Bachelor's thesis

NTNU
Norwegian University of Science and Technology
Department of Psychology

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Investigating the relationships between subjective sleep quality and positive and negative affect

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Supervisor: Ingvild Saksvik-Lehouillier
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Preface

This study was conducted in relation to the research project "Affect, sleep and mental health among shift workers: A pilot study" led by my supervisor Ingvild Saksvik-Lehouillier. My contribution to the project involved participating in the recruitment process prior to writing my thesis. In addition, students on the bachelor project contributed by testing the questionnaires to make sure no errors appeared in any of the questions. Questionnaires was developed and distributed to the sample by Ingvild and the student assistant on this project, Vilde Brødholt Vikene. I formulated the research question, with guidance from my counselor, based on gaps in the current knowledge of sleep and affect. The majority of the literature utilized in this thesis was collected independently, and the majority of the literature was found using Oria.no. In addition, my supervisor advised me on relevant studies and articles to include in my thesis. Variables was calculated independently with assistance from my counselor. All analyses performed in relation to this thesis was performed by me. All results were also interpreted by me.

I would like to give thanks to my supervisor, Ingvild, who have thoroughly guided me through the process of writing this thesis. In addition, I would also like to thank the other students on the bachelor project for their support throughout this semester. Lastly, I would like to thank my four friends and classmates who have provided me with emotional and academic support through my three years of attending the Norwegian University of Science and Technology.

Abstract

Sleep has long been a subject of interest in psychological and medicinal research. In spite of this, it seems as though a consensus has not yet been established regarding the ways sleep is related to the mental and physical health of humans. My aim with this study has therefore been to investigate in which ways positive and negative affect seems to be related to subjective sleep quality. A baseline questionnaire was therefore distributed to the participants. In addition, three daily questionnaires were distributed over a period of seven consecutive days. To investigate the relationships between sleep quality and affect, two correlation analyses and two regression analyses were run on a sample of night-shift workers (*N*=55-99). The main finding in this study was that both negative, r = .40, and positive affect, r = -.30, was cross-sectionally related to PSQI-scores, whereas only positive pre-sleep affect, β = .51, seemed to influence sleep quality positively the following night. These findings are supported by previous studies which have examined the associations between affect and sleep. Further research should focus on replicating the findings revealed in this study so that conclusions can be drawn regarding the practical implications for the patterns between sleep and affect.

Sammendrag

Søvn har lenge vært et interesseområde innen psykologisk og medisinsk forskning. På tross av dette virker det ut til at det ikke er etablert en konsensus for hvilke måter søvn er relatert til menneskers mentale og fysiske helse. Formålet med denne studien er derfor å utforske på hvilke måter positiv og negativ affekt ser ut til å være relatert til selv-rapportert søvnkvalitet. Et baseline-spørreskjema ble delt ut til deltakerne i studien. I tillegg ble det delt ut tre daglige spørreskjema i en periode av syv sammenhengene dager. For å undersøke disse forholdene har det blitt gjennomført to korrelasjonsanalyser og to regresjonsanalyser på et utvalg av skiftarbeidere (N=55-99). Hovedfunnet i tverrsnittsanalysen var at både negativ, r = .40, og positiv affekt, r = -.30, var relatert til søvnkvalitet, mens den andre regresjonsanalysen viste at kun positiv affekt målt før søvn, β = .51, så ut til å kunne predikere søvnkvalitet den følgende natten. Disse funnene stemmer overens med tidligere forskning som har undersøkt sammenhenger mellom affekt og søvn. For å kunne trekke konklusjoner angående de praktiske implikasjonene for disse funnene bør det gjøres mer forskning som bekrefter de mønstrene som er observert i denne studien.

Sleep has long been a subject of interest in psychological and medicinal research, and seems to be a mental and physical state necessary for overall everyday function (Kandel et al., 2014). Sleep consists of various states allowing processes such as affective memory consolidation, emotion regulation and hormonal regulation to take place (Kandel et al., 2014; Ten Brink et al., 2023; van der Helm & Walker, 2009). Still, there seems to be a gap in the knowledge concerning the ways in which sleep influence the mental and physical wellbeing of humans, as well as how sleep can, in turn, be influenced by humans mental and physical wellbeing.

Much previous research concerned with investigating the relationship between sleep and affect have focused on revealing the associations between sleep and negative affect. More specifically, the focus seems to have been on examining how sleep temporally preceding affect influences the mental wellbeing in humans, not vice versa (Ten Brink et al., 2022). Research done on the subject thus far points to a dependency of sleep on adaptive emotional regulatory behavior (Goldstein & Walker, 2014). There is – in other words – fewer studies that have examined how affect temporally preceding sleep can influence sleep outcomes such as sleep latency, sleep duration, or sleep quality (Ten Brink et al., 2022).

With this study I have aimed to further examine the intricate relationship between sleep and affect. The study has sought to test in which ways positive and negative affect seems to be related to subjective sleep quality among night-shift workers. To further understand this hypothesized relationship the predictive power of pre-sleep positive and negative affect on subjective sleep quality has also been investigated.

Sleep and affect

Sleep

REM and nREM sleep

Thanks to measures such as electroencephalogram (EEG) measuring brain activity; electrooculography (EOG) measuring eye movements; and electromyography (EMG) measuring muscle tone, there seems to be a consensus that sleep consists of two main periods; rapid eye movement sleep (REM), and non-rapid eye movement sleep (nREM) (Kandel et al., 2014). These periods of sleep are each characterized by specific patterns of frequencies and levels of arousal in oscillations, or neuronal activity.

