Subjective Sleep Disturbances are Associated with Intrinsic Motivation toward Sleep-related Thinking

Keisuke Takano[a] and Filip Raes[b]

[a] Department of Psychology, Clinical Psychology and Psychotherapy, Ludwig-Maximilians-University Munich, Germany;

[b] Center for the Psychology of Learning and Experimental Psychopathology, University of Leuven, Belgium

Correspondence concerning this article should be addressed to Keisuke Takano. Department of Psychology, Division of Clinical Psychology and Psychotherapy, Ludwig-Maximilians-University Munich, Leopoldstrasse.13, 80802 Munich, Germany. Telephone: +49 89 2180 5288. Fax: +49 89 2180 5224. E-mail: Keisuke.Takano@psy.lmu.de

Abstract

Biased information processing has been highlighted as a possible vulnerability factor for sleep problems. A theory states that perceived sleeplessness triggers a strong approach motivation (or craving) for sleep, and then activates persistent preoccupation with sleep. However, there is no clear evidence that perceived sleeplessness is associated with such a motivation toward sleep-related information. Thus, we examined the untested idea that people with subjective sleep disturbances would prefer sleep-related topics, using a modified version of the pay-per-view task. In this task, 58 participants were offered two question-type options: the “sleep” option, where participants were asked to answer a question about their sleep, and the “eat” option, where participants needed to answer a question about their eating habits and beliefs. Each option is associated with a variable amount of economic reward and therefore participants sometimes face a conflict between the economic reward and their intrinsic preference for a specific question type. Results showed that people with higher levels of subjective sleep disturbances forgo greater amounts of reward to have an opportunity to answer sleep-related (as opposed to than eating-related) questions. These findings suggest that people who perceive themselves as lacking sleep are highly motivated to engage in sleep-related information processing.

Keywords; intrinsic motivation, cognitive bias, sleep, insomnia

Subjective Sleep Disturbances are Associated with Intrinsic Motivation toward Sleep-related Thinking

Cognitive models of insomnia have highlighted the role of biased processing for sleep-related information (Espie, Broomfield, MacMahon, Macphee, & Taylor, 2006; Harvey, 2002). Several studies have shown that insomnia symptoms are significantly related to selective attention to sleep-related stimuli, i.e., objects that can be found in a bedroom such as a bed, pillow, and clock (for a review, see Harris, Spiegelhalder, Espie, MacMahon, Woods, & Kyle, 2015). Typically, people with sleep disturbances and/or a clinical diagnosis of insomnia attend to sleep-related stimuli faster than healthy controls (e.g., Jones, Macphee, Broomfield, Jones, & Espie, 2005; MacMahon, Broomfield, & Espie, 2006). Such biased attention is thought to contribute to excessive monitoring of internal (e.g., body sensation, mood) and external signals of sleep difficulty (e.g., clock monitoring; Woods, Marchetti, Biello, & Espie, 2009). Due to this monitoring process, sleep-related threats can be detected easily, thereby fueling rumination and worry about sleeplessness and daytime dysfunctioning (Harvey, 2002). Cross-sectional and prospective studies have suggested that ruminative (both sleep-focused and depression-focused) thinking is a good predictor of subjective and objective sleep problems (Carney, Harris, Moss, & Edinger, 2010; Takano, Iijima. & Tanno, 2012; Thomsen, Mehlsen, Christensen, & Zachariae, 2003; Wicklow & Espie, 2000).

Another important aspect of sleep-related cognition is that people who perceive sleep inadequacy would be atypically motivated by sleep. In their Attention-Intention-Effort (AIE) model, Espie and colleagues pointed out that people with (perceived) lack of sleep might place greater than normal value on sleep (Espie et al., 2006; Broomfield & Espie, 2005). In general, sleep is not a “special” state that requires conscious effort to be achieved, but rather is an involuntary psychophysiological process that should start automatically and spontaneously. Espie et al. (2006) used the analogy of food craving in hunger (e.g., people

who are hungry do not have any other interest than food) to describe the intrinsic motivation to sleep. Such a “craving” for sleep would trigger perseverative sleep preoccupation (e.g., “I want to sleep, but I can’t.”) and specific (sometimes irrational) behavioral strategies to induce sleep (e.g., drinking much alcohol before going to bed; Harvey, 2002). Supporting this notion, studies have suggested that inducing active intention to sleep (instructing participants to fall asleep as quickly as possible) prolongs sleep onset latency under high mental load (Ansfield, Wegner, & Bowser, 1996), and that an attempt to suppress pre-sleep thoughts (to initiate normal sleep) ironically prevents sleep onset (Harvey, 2003).

