scientific reports

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Trait and state predictors of the intensity of emotions experienced in everyday dreams: a multilevel approach

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In the dream literature, the emotional continuity hypothesis postulates that emotions in dreams are a reflection of emotions experienced in waking life. However, while between-subject bivariate correlations have been extensively investigated, the trait factors across individuals as well as the state factors within individuals that account for night-to-night variation in dream affect have been understudied. In the present study, a multilevel analysis was applied to investigate the association of waking trait- and state-variables with night-to-night variation in dream emotions (*N* = 130 participants; mean age = 20.57 ± 3.09). Daily sleep quality significantly predicted positive emotions in dreams. In addition, within-subject variation in daily stress and sleep quality, as well as the trait sensory processing sensitivity, significantly predicted negative emotions in dreams. Together, our results highlight the involvement of both trait and state factors in dream emotions, but also bring into focus the differential association of these factors depending on the emotional valence experienced in dreams.

Keywords Dreaming, Emotion, Sleep quality, Trait and state variables, Sensory processing sensitivity, Multilevel models

Sleep plays a central role in the reprocessing of everyday life emotional events[1–3]. Dream experiences, which are mental representations that occur during sleep and are reported upon awakening[4], often involve emotions[5,6], raising questions about the interplay between emotions in waking and dream life, and, by extension, of the continuity hypothesis of dreaming, which stipulates that dream content reflects the dreamer's current thoughts and concerns[7]. In addition, like emotions perceived in waking life, emotions experienced in dreams can vary greatly between individuals, but also within individuals across time[8]. To better understand the determinants of emotions in dreams, it is therefore crucial to consider both trait and state factors that can predict, on a day-to-day basis, the emotional tone in dreams.

The literature is rich in studies focusing on person-to-person variation factors that correlate with emotional tone in dreams, especially in relation to traits or personality factors. In clinical populations, in comparison with healthy controls, negative emotions in dreams have been related to anxiety or borderline personality disorders[9–11]. Similarly, in healthy populations, individuals with higher trait anxiety exhibit more negatively toned emotions in dreams[12,13], while individuals with more peace of mind (i.e., a measurement of well-being) express more positively toned emotions in dreams[13]. These results are in line with the emotional continuity hypothesis, which suggests that emotions perceived in waking life can carry over into subsequent dreams. In accordance with this hypothesis, Gilchrist et al.[14] reported that the intensity of discrete emotions (e.g., "joy") felt in waking life was related to their intensity experienced in dreams. Similarly, Schredl and Reinhard[15] reported that daytime mood and overall emotional valence of daytime events were related to the emotional tone experienced in subsequent dreams, i.e., the more positive were the daytime moods, the more positive were the dreams. However, while these latter studies applied a longitudinal approach and collected daily and dream emotions each evening and morning for a given period of time (over a 2 or 3-weeks period), their analyses did not allow distinguishing between-subject from within-subject associations. Another set of studies have highlighted the influence of sleep quality

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on the emotional tone experienced in dreams, especially by focusing on sleep disorders[16]. In comparison with participants without sleep disorders, patients with insomnia exhibit less positive emotions and more negative emotions in their dreams[17,18], and patients with narcolepsy exhibit intensified (negative and positive) emotions in dreams[19]. In addition, Conte et al.[20] reported an association between sleep quality and the ratio of positive/negative emotions in both wakefulness and in dreams. In this study, poor sleepers exhibited evenly distributed emotional tones across wakefulness and dreaming, while good sleepers, surprisingly, displayed more negative emotions in dreams[20]. Together, these results bring into focus sleep quality as an important factor related to dream emotions.

The within-person (day-to-day) variation factors that correlate with emotional tone in dreams have been, in comparison, understudied. Focusing on nightmares, Blagrove and Fisher[21] reported a relationship between the incidence (or absence) of nightmares and the daily variation in state anxiety or state depression, but only in participants with certain trait predisposition (i.e., thin boundariness). More recently, Samson-Daoust et al.[22] used a prospective, multilevel design to investigate simultaneously the influence of both trait and state factors on dream emotions. Healthy participants were asked to complete questionnaires about personality, trait anxiety, and past traumatic experience, and also to complete a series of daily questionnaires (morning and evening) during three consecutive weeks, to measure dream content, dream affect, and perceived daily stress (including bedtime stress). When all the trait and state variables were entered in the model, trait anxiety was the only variable to predict subsequent dream valence[22]. Importantly, daily measures of perceived stress did not predict subsequent affective tone of dreams[22], which runs counter to the prediction of the emotional continuity hypothesis and highlights the different influence of trait anxiety and state stress factors in dream emotions across time. However, this study did not use an established and validated measure of perceived (daily) stress, and did not consider day-to-day variations in (positive and negative) emotional intensity experienced in waking life as a potential predictor of the emotions experienced in dreams. In addition, sleep quality, known to be associated with the emotional tone experienced in dreams (see above) was not considered in this study.