Depending on the depth of the sleeping state, oscillations will appear less frequent and lower in arousal resulting in a decrease in eye movements, heart rate and respiration (Kandel et al., 2014). Although sleep is divided into two main periods, nREM-sleep is furthermore divided into four stages (Kandel et al., 2014). With each stage of nREM-sleep, ranging from stage 1 through 4, oscillations gradually appear slower and more synchronized. Upon entering the fourth and final stage of nREM-sleep the frequency of the oscillations will reverse, consequently increasing eye movements, heart rate and respiration (Kandel et al., 2014). These patterns are what characterizes the build-up to REM-sleep. This cascade of changes in neuronal activity lasts for approximately 90 minutes, and continues to follow the same pattern until it is disrupted by a decreasing need for sleep, or other factors such as sleep difficulties or external disturbances (Kandel et al., 2014).

It is commonly thought that sleep and sleep disturbances are associated with various symptoms of mental illnesses (Baglioni et al., 2016). Alterations in REM-sleep have been shown to be associated with disorders such as depression and post-traumatic stress disorder (Baglioni et al., 2016; van der Helm & Walker, 2009). REM-sleep seems, in other words, to play a crucial role in the domain of affect.

Two-process model of sleep regulation

In the late 70´s Alexander A. Borbély introduced the first version of his model of how sleep is regulated through a continuous build-up of sleep deficiency (Borbély, 2022). The model proposes two interacting processes determining when wakeful and sleeping states take place. Process S – being a homeostatic process – illustrates the growing need for sleep through the 24h circadian cycle, while process C illustrates the natural circadian rhythm and the change in alertness through the day and night (Borbély, 2022). The regulation of process S is associated with the occurrence of slow wave activity in nREM-sleep. Furthermore, it is hypothesized that – since process S governs sleep duration and intensity – a deviation in regulation of process S might explain the co-occurrence of sleep difficulties and affective disorders such as depression (Radwan et al., 2021). The interaction between these two processes is what makes out the sleep regulation in humans (Borbély, 2022). This model can pose as a framework for understanding how affective behaviour is influenced by sleep outcomes through the different stages of sleep, and vice versa.

Positive and negative affect

Affect is often considered a broad term describing psychological states such as moods and emotions (Gross, 2015). In this study I based my assumptions on associations between affect and sleep on the two-factor model of affect developed by Watson et al. (1988). Affect is hereby defined in two terms: positive affect and negative affect. This means affect is not measured on a bipolar scale but is instead differentiated and measured as two separate categories of affect. The former covers affective states such as feeling enthusiastic, pleasant engagement and high energy, whereas the latter reflects affective states of sadness, unpleasant engagement, and distress (Watson et al., 1988). Therefore, a low score on negative affect would not translate to a high score on positive affect, nor vice versa. Moreover, affect can

vary in degree of arousal and valence. An affective state can therefore be high in arousal and low in valence, meaning one might be experiencing negative emotions or feelings such as depression or anxiety. In addition, an affective experience can also be high in arousal and high in valence, being expressed as for example a feeling of ecstasy, passion or excitement. Affective expressions that are low in arousal can – on the other hand – be expressed as for example subtle nervousness (low valence) or calmness (high valence). Valence and arousal are, in other words, fundamental components of the expression of affective states.

The relationships between sleep and affect

A large body of research suggests that there are strong associations between sleep and affect (van der Helm & Walker, 2009). Although topics within the domain of sleep and affect have long been on the research agenda, there seems to be a lack of consensus regarding the ways in which the two are related. This current lack of knowledge is surprising considering that sleep abnormalities are commonly associated with the majority of psychological disorders (Palmer & Alfano, 2017), which are often characterized by various affect-related symptoms.

In addition, several people who work in healthcare, transportation and security – to mention a few – work nightshifts which is considered to disturb the circadian rhythm, sleep patterns and behavior of humans (Grønli et al., 2017). For example, a prospective study conducted in 2010 showed that working shifts impacted both sleep and feelings of alertness (Åkerstedt et al., 2010). Moreover, night-shift work is arguably an inevitable aspect of everyday societal function. It is therefore of interest to not only night-shift workers, but to the general population that night shift work is conducted in the healthiest way possible. However, the knowledge of how this type of work seems to influence the mental and physical health of nightshift workers is inadequate, making it urgent that the links between affect and sleep quality are uncovered.

In the general population, studies suggests an interaction between sleep deprivation and the ability to reactively regulate emotional experiences. Yoo et al. (2007) used fMRI to explore this relationship between sleep deprivation and affective experiences on a sample of healthy young adults. Both a sleep deprived group and a control group were then presented with visual stimuli aimed at eliciting emotional states in the participants. By doing this Yoo et al. (2007) found that sleep deprivation significantly inhibited the neuronal communication between the amygdala and prefrontal cortex. This is a circuit hypothesized to play a crucial role in the controlling and regulation of emotional expressions (Goldstein & Walker, 2014). This fact also become apparent in studies showing that sleep deprivation influences reward-motivated behaviors, indicating that sleep deficiencies have inhibitory effects on cognitive processes such as decision making (Goldstein & Walker, 2014).

Ten Brink et al. (2023) conducted polysomnographic (PSG) recordings to examine the links between sleep architecture and pre-sleep affect and found that both positive and negative pre-sleep affect were associated with frontal theta oscillations during REM, but not during nREM sleep. Although it is difficult to draw a conclusion to what the functional consequences of these associations might be, it has been suggested that theta oscillations during REM-sleep play a role in affective memory consolidation (Ten Brink et al., 2023). Findings from an experimental study performed by Delannoy et al. (2015) are also consistent with those mentioned above, where it was reported that pre-sleep affect modulated sleep architecture. In addition to this, Delannoy et al. (2015) found that experimentally induced positive and negative pre-sleep affect was linked to an activation in the sympathetic nervous system the following night of induction. This proposes the hypothesis that pre-sleep affect might have adaptive consequences for sleep outcomes.