Interestingly, such a motivational aspect has also been discussed in the literature about depressive rumination. Studies have suggested that vulnerable individuals tend to hold “positive” beliefs about ruminative thinking, believing that it would be a useful coping strategy to resolve current problems and to prevent future mistakes (Papageorgiou & Wells, 2001; Watkins & Moulds, 2005). Because of such positive beliefs, people likely and voluntarily engage in excessive rumination, which not only increases emotional distress and arousal, but also reinforces avoidance from taking overt action for actual problem solving (Jacobson, Martell, & Dimidjian, 2001; Kingston, Watkins, & Nolen-Hoeksema, 2014). In reality, rumination is known to interfere with effective problem solving, because it induces more pessimistic and fatalistic thinking (Lyubomirsky & Nolen-Hoeksema, 1995; Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). In the context of sleep disturbances and insomnia, people would be highly motivated to think/ruminate about their sleep (quality), because they are in need of an effective strategy to resolve their current sleep problems.

Although such motivational aspects seem to play an important role in biased cognition in sleep disturbances, researchers have exclusively focused on attentional functioning (Harris et al., 2015). Hitherto, no study has examined the AIE model’s prediction that people who perceive themselves as lacking sleep would be highly motivated to approach

and think about sleep-related topics (i.e., place greater than normal value on sleep). Thus, in the present study, we tested whether subjective sleep disturbances are associated with the intrinsic motivation toward sleep-related information. To assess this motivational bias, we used a modified version of the Pay-Per-View (PPV) task (Deaner et al., 2005; Takano, Iijima, Sakamoto, & Raes, 2015; Tamir & Mitchell, 2012). In this task, participants are offered two question-type options (Figure 1). The first is the “sleep” option, in which participants are asked to answer a question about their sleep habits and beliefs; the second is the “eat” option, which is a control condition where participants are asked to answer a question about their eating habits and beliefs. We used “eat” topics as a counterpart of “sleep,” because, like sleep, eating is a regular daily behavior triggered by physiological needs. Importantly, each of the two options is presented together with a variable amount of reward, or a money token in the current study. In some trials, the “sleep” question type is associated with a greater amount of reward (e.g., +3 points) than the “eat” counterpart (e.g., +2 points); for the other trials, the “eat” option is associated with a larger amount of reward than the “sleep” option. Participants are instructed that they would obtain real money as extra compensation if they acquire a certain amount of points during the task. Thus, participants sometimes face a conflict between the presented reward and their intrinsic motivation to think about a particular topic (“sleep” or “eat”). If a participant is willing to forego reward to obtain an opportunity to think about sleep (i.e., choosing the “sleep” option that is associated with a smaller amount of reward relative to the “eat” option), this choice behavior can be interpreted as indicating that this participant has a greater intrinsic preference for sleep-related than non-sleep-related information. We hypothesized that higher levels of subjective sleep disturbances would be associated with greater amounts of reward that participants would sacrifice for the opportunity to think about a sleep topic.

Method

Participants

Sixty-one participants were recruited from a large sample pool of the University of Leuven, which covers its students and community living in Leuven and surrounds. No inclusion/exclusion criteria were used for recruiting participants, except that all participants were required to be fluent in Dutch. However, for statistical analyses, data from three participants were excluded because (a) one participant had poor compliance to experimental instructions (i.e., pressed the same key throughout the experiment) and (b) two participants had extremely low sensitivity to the reward (point tokens) that we used in the current experiment[1]. Although the mean amount of the tokens that participants acquired during the experiment was 170.9 points (*SD* = 15.7), these two participants acquired only 139 points or fewer. The final sample included 58 participants (11 males and 47 females) with a mean age of 22.2 (*SD* = 0.5) years.