In the last few years, there has been a growing interest in Sensory Processing Sensitivity (SPS) in relation to dreaming[23–25]. SPS is a temperament trait that refers to ease of overstimulation, aesthetic awareness, and depth of processing, and shows conceptual overlaps with neuroticism, openness to experience, and thin boundariness, the latter three variables having associations, albeit inconsistent, with dream and nightmare variables[26]. Carr et al.[27] have shown that neuroticism and openness to experience are related to nightmare frequency, while SPS explained additional, independent variance, possibly reflecting its neurobiological basis. Carr et al.[27] also noted that SPS includes Aesthetic Sensitivity, which may be related to dream recall, and that SPS can augment reactions to positive and negative environments, whereas neuroticism is a diathesis for negative environments. Consistent with this view, Carr and Nielsen[23] suggested that high SPS may be a common personality trait in nightmare-prone individuals, and that high SPS may predispose certain individuals to negative dreaming experiences. Supporting this theory, Carr et al.[24] tested nightmare frequency and nightmare distress in individuals with high, medium, and low SPS, and how these relate to measures of mental wellbeing. The authors reported that nightmare frequency and nightmare distress were higher in the high and medium SPS groups compared with the low group. Also, lower mental wellbeing correlated with increased nightmare frequency within the high and medium groups, but not within the low group, and with increased nightmare distress only for high SPS individuals[24]. These findings demonstrate that although nightmares are more frequent for high and medium sensitive persons with lower mental wellbeing, nightmare distress is only associated with lower mental wellbeing for high SPS individuals. Together, these results highlight the importance of further exploring the susceptibility role of SPS in the relation between waking and dream emotions, and especially in healthy individuals and everyday dreams so as to extend this work beyond nightmares.

Finally, the assessment of dream emotions raises important methodological questions. Schredl and Doll[6] showed that negative emotions outweighed positive ones only when dream emotions were rated by external judges, whereas dreamer self-ratings yielded a more balanced ratio, suggesting an underestimation of positive emotions by external ratings. In addition, using external judges, Sikka et al.[28] showed that home dream reports were more emotional than laboratory early REM dream reports, and also contained a higher density of emotions than laboratory (early or late REM) dream reports. Together, these findings support the use of home-collected dreams and dreamer self-ratings.

In this exploratory study, we aimed to further explore the associations between both waking-life trait and state variables and self-reported dream emotions using multilevel analyses so as to simultaneously consider between- and within-subject levels of variance. Waking emotions were assessed through trait anxiety but also through daily stress and day-to-day variations in (positive and negative) emotional intensity. Similarly, sleep quality was assessed both over the past month but also through its day-to-day variation. In addition, trait sensory processing sensitivity was considered as an interacting personality trait, predicting negative and positive dream emotions.

Methods

Participants

Participants were recruited in Chambéry and Swansea University through postings to campus bulletin boards, word of mouth and web postings. This study was approved by the local ethics committees at University Savoie Mont Blanc (CER-2021-11; March 11th, 2021) and at Swansea University (2021-5210-4292; June 9th, 2021), and was conducted in accordance with the requirements of the Declaration of Helsinki. All potential candidates were required to complete a screening questionnaire to assess their eligibility. In the questionnaire, age (i.e., 18–40 yo), native language (i.e., French or English for the Chambéry and Swansea cohorts, respectively), dream recall frequency (i.e., 4–7 times/week in response to the question "*Usually, how often are you able to remember a dream in detail after waking up?*") and average nighttime sleep duration (i.e., at least 7 h/night) were used as inclusion criteria. Diagnosis of a psychiatric, neurological or sleep disorder, the occurrence of any medical complaint(s)

that affect sleep or mood, excessive alcohol intake (defined as intake greater than 5 units of alcohol per day, or greater than 15 units per week), excessive cigarettes consumption (defined as more than 7 cigarettes per day) and the use of recreational drugs were used as exclusion criteria.

Candidates meeting the criteria were contacted for further information. A description of the protocol was given and all questions were answered before participants signed the Informed Consent form.

Data collection took place from March 19th, 2021 to May 05th, 2022 in Chambéry, and from June 10th, 2021 to September 23rd, 2022 in Swansea. In total, $N = 142$ participants participated in the study but 12 participants were excluded from the analysis because they provided fewer than 5 dreams (see "Data preprocessing" section). The final sample was therefore composed of $N = 130$ participants (Mean ± SD, Age = 20.57 ± 3.09, min = 18, max = 36 ; 119 females, 11 males ; 84 recruited in Chambery and 46 in Swansea), which is consistent with previous studies using similar analytical approaches[22].