In other words, it seems likely that various biological mechanisms play a critical role in regulating our abilities to control our affective behavior. Latif et al. (2019) explored the

cross-sectional relationships between affect, maladaptive emotion regulation (ER) strategies, and sleep quality, finding that both negative affect and expressive suppression was positively correlated with subjective sleep quality measured with PSQI. In addition, it was reported that positive affect was negatively associated with subjective sleep quality, suggesting that emotional experiences – both positive and negative – as well as some regulation strategies, are related to subjective sleep quality (Latif et al., 2019). Furthermore, emotion crafting – which is an adaptive emotion regulation strategy – has been shown to be associated with self-reports of positive affect and vitality indicating a relationship between adaptive emotion regulation and feelings of alertness, wakefulness and energy (Van der Kaap-Deeder et al., 2023).

Moreover, Parsons et al. (2022) found in an experience sampling study that participants reported less frequent negative affective experiences when sleep quality was high. Another study examined, among other things, the relationship between sleep quality and emotional disturbances on a sample of Taiwanese shift nurses and found that poor sleep quality was associated with higher levels of emotional disturbances (Lee et al., 2015).

While it is clear that various studies report links between affect and sleep outcomes, other studies seem to not be able to report the same findings (Zhang et al., 2021). For example, Sin et al. (2020) completed interviews over a period of eight consecutive days to investigate the bidirectional links between sleep duration, stress factors, positive events, and affective experiences. In this study they found that longer sleep duration predicted lower negative affect and higher positive affect. In addition, it was reported that pre-sleep affect did not have any significant predictive value for sleep duration the following night (Sin et al., 2020). Similar findings were reported in a study investigating the influences of pre-sleep affect and sleep quality in a sample of 27 depressed patients and 27 healthy controls (Bouwmans et al., 2017). The main finding revealed in this study was that sleep quality

predicted both positive and negative affect, but pre-sleep positive and negative affect did not predict sleep quality (Bouwmans et al., 2017).

A recent review of the relationship between sleep and affect reveal that – while there does not seem to be consistent evidence for the bidirectional links between sleep and affect – cross-sectionally, there seems to be consistent patterns between self-reported sleep disturbances and negative and positive affect (Ten Brink et al., 2022). In the review it becomes clear that the same patterns appear for cross-sectional associations between self-reported sleep quality and short-term positive affect (Ten Brink et al., 2022).

Although the links between affect and sleep long have been a topic of interest in psychological research, there does not seem to have been established a complete consensus on the statistical nor functional links between the two. Particularly there seems to be a need for more research on the bidirectional links of pre-sleep affect and sleep outcomes (Ten Brink et al., 2022). This relationship needs further investigation considering it seems that the majority of research on sleep and affect has been directed towards understanding the relationship between sleep disturbances and negative affect.

Research question and hypotheses

Based on gaps in current knowledge of the sleep-affect domain in psychological research, my aim with this study has been to investigate in which ways positive and negative affect is associated with subjective measures of sleep quality. To answer this research question the following hypotheses were tested:

H_1 Positive affect is cross-sectionally associated with better subjective sleep quality.

H_2 Positive pre-sleep affect measured on Monday evening influence subjective sleep quality on Tuesday morning positively.

H_3 Negative pre-sleep affect measured on Monday evening influence subjective sleep quality on Tuesday morning negatively.

Method

Sample

Participants in this study were picked by convenience. The research group contacted workplaces where it was assumed that employees worked night-shifts. Selection criteria was that all participants had to work at least one night shift during the week of data collection. Participants who answered the baseline questionnaire but did not work a night shift during the week of daily data collection were excluded from the study. Due to the fact that the sample was initiated by convenience sampling there is no data giving information about the response rate in the sample.

The sample consists of 99 participants in total, whereas 65 of these represented women, and 34 of them represented men. A total of 31 % of the sample were in the age group 19-29, while 28 % ranged between 30-39 years, 17 % between 40-49 years, and 23 % were aged 49 years and up. Approximately 65 % of the sample were employed in the healthcare sector, whereas approximately 12% were employed in security, 12% in sales and service, and 8% in processing, machine operating and transport. The majority of the sample had obtained higher education such as a bachelor's or a master's degree (61 %), while the remaining 39 % had completed high school.

Procedure

This study was conducted in relation to the research project "Affect, sleep and mental health among shift workers: A pilot study", led by Ingvild Saksvik-Lehouillier. Ethical

considerations were taken prior to conducting the study, and the research project was approved by both Regional Committees for Medicinal and Health Research Ethics (REK) (655108) and Norwegian Agency for Shared Services in Education and Research (SIKT) (408999). Recruitment and data collection took place after receival of ethical approval from both REK and SIKT.

The recruitment process lasted from February until the start of March 2024. Participants got invited to partake in the study via email which was sent to various workplaces. Workplaces that were contacted ranged from gas stations, fire stations, night clubs, care homes and hospitals. The invitation email contained information about the purpose of the study, their right to withdraw consent, relevant privacy policies, contact information, as well as a link to the baseline questionnaire. The participants were provided with information regarding ethical approval of the study. Furthermore, participants were invited to answer three daily questionnaires during a period of seven consecutive days. Information about the duration of the study and the estimated completion time for each questionnaire was also given. Due to the fact that the daily measurements could be perceived as time-consuming, the participants who completed the baseline-questionnaire in addition to > 70 % of the daily questionnaires received a gift-card with a value of 200 Norwegian kroner.