Measures

Pittsburgh Sleep Quality Index (PSQI). Subjective sleep disturbances were assessed using the PSQI (Buysse et al., 1989). The PSQI comprises 19 items divided into seven sub-categories of insomnia symptoms: i.e., sleep duration, sleep disturbances, sleep latency, daytime dysfunction, sleep efficiency, sleep quality, and medication. These subcategories are scored on a 4-point scale ranging from 0 to 3 to reflect the severity of each symptom. The aggregation of these seven sub-scores is used as the global score of subjective sleep difficulty. The global score showed an acceptable internal consistency (α = .61).

Beck Depression Inventory-II (BDI-II). Depressive symptoms were measured using the BDI-II (Beck, Steer, & Brown, 1996; van der Does, 2002). The BDI-II consists of 21 items, and each item is rated on a 0–3 Likert scale. The aggregated score is used as an

[1] The problem is that their choice frequency of “sleep” did not increase monotonically as a (S-shaped) function of pay-offs. There were unpredictable ups and downs in their value function and, therefore, the PSE estimation was less reliable.

index of depressive symptoms. The BDI-II had a good internal consistency in the current data set (α = .93). We used the BDI-II to control for possible contamination by depressive symptoms and related negativity bias because some rating stimuli were phrased negatively.

Ruminative Response Scale (RRS). Depressive rumination was measured by using the RRS (Nolen-Hoeksema & Morrow, 1991; Raes & Hermans, 2007). This scale consists of 22 items, and each is rated on a 1-5 Likert scale. The aggregated score was used as an index of depressive rumination, which showed a good internal consistency in the current data (α = .89). We analyzed the RRS to test if the general persistency of negative cognition could be associated with the preference toward sleep-related topics (independently of the contents of thinking), or if the content-specificity plays a more important role over the thinking style.

Modified (sleep) version of the Pay-Per-View task

In each trial, participants were provided with two topic types (i.e., “sleep” and “eat”) that were associated with variable amounts of reward (Figure 1). In the choice display, which was presented for 2000 ms, participants were asked to indicate which topic they preferred to think about. As the two topic types were randomly allocated to the left and right sides of the display, participants pressed the corresponding “8” (left) or “9” (right) key to indicate their preference. Each option was always combined with reward, and participants were expected to make a choice while taking into account of the amount of reward, in addition to their preference for the “sleep” and “eat” topics. The reward was provided as a point token, which ranged from 0 to 4 points. Participants were informed that if the total amount of points that they acquired during the task exceeded a certain criterion, they would receive extra 10 euros in addition to the base compensation of 10 euros (i.e., 20 euros in total). The criterion for the extra compensation was not explicitly indicated in the instructions in order to avoid reward devaluation after achieving the criterion in the task. After the experiment, participants who achieved the criterion (i.e., 181 points) received 20 euros.

In the next rating display, participants were provided with a question about their sleeping or eating habits and beliefs. If participants chose the sleep option, they were asked to rate to what extent the presented sleep item is applicable to them (e.g., “I need 8 hours of sleep to function well during the day”), on a 5-point Likert scale with anchors ranging from (1) *not at all* to (5) *very much*. If participants chose the eat option, they were provided an eating related item (e.g., “I need 3 meals a day to work well during the day”) for the self-applicability rating. The “sleep” and eat “items” were randomly selected from a stimulus list, which consisted of 42 pairs of “sleep” and “eat” sentences that describe habits and beliefs about sleeping and eating behaviors. These questions were adapted from existing questionnaires, such as the Dysfunctional Beliefs and Attitudes about Sleep Scale (Morin, Vallieres, & Ivers, 2007) and the Eating Disorder Inventory (Garner, Olmstead, & Polivy, 1983)[2]. The paired questions were made to have a similar structure and meaning, for example:

Sleep: “People are happier when they sleep well.”
Eat: “People are happier when they eat well.”

Sleep: “Without sufficient sleep I can hardly function the next day,” and
Eat: “Without sufficient food I can hardly function during the day.”

Note that the sleep items included dysfunctional and irrational beliefs that are often observed in people with sleep difficulties or insomnia symptoms (e.g., Morin et al., 2007). This is mainly because we expected that people with subjective sleep disturbances would rate those items as more applicable to themselves than “rational” items.

[2] The full list of stimuli is available from the first author.