Procedure

The time-course of the experiment is presented in Fig. 1A. During the first phase of the experiment (i.e., retrospective measures), the participants completed the Pittsburgh Sleep Quality Index questionnaire (PSQI)[29], the trait scale of the State-Trait Anxiety Inventory - Form Y (STAI-T)[30] and the HSPS scale measuring Sensory Processing Sensitivity (SPS)[31].

During the second phase of the experiment (i.e., prospective measures), the participants were asked to complete, for 21 consecutive days, questionnaires every night before going to bed and every morning just after waking up. At the end of the day, the questionnaire assessed the intensity of emotions experienced during the day as well as daily stress level using the 10-item Perceived Stress Scale[32]. At the end of the night, the questionnaire assessed the intensity of emotions experienced in the dreams as well as the nightly sleep quality using the Karolinska sleep diary[33–35]. The retrospective and prospective measures are presented in detail below, and the questionnaires used in the present study are available for free for research purposes. In addition, when participants completed one or more days of data collection beyond the 21 consecutive days required (e.g., to catch up for a missing day), the data were included.

Retrospective measures

Overall sleep quality

The overall sleep quality of the participants was assessed using the Pittsburgh Sleep Quality Index questionnaire (PSQI)[29] and in its French version[36]. It contains 19 self-rated questions assessing different components of sleep (e.g., sleep quality, sleep latency) over the past month, and exhibits a good internal consistency[37]. The final score ranges from 0 (indicating no difficulty) to 21 (indicating severe difficulties in sleep). In the present study, using the seven components scores, the internal consistency (Cronbach's alpha) was 0.58.

Trait anxiety

The trait scale of the State-Trait Anxiety Inventory - Form Y (STAI-T, French adaptation by Bruchon-Schweitzer and Paulhan)[30] was used to measure anxiety as an enduring personality trait. It consists of 20 statements that assess how participants "*generally feel*". Each item is rated on a 4-point Likert scale [almost never(1), sometimes(2), often(3), almost always(4)]. Eleven items are identified as anxiety-present (e.g., "*I feel nervous and restless*") and nine items as anxiety-absent (e.g., "*I feel pleasant*"). The final STAI-T score is computed by adding up the score of each item (after having reversed the anxiety-absent items scores), and vary from a minimum of 20 (lower level of anxiety) to a maximum of 80 (higher level of anxiety). Previous studies using the French version of the questionnaire exhibit very good internal consistency[38]. In the present study, the internal consistency (Cronbach's alpha) was 0.92.

Sensory processing sensitivity

The Highly Sensitive Person Scale (HSPS) was used to measure Sensory Processing Sensitivity (SPS)[31]. The French version was translated and verified by three researchers (JV, MP and JBE). This has 27 items, responded to on a 7-point Likert scale [Not at all(1) - Extremely(7)]. Items include "*Do you seem to be aware of subtleties in your environment?*" or "*Are you deeply moved by the arts or music?*". The questionnaire shows a very good internal reliability[39], and the final score is computed by averaging the score of all the items, and varies from a minimum of 1 (little sensitive) to a maximum of 7 (highly sensitive). In the present study, the internal consistency (Cronbach's alpha) was 0.88 and 0.92, for the French and English versions, respectively.

Prospective measures

Positive and negative affect in daily life

Two questions were used to assess positive and negative emotions experienced during the day. For each question, examples of emotions were provided as used in the Positive and Negative Affect Schedule (PANAS)[40], and each question was rated on a 5-point Likert scale [very slightly or not at all(1), a little(2), moderately(3), quite a bit(4), extremely(5)]. The two questions were formulated as "To what extent did you experience positive emotions in your day such as feeling enthusiastic, excited, inspired, interested or proud?" and its counterpart for negative emotions (and using as examples feeling afraid, ashamed, guilty, nervous or scared).