In addition to inviting participants via email, the research group put up posters containing essential information about the study, and a QR-code directing the participant to the full information text about the study and the baseline questionnaire. These posters were put up in workplace breakrooms, gas stations, shopping malls, NTNU Campuses and gym studios. Moreover, members of the research group shared information about the study on social media platforms like Instagram and Facebook.

Participants based in Trondheim got an invitation to spend a week wearing an actigraphy watch. Information about the actigraphy watches and their role in the study was

provided to all potential participants in the recruitment period. The analyses done in relation to this thesis do not utilize data collected from the actigraphy watches.

Instruments

Positive and Negative Affect schedule (PANAS)

The Positive and Negative Affect Schedule (PANAS) is a 20-item validated instrument aimed at measuring subjective reports of positive and negative affective states (Watson et al., 1988). There are 10 items measuring positive affect (Interested; Attentive; Inspired; Active; Enthusiastic; Proud; Strong; Determined; Alert; Excited) and 10 items measuring negative affect (Irritable; Upset; Scared; Nervous; Hostile; Distressed; Ashamed; Afraid; Jittery; Guilty) (Watson et al., 1988). Each item contains an emotion word which the participant must rate to what extent they have experienced in the last week.

All items are measured on a 5-point Likert-scale, 1 being “very slightly or not at all” and 5 being “extremely”. All items of the affect schedule were translated from English to Norwegian by members of the research group. In the present study the instrument had high internal reliability for measuring both positive affect, $\alpha = .88$, and negative affect, $\alpha = .85$.

12-Point Circumplex Structure of Core Affect

The 12-Point Circumplex Structure of Core Affect is a model illustrating the relationship between two dimensions of affect; valence and arousal (Yik et al., 2011). Based on this theoretical framework of affect, the daily questionnaire contained questions asking the participants on a scale from 0-100 how intensely they experienced each affective state at the moment of answering the questionnaire. The same scale has been utilized in other studies using the 12-point model as a framework for measuring affect (Moeck et al., 2023).

The daily questionnaires developed for the purpose of this studies asked five questions regarding experiences of positive affect (Energized; Enthusiastic; Satisfied; Peaceful; Calm) and five questions regarding experiences of negative affect (Anxious; Upset; Dissatisfied; Sad; Sluggish). In addition to varying in valence, the affective states vary in degree of arousal. For example, reports of high energy therefore indicate being in an affective state characterized by high valence and arousal, while reports of calmness indicates being in an affective state that is high in valence but low in arousal. When developing the daily questionnaires, items from the 12-point model were picked with the intention of having items representing different degrees of valence and arousal. Similar selection techniques have been used in other studies (e.g. Moeck et al., 2023).

All of the names of the affective states in the model were translated from English to Norwegian by members of the research group. The questions developed from this model turned out to have a good internal reliability for both positive affect, $\alpha = .78$, and negative affect $\alpha = .76$.

Pittsburgh Sleep Quality Index (PSQI)

As a measure of subjective sleep quality, the baseline questionnaire contained the items from the Pittsburgh Sleep Quality Index (PSQI). The original PSQI is a validated and frequently used instrument when investigating sleep quality. The instrument consists of 19 self-rated items and five items rated by either a sleep partner or roommate. The baseline questionnaire in this study included 17 items from the PSQI, excluding question 5j and question 10. Question 5j asked the participant to elaborate on reasons for sleep-trouble, while question 10 asked whether or not the participant had a bed partner or roommate. Questions 1 through 4 requires the participant to write their answers concerning bedtime, number of minutes to fall asleep, waking time, and numbers of hours of sleep. For questions 5 through

10, each item is investigating to which degree – on a scale of 1 - 4 – the participant has different sleep troubles. The questions have different scales dependent on the formulation of the question. For example, question six asks “During the past month, how would you rate your sleep quality overall?”, requiring the respondent to rate their answer alternatives from 0 = “very good” to 3 = “very bad”. A score of 6 commonly acts as a threshold for characterizing an individual as a good or bad sleeper, meaning that a PSQI-score of > 6 is considered as having poor sleep quality (Pallesen et al., 2005).

Items were computed into seven components making the total PSQI score a measurement of 1) subjective sleep quality; 2) sleep latency; 3) sleep duration; 4) sleep efficiency; 5) sleep disturbances; 6) use of sleeping medication; 7) daytime dysfunction.

A Norwegian version of the instrument was utilized in the development of the baseline questionnaire. This translated version has been back translated (Pallesen et al., 2005), and utilized by other researchers and professionals in the field of insomnia and sleep (e.g. Bøe Lunde et al., 2012; Dørheim et al., 2009). A reliability-test showed that the instrument had a good internal reliability, $\alpha = .75$.

The Consensus Sleep Diary (CSD)

The Consensus Sleep Diary (CSD) is a standardized instrument developed by insomnia experts and is frequently used to map out sleeping habits and difficulties (Bjorvatn, 2023; Carney et al., 2012). It contains nine items investigating bedtime, sleeping time, sleep onset latency, number of awakenings, length of awakenings, time of last awakening, rising time, and subjective sleep quality (Bjorvatn, 2023). In this study the subjective sleep quality variable was translated into Norwegian and included in the daily questionnaires. The participants were asked to rate last night’s sleep quality on a five point Likert-scale where 1 = “Very light” and 5 = “Very deep”.

