz, F. A., & Walker, M. P. (2007). The human emotional brain without sleep — a prefrontal amygdala disconnect. *Current Biology*, *17*(20), R877–R878. https://doi.org/10.1016/j.cub.2007.08.007

Zohar, D., Tzischinsky, O., Epstein, R., & Lavie, P. (2005). The Effects of Sleep Loss on Medical Residents' Emotional Reactions to Work Events: a Cognitive-Energy Model. *Sleep*, *28*(1), 47–54.

https://doi.org/10.1093/sleep/28.1.47

Figures

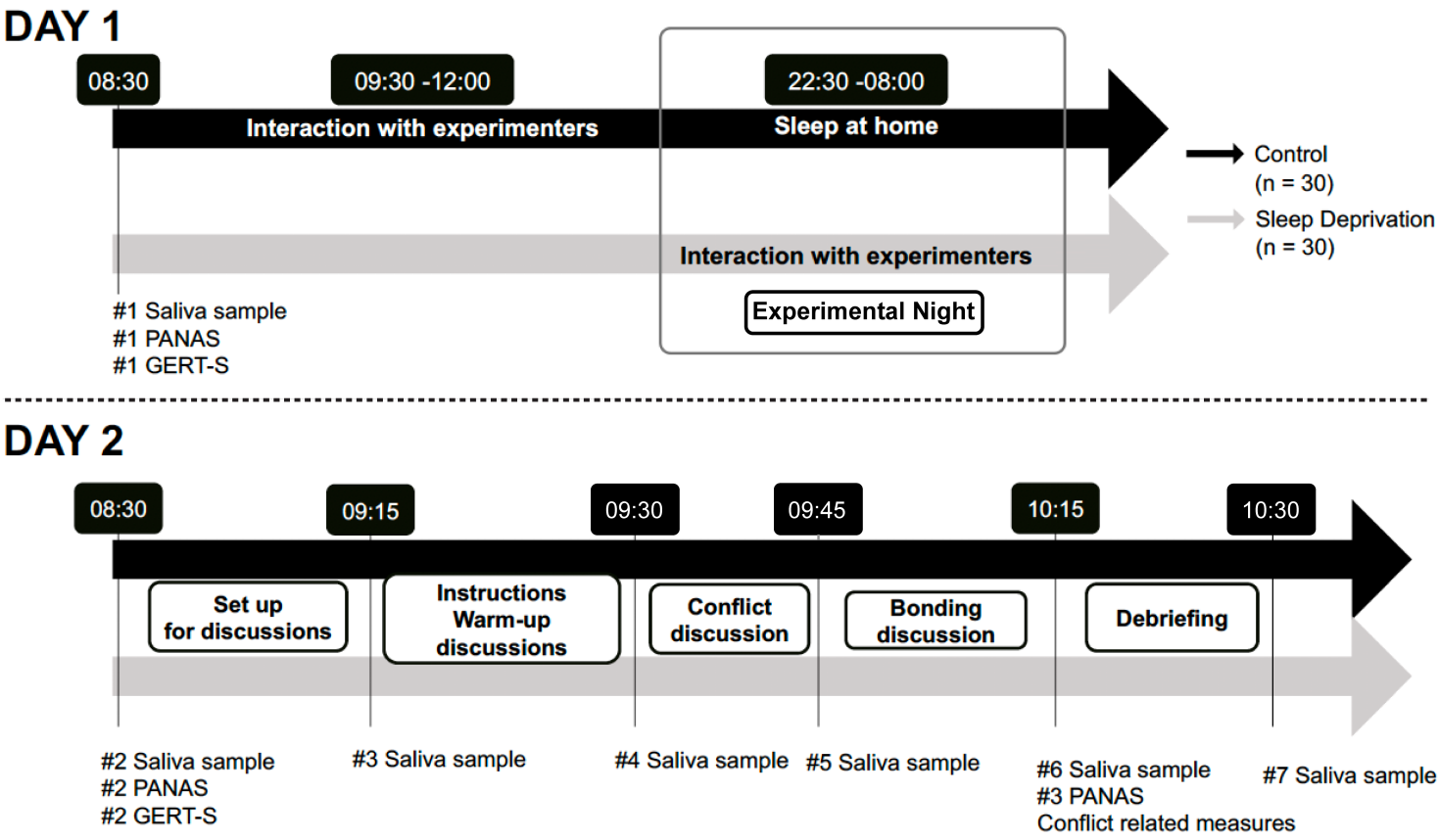

Figure 1

Study procedure for participants in both conditions (Sleep Deprivation, Control Condition). PANAS = Positive Affect Negative Affect Schedule; GERT-S = Geneva Emotion Recognition Test