Daily stress level (PSS)

Daily stress levels were assessed using the 10-item Perceived Stress Scale[32,41], including statements such as "*Today, how often have you been upset because of something that happened unexpectedly?*" or "*Today, how often have you felt confident about your ability to handle your personal problems?*". Each item is scored on a 5-point Likert scale [never(0), Almost never(1), sometimes(2), fairly often(3), very often(4)]. After having reversed

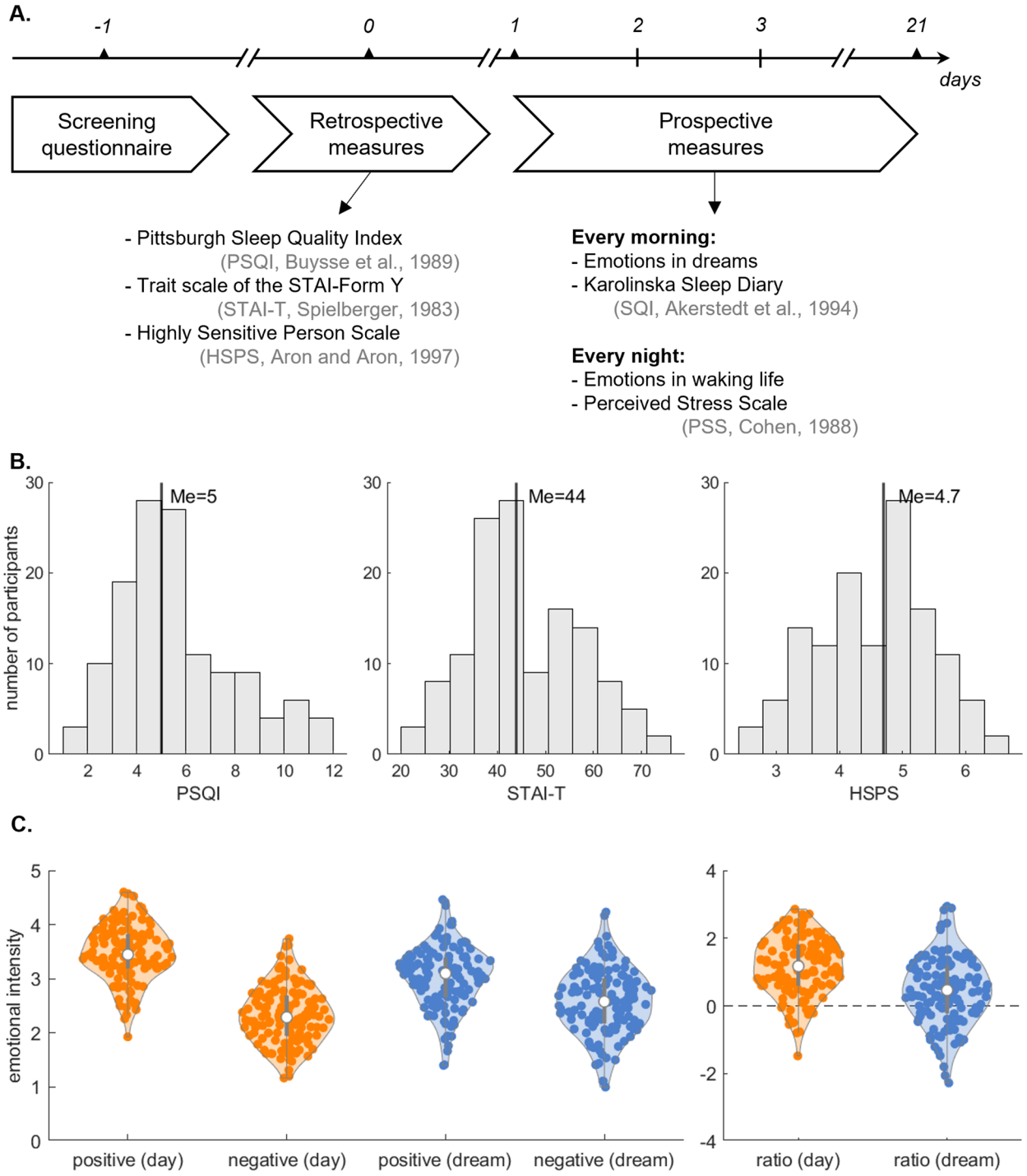

Fig. 1. (**A**) Schematic of the experiment. (**B**) Emotional intensity scores for positive and negative emotion during the day and in the dreams, respectively. Note that for each participant, the averaged score was computed across occurrences. A repeated measures ANOVA showed a main effect of time ($F(1, 129) = 15.64$, $p < 0.001$), a main effect of the emotional valence ($F(1, 129) = 127.73$, $p < 0.001$) and an interaction effect ($F(1, 129) = 67.96$, $p < 0.001$). Post-hoc comparisons showed that each individual condition was different from each other (all p-values < 0.001 after bonferroni correction). (**C**) Distribution of PSQI, STAI-T and HSPS scores as well as their median (Me). PSQI: Pittsburgh Sleep Quality Index. STAI-T: trait scale of the State-Trait Anxiety Inventory - Form Y. HSPS: Highly Sensitive Person Scale.

scores for the positive statements (0 = 4, 1 = 3 and so on), the final score is computed by adding up the scores on each item, leading to a score ranging from 0 (lower level of stress) to 40 (higher level of stress).