Statististical analyses

A correlation analysis was conducted on the following variables from the baseline questionnaire: PANAS, PSQI, age, gender, and educational level. Before running the analysis, normality, linearity, outliers and homogeneity of variance was inspected to assure that assumptions for correlation analysis was met. Thereafter, a multiple regression analysis was conducted to examine the directional associations between positive and negative affect, and subjective sleep quality. Prior to this, it was checked whether assumptions for additivity, normally distributed residuals, multicollinearity, and independent errors were met in the dataset.

After assessing the results from the analyses done on the baseline-data, a correlation analysis was run on variables measuring daily reports of pre-sleep positive and negative affect and subjective sleep quality. Pre-sleep affect was measured on Monday evening, and subjective sleep quality was measured on Tuesday morning. Assumptions was checked prior to running the second correlation analysis. A second multiple regression analysis was performed to further investigate the predictive power of positive and negative pre-sleep affect on subjective sleep quality. Scatterplots, p-p plots, VIF and Durbin-Watson´s test was also inspected prior to conducting the second multiple regression analysis.

Results

Descriptive statistics

In a sample of 99 informants, the mean PSQI score was approximately 7, $M = 7.24$, $SD = 3.68$, $n = 93$. On a scale from 10-50, the mean score for negative affect was 19, $M = 19.27$, $SD = 6.10$, $n = 94$, and 32 for positive affect, $M = 32.16$, $SD = 7.63$, $n = 97$.

For the daily measurements the total sample size was 55. Subjective sleep quality was scored on a scale from 1-5 where the mean score was a little over 3, $M = 3.32$, $SD = .87$, n = 38. On a scale from 0-100 the mean score for positive affect was approximately 302, $M = 301.84$, $SD = 80.31$, $n = 55$, and approximately 80 for negative affect, $M = 80.10$, $SD = 68.00$, $n = 55$.

Investigating the associations between positive and negative affect, and subjective sleep quality

Assumptions for correlation analysis were mostly met. Although Kolmogorov-Smirnov test was significant for all variables excluding positive affect, histograms indicated normality in the sample. Scatterplots suggested that there were weak correlations between the variables. No influential outliers were detected.

The variables age, gender, educational level, positive affect, negative affect, and sleep quality was examined in a correlation analysis (Table 1). Positive affect had a small positive correlation with age, $r(95) = .29$, $p = .004$. Positive affect was furthermore negatively correlated with negative affect, $r(92) = -.39$, $p < .001$. In addition, positive affect had a moderate negative correlation with subjective sleep quality, $r(89) = -.30$, p = .004. Negative affect had a small yet significant negative correlation with age, $r(92) = -.23$, $p = .025$. There was also a moderate correlation between negative affect and subjective sleep quality, $r(86) = .40$, $p < .001$).

There were no relevant significant correlations between subjective sleep quality and the demographic variables. Positive and negative affect was not correlated with neither gender nor education level.

Table 1

Correlations between demographics, positive and negative affect and subjective sleep quality (N=93-99).

Variable name	M	SD	1	2	3	4	5	6
1. Age	2.32	1.15	-					
2. Gender	1.66	0.447	-.21*	-				
3. Education	2.61	0.491	-.04	.29**	-			
4. Positive affect	32.17	7.63	.29**	-.10	-.12	-		
5. Negative affect	19.27	6.10	-.23*	.02	-.05	-.39***	-	
6. Sleep quality	7.24	3.70	-.07	.14	-.02	-.30**	.40**	-

* Correlation is significant at the .05 level (2-tailed)

** Correlation is significant at the .01 level (2-tailed)

*** Correlation is significant at the .001 level (2-tailed)

Not all assumptions for correlation analysis on data from the daily measurements were met. Histograms suggested normality in the dataset. Although Kolmogorov-Smirnov test was significant for subjective sleep quality, it was not significant for positive or negative affect, indicating that the assumption for normality was not met. Scatterplots suggested weak correlations between the variables, and one potential influential outlier was detected in the correlation between negative affect and subjective sleep quality.

For the daily measurements, positive and negative pre-sleep affect on Monday evening, and sleep quality on Tuesday morning was examined in a correlation analysis (Table 2). Demographic data was not available for the purpose of running analyses on daily measurements and was therefore excluded in this correlation analysis. Positive pre-sleep affect on Monday evening was positively correlated with subjective sleep quality the following morning, $r(27) = .45$, $p = .015$. Positive pre-sleep affect was furthermore negatively correlated with negative pre-sleep affect, $r(53) = -.39$, $p = .003$. Negative pre-sleep affect on Monday evening had no significant correlation with subjective sleep quality measured on Tuesday morning.

Table 2

Correlations between positive and negative pre-sleep affect on Monday and subjective sleep quality on Tuesday morning (N=38-55).

Variable name	M	SD	1	2	3
1. Positive pre-sleep affect	25.86	12.07	-		
2. Negative pre-sleep affect	24.29	5.18	-.39**	-	
3. Subjective sleep quality	16.08	3.99	.45*	-.04	-

* Correlation is significant at the .05 level (2-tailed)

** Correlation is significant at the .01 level (2-tailed)

Investigating the links between positive and negative affect and subjective sleep quality

Scatterplot, p-p plot, VIF and Durbin-Watson's test was inspected to check assumptions for independent errors, multicollinearity, normality, and linearity. No influential cases or extreme outliers were observed in the dataset.

A regression analysis was performed to investigate the relations between positive affect and negative affect on subjective sleep quality (Table 3). Positive and negative affect (Model 1) explained 19% of the variance (R^2 = .19, $F(2, 85) = 9.70$, $p < .001$). Negative affect, β = 0.34, p = .002, but not positive affect, β = -0.17, p = .115, was a significant predictor for sleep quality in the model.