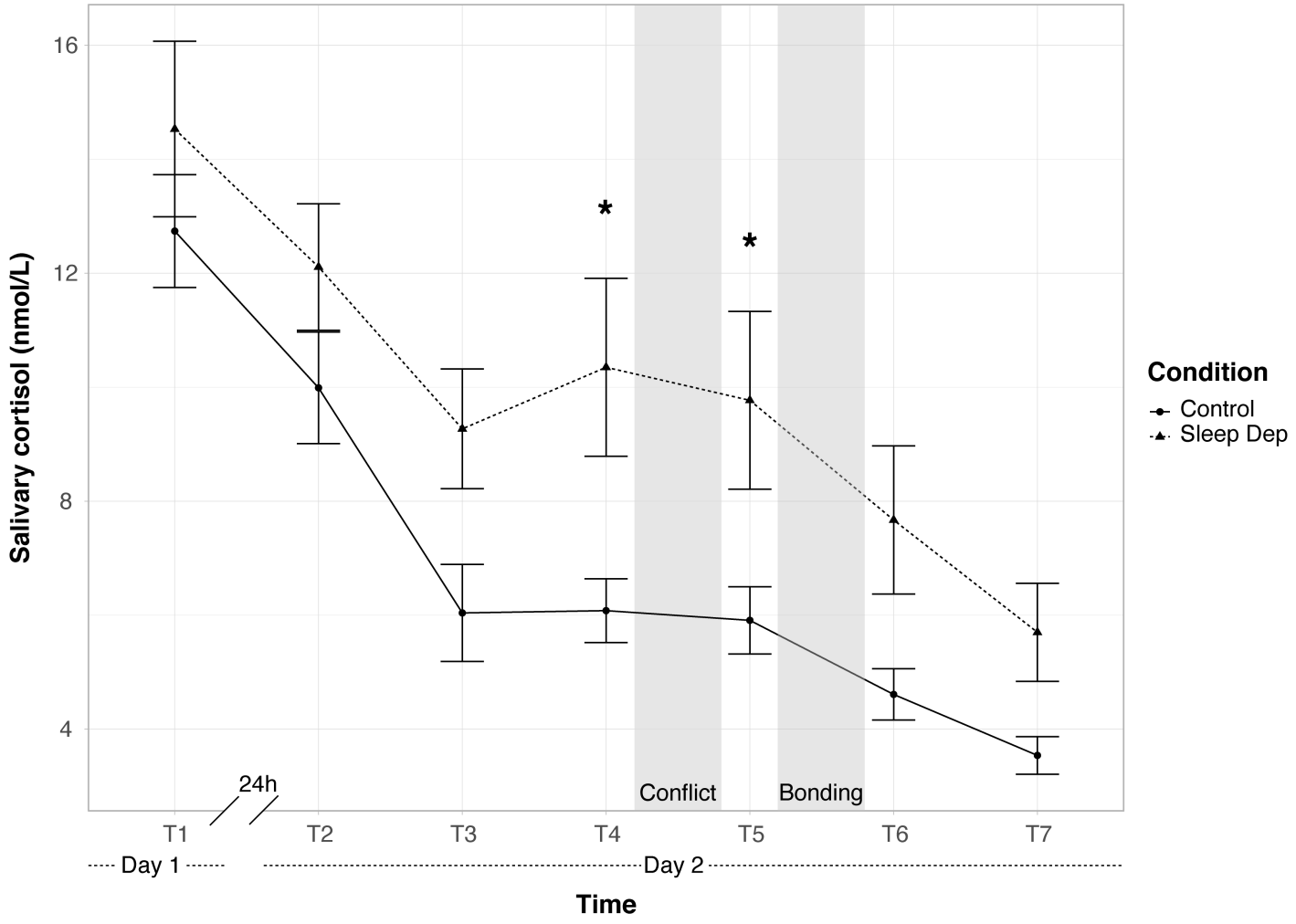

Figure 2

Mean of cortisol levels (nmol/l) as a function of condition (Sleep Deprivation, and Control Condition). *p < .05. Bars represent ± 1 standard errors of the mean. Sleep Dep. = Sleep Deprivation