Positive and negative affect in dreams
Dream recall was assessed by asking the participants "*Did you dream last night?*" with a "*Yes-No*" answer format. A "*No*" answer closed the dream questionnaire while a "*Yes*" answer was followed by the two questions assessing positive and negative emotions in dreams. The questions were created to closely resemble the ones used for assessing emotions in waking life: the same examples of emotions were provided, and each item was rated on a 5-point Likert scale [very slightly or not at all(1), a little(2), moderately(3), quite a bit(4), extremely(5)]. The two items were formulated as "*To what extent did you experience positive emotions in your dreams such as feeling enthusiastic*, *excited*, *inspired*, *interested or proud?*" and its counterpart for negative emotions (and using as examples feeling afraid, ashamed, guilty, nervous or scared).

Nightly sleep quality

The Karolinska sleep diary[33–35] was completed every morning, and included the following items: Bedtime (h), Time of awakening (h), Sleep quality [very well(5) - very poorly(1)], Calm sleep [very calm(5) - very restless(1)], Slept throughout the time allotted [yes(5) - woke up much too early(1)], Ease of falling asleep [very easy(5)-very difficult(1)]. The French version was translated and verified by three researchers (JV, MP and JBE).

The item scores were summed to compute a sleep quality index (SQI). As the 4 items used a 5-point Likert scale ranging from (1) to (5), final SQI score ranges from 4 (indicating worst quality) to 20 (best quality). This index has been shown to be correlated with objective measures of sleep quality (i.e., sleep efficiency) as quantified using polysomnography[33,34,42].

Missing data

On the PSQI, one component's score (over the seven components) was missing for 3 participants. For these participants, the final PSQI score was computed by adding the score of the remaining six components (n/18) and by reporting the value on 21 (m=(n*21)/18). On the STAI-T and HSPS questionnaires, when one or several item-scores were missing the mean of the remaining scores was computed and used to replace the missing data (in 1 and 2 participants for STAI-T and HSPS, respectively).

Data preprocessing

The prospective day (i.e., affect in daily life and PSS) and night (i.e., affect in dreams and nightly sleep quality) questionnaires were pre-processed as described below. Incomplete questionnaires were excluded, as were questionnaires that were not completed within a specified time window. This time window was spread out over a time range of 14 h, between 6pm and 8am for the questionnaire assessing the day's variables (i.e., at the end of the day), and between 3am and 5pm for the questionnaire assessing the night/dream variables (i.e., at the end of the night). While permissive, this temporal constraint allowed the exclusion of abnormal/unexpected entries (e.g., completing a questionnaire about the day at midday). In addition, when a questionnaire was completed more than once for a given day/night, only the last responses were kept for that day/night. Finally, participants with less than 5 dream occurrences during the study were excluded.

Statistical analysis

Because of the nature of the data, including repeated longitudinal data nested within participants, multilevel model (MLM) analysis, also known as hierarchical linear modeling (HLM), was applied. To fit the models, we used the R programming language (v. 4.2.2; R Core Team, 2024)[43] with the following packages: *lmerTest* (v. 3.1.3), based on *lme4* (v. 1.1.36) to compute multilevel modeling[44,45], *car* (v. 3.1.2) to compute VIF values[46], r2glmm (v. 0.1.3) to compute marginal R^2 values[47], performance (v. 0.15.3) to compute intraclass correlation coefficients[48] and *dplyr* (v. 1.1.4) for data manipulation[49].

There were two models to individually test the outcome variables of positive and negative dream emotions. To test these models, the dataset contained the outcome variables of negative dream emotions and positive dream emotions, which were predicted by the within-subject variables (Level 1 predictors) of SQI, PSS, and daily affect (i.e., positive and negative day emotions). Thus, day questionnaires and subsequent night questionnaires were matched (day-night match). For example, the "day" questionnaire completed at night on the first day of the experiment (i.e., day01) was matched with the "night" questionnaire completed the following morning (i.e., day02). The dataset also contained between-subjects variables (Level 2 predictors) of HSPS, PSQI, STAI, gender, and age. Gender (dummy coded, 0 = Male, 1 = Female) and age were included as control variables.

Level 1 predictors were cluster-mean centred (centred to each participant's mean value), and Level 2 predictors were grand-mean centred. We evaluated key assumptions of the multilevel model. Level-1 and level-2 residuals were inspected for normality and correlation with same and other level predictors. All correlations were close to zero, suggesting no dependency between our residuals and predictors. Additionally, correlations between level-1 and level-2 residuals were negligible, indicating no systematic relationship across levels. Multicollinearity (VIF) was checked and no VIF value exceeded 3.0, suggesting no issues with multicollinearity (all VIF values < 2.0 except for PSS with VIF = 2.017 and 2.018 for positive and negative emotions, respectively).