The PPV task consisted of 7 conditions in terms of relative payoffs (i.e., -3 to 3 points), which were defined as differences in the amount of reward between the “sleep” and “eat” options. Each of the 7 conditions had 8 trials, which resulted in 56 trials across the experiment. The order of the relative-payoff conditions was randomized.

Procedure

On arrival at the lab, the procedure of the experiment was explained to the participants, after which they provided written informed consent. First, participants completed a booklet of questionnaires, including the PSQI and BDI-II. Second, they engaged in three computer-based cognitive tasks, the PPV task, the dot-probe task (MacMahon et al., 2005), and the n-back task (cf. Levens & Gotlib, 2010). Results of the latter two tasks will be reported elsewhere as they relate to different research questions. The order of the tasks was randomized across participants. All study protocols were approved by the Social and Societal Ethics Committee of the University of Leuven.

Statistical analyses

As a preliminary analysis, we examined the associations between the PSQI score and self-applicability ratings on sleep- and eat-related stimuli in the PPV task. Because the “sleep” items should be more self-relevant for individuals with subjective sleep disturbances, the PSQI was expected to be positively correlated with the applicability ratings on the sleep questions.

Second, we examined simple correlations between the PSQI and choice frequency of the “sleep” option for each relative-payoff condition. If subjective sleep disturbances are associated with preference toward sleep-related materials, people with greater PSQI scores should choose the “sleep” option more frequently even when a payoff attached to the “sleep” option is relatively unfavorable compared to the “eat” counterpart.

Third, we modeled participants’ choice behavior as a function of the PSQI in the

framework of multilevel logistic regression analysis. This analytic approach allowed us to test the association between PSQI scores and the point of subjective equality (PSE). PSE indicates the amount of token points at which the values of the two question types were perceived to be equal, e.g., PSE of -1 indicates that participants perceived the “sleep” option as more valuable than the “eat” option by 1 token point. In this model, we assumed that the participants’ binary judgments (“sleep” vs. “eat”) followed a simple logistic function:

$$y_{ij} = \frac{1}{1+e^{-(\beta_{0j}+\beta_{1j}x_{ij})}},$$

where y_{ij} is the choice on the *i*-th trial of the *j*-th participant, which is coded as 1 for a “sleep” and 0 for an “eat” choice. The probability of choosing the “sleep” option can be assimilated by an S-shaped logistic function of the relative payoffs, x_{ij}, which ranges from −3 to +3 points. The shape of this function is determined by the intercept (β_{0j}) and slope (β_{1j}). The intercept influences the overall probability of a “sleep” response and the slope determines the steepness of the logistic function. Both the intercept and slope may vary across participants. Such individual differences are modeled by the person-level equations, as follows:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}PSQI_j + u_{oj}$$
$$\beta_{1j} = \gamma_{10} + \gamma_{11}PSQI_j + u_{1j},$$

$PSQI_j$ is the PSQI score (levels of subjective sleep disturbances) of the *j*-th participant, and the random effects, u_{0j} and u_{1j}, express unexplained individual differences in the intercept and slope. At this person level, we controlled levels of depressive symptoms (i.e., BDI-II scores) to examine the unique effect of the PSQI on “sleep” responses. Both the PSQI and BDI-II scores were standardized for ease of interpretation. By using the intercept and slope, PSE can be defined as follows:

$$PSE_j = -\frac{\beta_{0j}}{\beta_{1j}}.$$

Two conditional PSEs were calculated for higher and lower levels of subjective sleep

disturbances by substituting specific values of PSQI scores (i.e., mean ± 1*SD*; Preacher, Curran, & Bauer, 2006). As mentioned, PSE is a metric of intrinsic motivation to think about a “sleep” relative to “eat” topic, which is mapped on an economic (monetary) value scale. With a zero value, PSE infers no preference for either the “sleep” or “eat” question type. On the other hand, a negative PSE value indicates the amount of reward (or payoffs) that participants are willing to forgo for an opportunity to think about a “sleep” topic. The multilevel logistic analysis was performed using the SAS (version 9) NLMIXED procedure, and conditional PSEs (means, *SD*s, and confidence intervals) were estimated by the ESTIMATE statement.