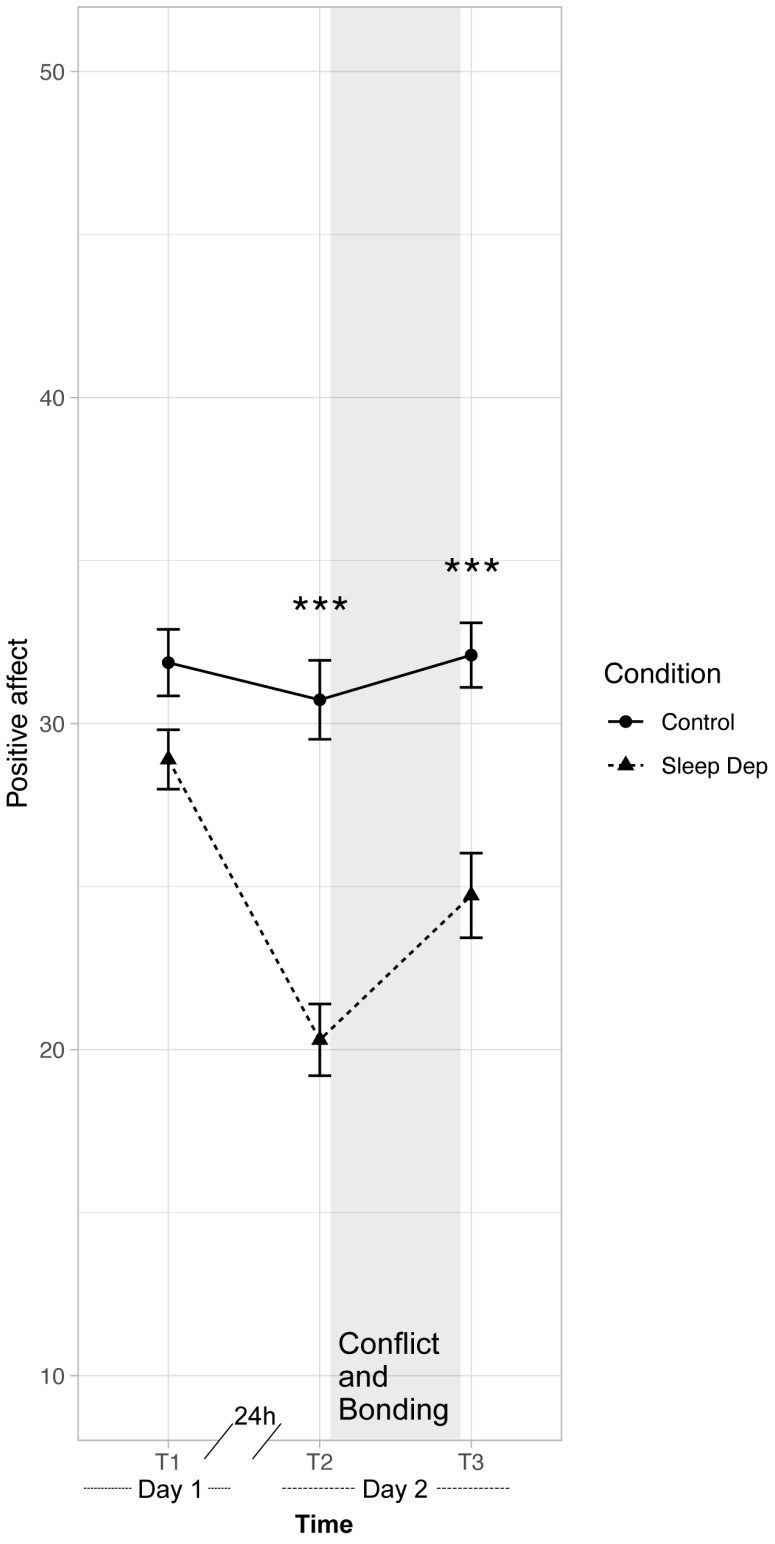

Figure 3

Mean of positive affect levels (assessed by the Positive Affect Negative Affect Schedule) as a function of condition (Sleep Deprivation, and Control Condition). ***p < .001. Bars represent ± 1 standard errors of the mean. Sleep Dep. = Sleep Deprivation