Results

Descriptive statistics

Table 1 and Fig. 1B and C summarize the retrospective and prospective measures and intercorrelations among the measures are presented in Table S1 and Figs. S1 and S2.

	Mean	SD	Min	Max
PSQI	5.16	2.41	1	12
STAI-T	45.72	11.30	23	76
HSPS	4.55	0.90	2.56	6.59
Averaged positive emotion during the day	3.47	0.52	1.93	4.60
Averaged negative emotion during the day	2.33	0.52	1.17	3.74
Averaged PSS	14.45	5.27	1.80	27.95
Averaged number of dreams	15.52	3.82	5	24
Averaged positive emotion in dreams	3.03	0.57	1.40	4.46
Averaged negative emotion in dreams	2.57	0.61	1.00	4.23
Averaged SQI	15.24	2.35	6.08	19.62

Table 1. Descriptive statistics for retrospective and prospective variables. $N = 130$. Please note that for the prospective (longitudinal) scores, the averaged score across occurrences was computed for each participant. PSQI: Pittsburgh Sleep Quality Index. STAI-T: trait scale of the State-Trait Anxiety Inventory - Form Y. HSPS: Highly Sensitive Person Scale. PSS: Perceived Stress Scale. SQI: Sleep Quality Index.

	Beta	SE	*p*-value	Lower	Upper
Intercept	3.470	0.352	***< 0.001	2.777	4.166
Within-subject predictors (Level-1)					
Positive day emotions	0.040	0.029	0.167	− 0.017	0.096
Negative day emotions	− 0.050	0.030	0.092	− 0.108	0.008
Daily stress (PSS)	− 0.004	0.005	0.399	− 0.014	0.006
Daily sleep quality (SQI)	**0.085**	**0.007**	***< **0.001**	**0.071**	**0.099**
Between-subject predictors (Level-2)					
PSQI	− 0.043	0.023	0.063	− 0.089	0.002
STAI-T	− 0.004	0.006	0.476	− 0.015	0.007
HSPS	− 0.030	0.064	0.641	− 0.155	0.096
Control variables (Level-2)					
Gender	0.007	0.198	0.972	− 0.385	0.397
Age	− 0.022	0.017	0.201	− 0.057	0.012

Table 2. Multilevel model predicting positive emotions in dreams. Lower and Upper correspond to the 95% confidence interval (CI). $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$. Number of observations = 1818. Please note that higher scores in PSQI mean more sleep difficulties.

Retrospective measures: internal consistency and inter-correlations

The correlations between the retrospective measures were in the expected direction. PSQI was positively correlated with both STAI-T and HSPS, while HSPS was positively correlated with STAI-T (see Table S1 and Fig. S1).

Multilevel models predicting dream emotions as outcome

We first estimated unconditional (null) models for each outcome variable and calculated the Intraclass Correlation Coefficient (ICC). The ICCs were 0.20 for positive dream emotions and 0.17 for negative dream emotions, indicating that 20% and 17% of the variance, respectively, were attributable to between-person differences.

On average, the positive affect experienced in dreams was scored at 3.03 (± 0.57) and the negative affect at 2.57 (± 0.61). Results of the multilevel models predicting separately positive and negative emotions in dreams are displayed in Tables 2 and 3, respectively. In the models, positive and negative emotions during the day, daily stress (PSS) and daily sleep quality (SQI) were included as within-subject predictors (Level 1), and PSQI, STAI-T and HSPS were included as between-subject (Level 2) predictors. Gender and age were included as control variables.

Daily sleep quality measures (SQI) predicted the intensity of positive emotions in dreams, uniquely explaining 5.8% of outcome variance: better sleep as assessed on a daily basis was associated with higher positive emotions in dreams (Table 2). As for negative emotions in dreams, daily variations in sleep quality (SQI) negatively predicted, while daily stress and HSPS positively predicted their intensity (Table 3), respectively explaining 4.6%, 0.3% and 0.7% of outcome variance.

	Beta	SE	*p*-value	Lower	Upper
Intercept	2.690	0.369	***< 0.001	1.961	3.419
Within-subject predictors (Level-1)					
Positive day emotions	0.047	0.033	0.157	− 0.018	0.113
Negative day emotions	0.051	0.034	0.140	− 0.017	0.119
Daily stress (PSS)	**0.015**	**0.006**	***0.013**	**0.003**	**0.026**
Daily sleep quality (SQI)	**− 0.085**	**0.008**	***< 0.001**	**− 0.102**	**− 0.069**
Between-subject predictors (Level-2)					
PSQI	0.005	0.024	0.845	− 0.043	0.053
STAI-T	0.009	0.006	0.115	− 0.002	0.021
HSPS	**0.133**	**0.066**	***0.048**	**0.002**	**0.265**
Control variables (Level-2)					
Gender	0.032	0.209	0.880	− 0.380	0.444
Age	− 0.007	0.018	0.695	− 0.043	0.029

Table 3. Multilevel model predicting negative emotions in dreams. Lower and Upper correspond to the 95% confidence interval (CI). $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$. Number of observations = 1818. Please note that higher scores in PSQI mean more sleep difficulties.