Table 3

Statistics from multiple regression analysis investigating the relationship between affect and subjective sleep quality (N=93-97).

Variable name	*b*	*SE b*	β	R^2
Model 1[a]				.19***
Positive affect	-0.08	0.05	-0.17	
Negative affect	0.20**	0.06	0.34**	

Note. [a] Dependent variable: PSQI

** Correlation is significant at the .01 level

*** Correlation is significant at the .001 level

Investigating the predictive power of affect on subjective sleep quality

Not all assumptions for regression analysis were met in the data of the daily measurements. Assumptions for independent errors (Durbin-Watson = 1.48), multicollinearity (VIF = 1.18), and normality were met. Histogram showed signs of outliers in the dataset. However, further inspection of standardized residuals (< + / -3) and Cook's distance (< 1) indicated that there were no influential cases or extreme outliers in the dataset. Clusters were observed in the scatterplot, indicating linearity in the dataset.

The role of positive and negative affect measured at Monday evening was examined in a multiple regression analysis to investigate the role of pre-sleep affect on subjective sleep quality (Table 4). Overall, the model explained 22% of the variance in scores on subjective sleep quality ($R^2 = .22$, $F(2, 26) = 3.74$, $p = .037$). Positive affect was the only significant predictor in the model ($\beta = 0.51$, $p = .011$).

Table 4

Statistics from regression analysis investigating the predictive power of pre-sleep affect and subjective sleep quality (N=29).

Variable name	*b*	*SE b*	β	R^2
Model 1[a]				.22*
Positive pre-sleep affect	0.01*	0.00	0.51*	
Negative pre-sleep affect	0.00	0.00	0.16	

Note. [a] Dependent variable: CSD

* Correlation is significant at the 0.05 level

Discussion

The main finding in this study is that both positive and negative affect seems to be related to subjective sleep quality. However, only positive pre-sleep affect, and not negative, seems to influence subjective sleep quality, indicating that experiencing positive emotions and feelings the final hours before sleeping can make the following night's sleep more satisfactory.

Considering that results from the baseline-data indicate that positive affect is cross-sectionally related to better subjective sleep quality, one can conclude that hypothesis 1 is supported. This indicates that positive valence is somehow related to higher self-reported sleep quality. This finding does not discriminate between different affective states, but it seems as though satisfying emotions and feelings in general are linked to more satisfactory sleep-reports.

When investigating the relationships between pre-sleep affect and subjective sleep quality evidence was provided to support the second hypothesis postulating that positive pre-sleep affect influence subjective sleep quality positively the following night. This suggests that experiences of positive affect at night-time can influence how satisfactory the following night's sleep is perceived.

The results from the analyses contradicted the third and final hypothesis in this study proposing that negative pre-sleep affect influence subjective sleep quality negatively. This indicates that experiencing negative emotions and feelings the final hours before sleeping would likely not influence how satisfactory the following night's sleep is perceived.

Positive affect is less associated with subjective sleep quality than negative affect

Although positive affect was associated with subjective sleep quality, this association was smaller than the association between negative affect and subjective sleep quality. The

finding that positive and negative affect is related to sleep quality is consistent with previous research reporting that low negative affect and high positive affect is linked to higher self-reports of sleep quality (Ten Brink et al., 2022). While the review performed by Ten Brink et al. (2022) included studies done on healthy adults, this study adds to the knowledge of the links between sleep and affect in that it was performed on a sample of adult shift-workers. This suggests that the cross-sectional sleep-affect associations that are true for the general population also are true specifically for the sample of night-shift workers.

Positive pre-sleep affect predicting subjective sleep quality

Arguably the most important finding in this study was the role of positive pre-sleep affect in subjective sleep quality outcomes. This finding says that positive affect at night-time explained approximately one fifth of the self-reports of sleep quality amongst night-shift workers. To this date it seems as though little research has been dedicated to exploring this bidirectional relationship between positive self-reported pre-sleep affect and self-reported sleep quality.

In other words, the analyses of the daily measures indicate that – while it seems as though positive affect can influence sleep quality – negative affect cannot. This might appear as surprising given the fact that a great amount of research have reported associations between negative affect and sleep quality (e.g. Fortunato & Harsh, 2006; Lee et al., 2015), and other sleep outcomes such as sleep disturbances (Granö et al., 2008). However, the conceptual review of sleep and affect support the hypothesis that negative affect does not predict worse sleep quality, as it appears that a large number of studies have revealed similar patterns as those in this study (Ten Brink et al., 2022). In fact, subjective sleep quality was the only sleep domain that turned out to be influenced by pre-sleep affect, according to the review performed by Ten Brink et al. (2022). For example, one 7-day long study preformed in 2022 found that

positive emotion regulation strategies, but not negative emotion regulation strategies, were related to better subjective sleep quality (Parsons et al., 2022).

Similar patterns as those in this thesis have also been uncovered in studies investigating the influences of pre-sleep affect on objective measures of sleep. For example, it was revealed that feelings of calmness before sleep shortened sleep latency in adolescents (Tavernier et al., 2016). In addition, it has been revealed that EEG-measured neural activity can be influenced by positive pre-sleep affect (Zhang et al., 2023). Furthermore, polysomnographic (PSG) and electrodermal activity (EDA)-measures reveal that induced positive pre-sleep affect can cause an increase in REM sleep rate through the whole night, while the influence of induced negative pre-sleep affect only lasted through the second half of the night (Delannoy et al., 2015).