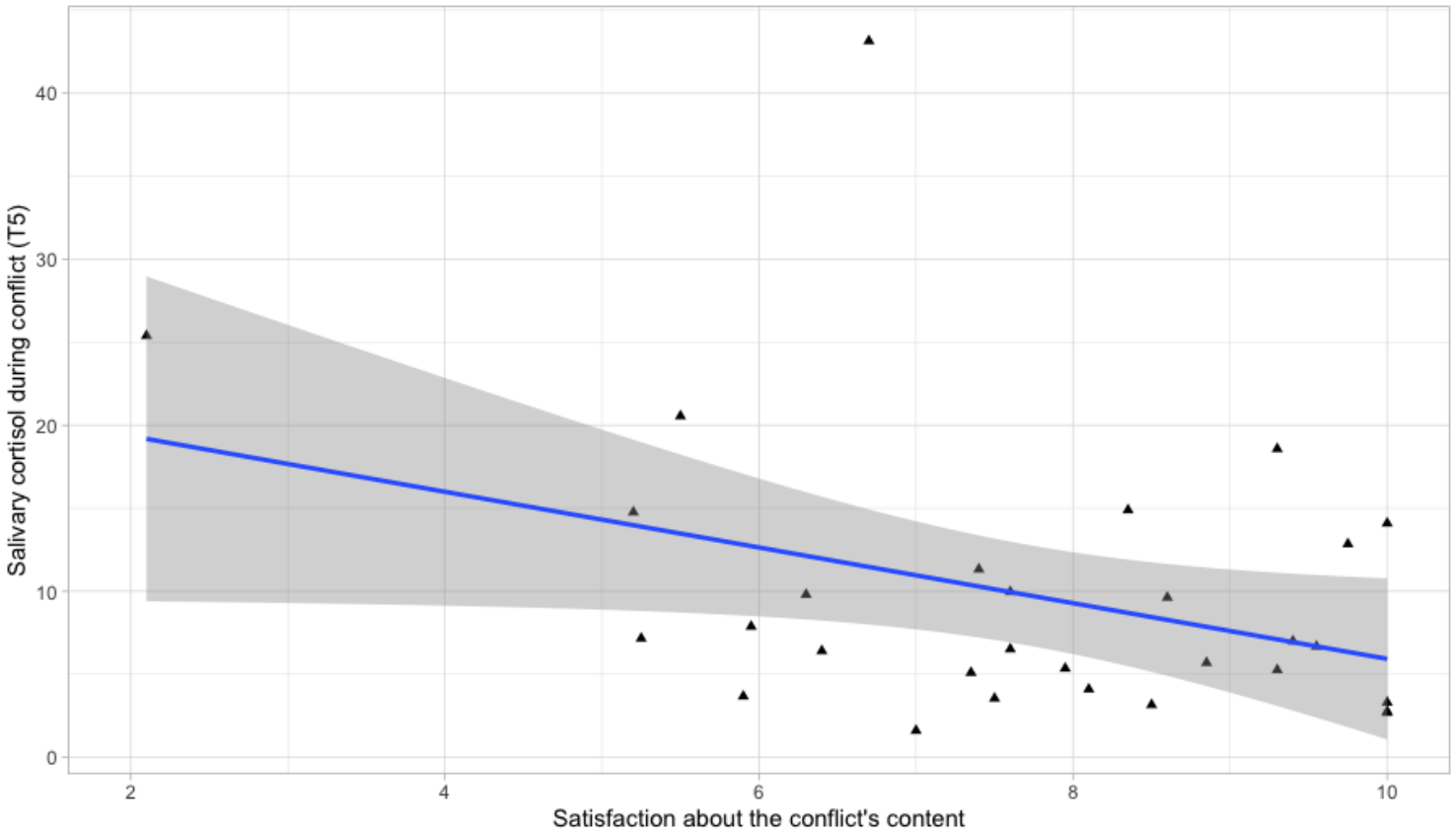

Figure 4

Higher cortisol levels in the sleep deprivation condition predict lower satisfaction about conflict's content. Scatter plot depicts the relationship between cortisol levels and self-reported satisfaction about the content of the conflict discussion. When removing the outlier (i.e., with a cortisol level of 43.15 nmol/l), the correlation between cortisol levels during the conflict discussion and satisfaction about conflict's content remained significant, r = - .43, p = .02, (95% CI [-0.69, -0.08]).

Supplementary Files

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- ESM1.pdf