Results

Descriptive statistics are shown in Table 1. There were 26 participants (45%) who had clinically significant levels of insomnia symptoms (> 5 on the PSQI) and 14 participants (24%) showed mild or even more severe levels of depressive symptoms (> 13 on the BDI-II). Participants with higher levels of insomnia symptoms rated sleep items as being more applicable to themselves. BDI-II and RSS scores were also significantly correlated with self-applicability ratings of sleep topics. This might be because sleep difficulty is also considered a typical symptom of depression.

Overall participants chose the option with a greater amount of reward, showing an S-shaped value function of relative payoffs for the “sleep” option (Figure 2). At the same time, participants preferred “sleep” over “eat” topics, as the average choice frequency of “sleep” was above chance (0.50) for the even pay-off condition and for the mean choice frequency across all pay-off conditions (Table 1). As expected, there were significant individual differences in subjective sleep disturbances in the “sleep” choice frequency. Correlational analyses showed (marginally) significant associations between PSQI scores and choice frequency of the “sleep” option for the relative-payoff conditions of -3, -2, and -1

points (*r*s = .25, .35, .28, respectively; *p*s < .055), wherein participants were offered a smaller amount of reward for the “sleep” than the “eat” option (Figure 3). However, for the equally or more favorable payoff conditions (0 to +3 points), PSQI scores were not significantly correlated with “sleep” choice frequency (*r*s = .08, .01, -.19, and -.16, for relative payoffs = 0, +1, +2, and +3, respectively). Although Figure 2 appears to indicate that people scoring low on the PSQI choose the “sleep” option more frequently for the pay-off conditions of +1 to + 3 points, this tendency was not supported in the correlational analyses on the whole sample. Overall, the current results suggest that people with greater levels of subjective sleep disturbances choose “sleep” topics more frequently, when the “sleep” option is associated with unfavorable payoffs.

To inspect the general preference toward “sleep” relative to “eat” topics, we estimated PSE using a multilevel logistic model, in which the “sleep” response was predicted by relative payoffs, PSQI scores, and their interactions. Even after controlling for depressive symptoms, PSQI scores were a significant predictor of the intercept of the logistic function, which suggests that individuals with higher levels of insomnia symptoms tend to choose the “sleep” option more frequently (Table 2). PSEs were computed by substituting specific values (i.e., mean ± 1*SD*) of PSQI scores into the estimated logistic model for higher and lower levels of subjective sleep disturbances. Mean PSE was significantly lower for individuals with higher levels of sleep disturbances, *M* = -0.43, *SE* = 0.09, 95% CI [-0.61, -0.24], than for those with lower levels, *M* = -0.12, *SE* = 0.07, 95% CI [-0.27, 0.03], $t(56) = 2.46$, $p = .02$. These results suggest that individuals with subjective sleep disturbances have a greater preference for sleep-related information; more precisely, those individuals perceive a sleep-related topic as having a greater value than an eat-related topic by 0.43 points. On the other hand, people without subjective sleep disturbances dot not have such specific preferences either toward sleep- or eat-related materials, as PSE was distributed around zero.

These results remained unchanged even after excluding the “sleep disturbances” subscale from the total score of the PSQI. This may suggest that the increased preference is not due to a third factor that influences sleep quality (e.g., sleep apnea, pain).

The results of the multilevel logistic analysis also showed that individuals with higher levels of depressive symptoms had a less steep logistic function with a lower intercept. However, PSE was not significantly different between higher and lower levels of depressive symptoms, M = -0.16 (SE = 0.09) vs. M = -0.35 (SE = 0.07), $t(56) = 1.50$, $p = .14$. These results imply that there is no significant difference in the overall preference for sleep (and eat) topics between people with higher and lower levels of depressive symptoms. Instead, the individual differences in the value function (i.e., the intercept and slope) suggest a general deficit in reward sensitivity for people with depressive symptoms, who sometimes chose an option with an unfavorable payoff independently of the topic. Depressive rumination, which had a similar correlation matrix to that of the BDI-II (Table 1), showed no significant effect on sleep-choice frequency when added to the logistic regression model: for the intercept, B = -0.12, SE = 0.13, t = 0.96, p = 0.34; for the slope, B = -0.28, SE = 0.23, t = 1.20, p = 0.24. These null effects suggest that depressive rumination is not associated with the preference toward sleep-related information.