Theoretical application

The findings reported in this study can be put into context of the two process model of sleep regulation proposed by Borbély (2022). The finding that positive affect is associated with subjective sleep quality can be explained by process C which illustrates the changes in alertness through the 24h circadian cycle. Notably, sleep regulation is considered to be composed by the interaction between process C and process S. Therefore, a change in alertness (process C) partially caused by positive affect might suggest that experiencing positive emotions and feelings cause more intact interaction between the two sleep-processes than when alertness is high.

An increase in sleepiness is, according to the two-process model, associated with a decrease in alertness. This might pose as an explanation for the finding that positive pre-sleep affect can influence subjective sleep quality. Extending this hypothesis could imply that positive affective states are characterized by low alertness. This hypothesis appears to be true

in the study performed by Tavernier et al. (2016), where feelings of calmness was found to be associated with subjective sleep quality. However, conclusions regarding this hypothesis should not be drawn without further investigation of the constructs of affect and its relation to sleep.

Methodological strengths and limitations

This study utilized mostly validated instruments to measure sleep quality and affect among night-shift workers, the exception being the item measuring affect in the daily questionnaires. All assumptions are based on data collected directly from self-reports from the sample, which can be seen as a strength in this study. Using digital questionnaires furthermore acts as a strength in this study, considering this to be an economical way of collecting data. Although collecting daily measurements was somewhat time-consuming, this allowed for a thorough investigation of the predictive power of affect on sleep quality.

Firstly, one limitation with this study is that all analyses are performed on small sample sizes. This consideration is notably relevant for the daily measurements, whereas the analyses on the sleep-affect relationship was performed on a sample size of 29 shift workers. Although other assumptions for regression analysis were met, the assumption for linearity was not, and the insufficient sample size might explain the clusters observed in the scatterplot. Although potential influential outliers and extreme outliers were inspected, it could also be argued that the linear clusters in the scatterplot was a result of outliers in the dataset. The observed linear patterns in the scatterplot compromise the interpretation of the results presented in this thesis. It could be argued that a regression analysis would not be appropriate method of analysis considering the linearity-issue, but seeing that other assumptions were met the analysis was performed in spite of this. However – despite observing a statistically significant influence of positive pre-sleep affect on subjective sleep quality – it is difficult to

draw conclusions on the practical implications of how affect and subjective sleep quality is related.

Secondly, one limitation in this study was the sole use of self-reported measures of affect and sleep. Although actigraphy watches were handed out to some participants in the sample, the analyses preformed for the purpose of this thesis did not include data from actigraphy watches or any other objective measures. Basing assumptions on the relationship between sleep and affect solely on subjective measures, makes the findings reported in this study prone to bias. In addition to this, different instruments were used to collect data on affect and subjective sleep quality in the two questionnaires. The different instruments varied in total items, although however, each of the instruments received good internal reliability or have been validated in previous research.

Thirdly, this was limited to studying the predictive power of pre-sleep affect on subjective sleep quality across a 2-day period. Prolonging this examination period could have benefited the study leaving more robust results. This could furthermore contribute to the knowledge of the practical implications of the patterns revealed in this study.

Finally, although baseline data suggest that there are small gender differences in scores on affect, demographic data in the daily measurements was not available for the analyses performed in relation to this thesis, inhibiting the possibility of investigating the potential influences of gender on affect further. By including information about age, gender and education in analyses on the daily measurements, the nuances of the relationship between pre-sleep affect and subjective sleep quality could have been understood on a deeper level. However, the sample from the daily measurements are taken from the sample from the baseline-questionnaire. Therefore, conclusions about the demographic associations observed in the baseline-analyses could be assumed to be true in the sample of the daily measurements.

Implications for future research

There seems to be relatively little research that have examined the predictive power of pre-sleep affect on subjective sleep quality. The patterns uncovered in this study therefore needs further investigation, and one implication for future research would be to replicate this current study. Preferably, future research should test these relationships on bigger samples across longer stretches of time.

It would be of great importance for further research to investigate potential work-group differences in the bidirectional relationships observed in these data. This would open up for a deeper understanding of the sleep-affect relationship and the practical implications of the empirical findings revealed in the present study. Moreover, this could strengthen the ecological validity of the sleep-affect patterns that were observed in this dataset.

Additionally, future research should be directed towards investigating the practical implications of the findings reported in this study. Emotion regulation strategies have been shown to be related to sleep outcomes (Palmer & Alfano, 2017), and mental disorders such as depression and PTSD are both characterized by difficulty with emotion regulation and sleep-related problems (Goldstein & Walker, 2014). For example, future research should consider investigating the links between positive affect, emotion crafting, and sleep quality, considering that emotion crafting is an adaptive emotion-regulation strategy associated with positive affect and well-being (Van der Kaap-Deeder et al., 2023). Therefore, it could be of interest for future research to investigate how effective emotion regulation strategies are in relation to the influences of pre-sleep affect on subjective sleep quality.

It should also be investigated how individual differences in personality moderate the influence of pre-sleep affect on subjective sleep quality. In the domain of personality psychology, it is commonly assumed that some traits are associated with positive and negative affect as well as overall well-being (Larsen et al., 2021). Investigating this hypothesis further

could give an indication to which extent affect should be seen as traits within individuals, or if it should be considered as fluctuating states of emotions and feelings independent of individual predispositions.

Considering that positive pre-sleep affect turned out to be a predictor for subjective sleep quality, it would also be interesting to investigate whether there are differences between the various items of affect. Some studies indicate that certain types of positive affective states better predict sleep quality than others (e.g. Kalmbach et al., 2014), and this hypothesis should be tested further. Future research should therefore seek to differentiate between different levels of valence and arousal when investigating the links between affect and sleep quality.