Discussion

The present study investigated the influence of waking trait and state variables on dream emotions using multilevel analyses that accounted for both between- and within-subject levels of variance. Waking emotions were assessed using trait anxiety as well as daily stress and day-to-day variations in (positive and negative) emotional intensity. Sleep quality was measured both over the past month and at the daily level, while sensory processing sensitivity was assessed as a personality trait. Daily sleep quality significantly predicted the intensity of positive emotions in dreams, whereas daily sleep quality, daily stress and trait sensory processing sensitivity predicted the intensity of negative emotions in dreams. Together, these results highlight the interplay of both state and trait factors in night-to-night dream emotions in healthy individuals, but also highlight the differential association of these factors depending on emotional valence, as also reported in previous studies[13]. Indeed, except for daily sleep quality, which predicts both negative and positive dream emotions (see discussion below), daily stress and trait sensory processing sensitivity were only related to negative dream emotions. This latter finding stresses the importance of considering positive and negative emotions in dreams separately, rather than on a unique continuum from positive to negative.

Daily stress predicts negative emotions in dreams

In the present study, higher perceived stress during the day was associated with higher negative emotions in subsequent dreams. This finding is consistent with the emotional continuity hypothesis, which suggests that emotions experienced in waking life can carry over into subsequent dreams, but it also provides important new insights by demonstrating this continuity within subjects and on a daily basis. Our findings extend to everyday dreams, previous results showing a relationship between the occurrence (or absence) of nightmares and the daily variation in state anxiety or state depression[21]. However, our results are in apparent contradiction with Samson-Daoust et al. (2019)[22], who did not find a significant effect of daily perceived stress on the affective tone of dreams despite a similar experimental design[22]. A possible reason for this could be the scales used to measure daily perceived stress. In the present study, we used the 10-item Perceived Stress Scale[32,41], which is designed to measure the degree to which waking situations are "*unpredictable*, *uncontrollable and overloaded*" (pages 33–34)[32]. The scale has good internal reliability[50], and has been correlated with various health and behavioral factors. In contrast, Samson-Daoust et al.[22] focused on the maximum level of stress experienced during the day or experienced prior to bedtime, and using a single-item scale (from not stressed at all [0] to extremely stressed [9]). Therefore, it is plausible that the measure in the present study was more comprehensive and allowed to better quantify daily stress.

Sensory processing sensitivity, but not anxiety, is a trait predictor of negative dream emotions

In the present study, trait anxiety was not associated with the intensity of negative emotions experienced in dreams, in apparent contradiction with recent studies using similar approaches[13,22]. To better understand this apparent discrepancy, in a complementary analysis we re-ran multilevel models predicting negative emotions in dreams by adding each state and trait variable, one at a time, starting with trait anxiety (STAI-T). In all models, STAI-T was significantly and positively related to negative emotions in dreams, i.e., individuals with higher trait anxiety showed more negative emotions in dreams, until the trait factor sensory processing sensitivity was added to the model. It is important to note that we checked for multicollinearity (see Methods). In addition, STAI-T and HSPS exhibit a Pearson's correlation coefficient of $r = .523$ (see Table S1 and Figure S1). Overall, this additional analysis shows that HSPS and STAI-T share some variance, but also suggests that HSPS is a stronger predictor of negative emotion intensity in dreams compared to STAI-T. From a theoretical standpoint this suggests that it is susceptibility and reactivity to anxiety that has priority to anxiety itself in predicting negative dream emotion.

Contrary to the differential susceptibility framework, HSPS score was not related to positive dream emotions in the present study. This is contrary to the characterization of SPS as a vantage trait, which sensitizes individuals to both positive and negative experiences[51]. Whereas our findings are in accord with Carr and Nielsen[23] and Carr et al.[24] regarding SPS being a predisposing trait for nightmares, our finding of no relationship of SPS with positive emotions in dreams should now be replicated and the consequences for the vantage characterization of SPS should be further explored.

The impact of sleep quality on dream emotions

In the present study, measures of sleep quality predicted the intensity of emotions experienced in dreams. SQI, a daily measure of sleep quality, was positively associated with positive emotions. In addition, PSQI, a measure of overall sleep quality over the past month, tended to be negatively associated with positive emotions in dreams. Given that better sleep quality is reflected by lower PSQI but higher SQI scores, these findings are consistent and suggest that good sleep facilitates positive emotions in dreams. Regarding negative emotions in dreams, we found an inverse relationship with SQI, with the latter being negatively related to emotional intensity, i.e., poorer sleep quality was associated with more intense negative emotions. It has been reported that SQI is positively correlated with objective sleep parameters, including total sleep time and sleep efficiency, and thus reflects sleep continuity[34,42,52]. Therefore, these results suggest that more stable and continuous sleep, on a daily basis, is associated with a reduction of negative emotions in dreams and a shift towards positive emotions.

These results are in line with several previous studies showing a relationship between poor sleep quality and nightmare frequency[53–57], and also between poor sleep quality and negative emotions in dreams[17,54,58]. However, the aforementioned studies examined between-subjects associations, and the present study extends these findings by demonstrating a within-subject relationship between sleep quality and dream affect. Because dream content can be viewed, at least to some extent, as a reflection of ongoing sleep-related processes[59,60], it is appropriate to discuss our findings in the light of the role of sleep in emotion regulation. A large literature has documented the role of sleep, and specifically of rapid eye movement (REM) sleep, in the re-processing of recent emotional experiences[3,61]. In particular, it has been proposed that REM sleep serves as an "overnight therapy" by depotentiating the emotional strength associated with past affective experiences[1,2,62]. One prediction that emerges from this model is that this reduction in affective tone is a gradual process that occurs as REM sleep progresses through the night. Our results are consistent with this prediction, and with the model in general, in that a better night's sleep implies a more pronounced sleep-dependent reduction in affective tone, which in turn may be reflected in dreams by a reduction in their negative emotions. Beyond the role of sleep in the re-processing of emotional memories, dreaming itself might be involved in these processes[63–65]. Accordingly, a better night's sleep would allow for a more pronounced dream-dependent re-processing of emotional memories, and thus a reduction of negative emotions in dreams.

Limitations and future directions

To enhance the generalizability of the findings, participants in the present study were recruited from two laboratories located in France and in the UK. Nevertheless, the sample consisted predominantly of female undergraduate students in Psychology or related disciplines, which might limit the representativeness of the findings. Despite this unbalanced sample, gender was still included as a control variable in our analysis to account for potential confounding effects. Moreover, although recruitment from two Western European countries was intended to improve generalizability, cultural differences between the two samples cannot be excluded.

The incorporation of waking-life events into dreams has been found to be highest on the night following an event, but also 5–7 nights after events (the day-residue and dream-lag effects, respectively)[66–68], particularly for personally significant events[69,70]. Accordingly, it is not excluded that the observed association between daily stress and negative emotions in dreams is partially driven by putative recurring weekly stressors.

Given the observational design, causal inferences cannot be made in the present study. Although REM sleep is known to subserve emotional processing during sleep[3,61], and that this processing may be reflected by or causally linked to dream content[8,71], recent evidence challenges these associations. Specifically, Sikka et al.[72] showed that although negative dream affect is related to post-sleep waking affect, it was not related to affect reactivity to pictures presented after sleep, nor to the ability to down-regulate negative affect in response to these pictures. Research into this could use methods known to affect emotion regulation, such as meditation and relaxation[73], mindfulness[74] and Virtual Reality stimulation[75], so as to test for changes in dream content. Such experimental intervention techniques would extend the substantial correlational findings showing bidirectional links between pre-sleep wake life emotions, sleep, dreaming, morning mood and mood regulation[76].

Conclusions

In sum, results of the present study showed that daily sleep quality was related to positive dream affect, whereas daily stress and sleep quality, as well as trait sensory processing sensitivity, was related to negative dream affect. These results highlight the interplay of both trait and state factors in everyday dream emotions, but also provide further evidence for the emotional continuity hypothesis within subjects and across nights. In addition, our results bring into focus daily sleep quality as a determinant of emotions in dreams. Finally, contrary to the differential susceptibility framework, sensory processing sensitivity did not predict positive dream emotions. This finding needs replication as it is contrary to the characterization of SPS as a vantage trait that sensitizes individuals to negative and positive experiences.

Data availability

All data and analysis scripts that support the findings of this study are available in a public repository (OSF: [https://osf.io/kaj5y/](https://osf.io/kaj5y)).

Received: 18 February 2025; Accepted: 7 April 2026
Published online: 15 April 2026

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Funding statement

This research received no specific financial support or grant.

Declarations

Competing interests

The authors declare no competing interests. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Additional information

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1038/s41598-026-48302-y.

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