Moreover, future research should consider investigating differences in the influences of pre-sleep affect on the different components of subjective sleep quality. One example could be to investigate whether components of the PSQI, such as habitual sleep efficiency or sleep disturbances, are influenced differently by pre-sleep affect.

Lastly – considering all measures in this study was self-reported – it would be not only interesting, but useful to gain more insight in the ways pre-sleep affect might influences objective sleep measures. This would also strengthen the findings reported in this thesis, making the chances of self-report bias less probable. Considering that, on a general basis, affect seems to be associated with subjective sleep quality, and the fact that positive pre-sleep affect seems to predict subjective sleep quality outcomes, it would be interesting to investigate whether or not similar patterns appear in objective measures of pre-sleep affect and sleep.

Conclusion

My aim with this study has been to contribute to the gaining of knowledge on the ways positive and negative affect, and subjective sleep quality are related. So far, it seems that little research has sought to examine the predictive power of pre-sleep affect on subjective sleep quality in night-shift workers. With this study, however, I have started to examine this bidirectional relationship and to see to which degree it is possible to argue that affective valence influence subjective sleep quality the following night's sleep. It seems as though, cross-sectionally, negative affect is more strongly associated with subjective sleep quality, while over longer periods of time positive affect influence sleep quality while negative affect does not. The sleep-affect relationship has long been of interest in the world of psychological and medicinal research, but it seems as though a great amount of attention has been brought to investigate how sleep and sleep outcomes predict affect the following day, not vice versa. It is important to investigate the dimensions of this sleep-affect relationship which seems to influence various aspects of the mental and physical health of night-shift workers. A strength with this study has been that is has participated in the uncovering of the bidirectional relationship between affect and subjective sleep quality.

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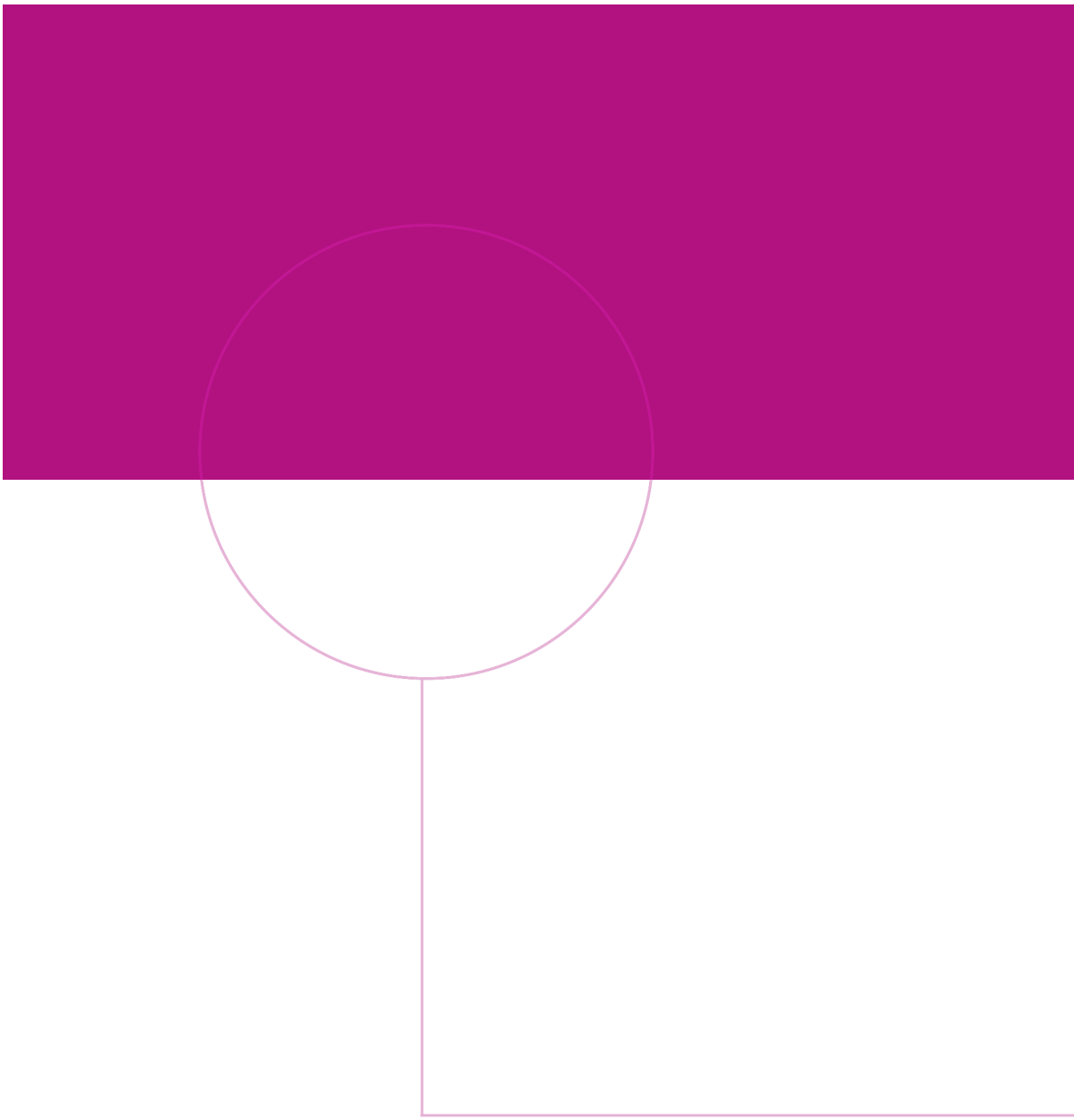

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