Discussion

In the present study, we examined individual differences in biased preference toward sleep-related information according to the levels of subjective sleep disturbances. Results suggest that individuals with subjective sleep disturbances are willing to forego economic reward to obtain an opportunity to think about their sleep habits and beliefs. This is, to the best of our knowledge, the first evidence that subjective sleep disturbances are associated with intrinsic motivation to engage in sleep-related information processing.

Cognitive studies (e.g., Harris et al., 2015) have suggested that insomnia is

associated with selective attention to sleep-related stimuli. As attention is easily captured by sleep-related information, people with insomnia are likely to engage in excessive monitoring of internal and external cues of sleep (e.g., Woods et al., 2009), and therefore worry and rumination about sleeplessness and daytime dysfunctions would be activated (e.g., Harvey, 2002). In addition to the attentional bias, our findings suggest that people who perceive lack of sleep tend to engage in sleep-related thinking voluntarily even when it is associated with unfavorable payoffs. Such intrinsic motivation toward sleep-related information appears to be consistent with the intention and effort pathways in the Attention-Intention-Effort model (Espie et al., 2006). This model proposes that the perception of sleeplessness triggers cravings for sleep, which further contributes to perseverative sleep preoccupation. This motivational perspective could well explain why people continue to worry and rumination about their sleep(lessness). Attention per se may be most relevant to the initiation of sleep-related information processing, given the relatively short and fast timeframe of selective attention. On the other hand, the motivational process would be more relevant to a bias operating at a later stage. After attention being captured by sleep-related stimuli and lack of sleep is perceived, people would voluntarily and willingly try to find a possible strategy to resolve their (perceived) sleep problems (cf. Papageorgiou & Wells, 2001). Such an active intention to sleep may cause an effortful process, where people struggle to fall asleep, ironically disturbing normal sleep initiation (Espie et al., 2006).

There are alternative explanations for the results apart from the beliefs about sleep(lessness); e.g., people scoring high on the PSQI might be unable to keep the task goal (i.e., maximizing the token points) in mind, and therefore they may - to some extent - have ignored the favorable pay-offs that were associated with the “eat” option. This ignorance could be partly attributed to the reduced reward sensitivity, which was more clearly associated with depressive symptoms in the current data. Given the substantial overlap

between subjective sleep disturbances and depressive symptoms, it is possible that impairment in such a basic reward processing system interacted with the beliefs about sleep to generate the biased intrinsic motivation toward sleep-related information.

It is also noteworthy that the current study uses a parallel behavioral experiment that examined self-negativity bias in people with depressive symptoms. Our previous work using a similar PPV task (Takano et al., 2016) suggests that people with depressive symptoms are willing to forego monetary reward to obtain an opportunity to think about negative aspects of the self, which may indeed be indicative of “positive beliefs” about negative self-reference in vulnerable individuals (see also Papageorgiou & Wells, 2001). Given the similarity between the two variants of the pay-per-view task, the intrinsic motivation to thinking about a symptom-specific theme can be a common feature of pathological cognition for depression and sleep disturbances. Still, the domain specificity as for the targets and contents of preferred information (“negative self” for depression and “sleep” for sleep disturbances) would play an important role in individual symptomatology. It is not that surprising that we found no significant effect of depressive rumination on the preference toward sleep-related information as the PPV task likely captures a more domain- or topic-specific (in this case sleep-related) preference of thinking rather than a general persistent thinking style. In the current study, we only assessed ruminative responses to depressive symptoms but not ruminative thinking about sleep (problems), because there exists, to the best of our knowledge, no rumination measure that specifically taps into sleep-related concerns. To establish the hypothetical link between biased intrinsic motivation and persistent cognition in the context of sleep and insomnia, future research should focus on developing a specific tool to assess sleep-related preoccupations.

Of course, there are limitations that should be mentioned. In the current study, we solely relied on a self-report measure (i.e., PSQI) to assess subjective sleep disturbances.

Although subjective complaints are one of the most important criteria of insomnia (e.g., Buysse, 2008) and we primarily focused on cognitive problems in sleep disturbances, sleep is a physiological phenomenon by nature. Future research should use objective measures of sleep, such as polysomnography and/or actigraphy, to clarify whether the motivational bias is evident for people with “real” deficits in sleep or only for those with a perception of sleeplessness (misperception of sleep; Harvey & Tang, 2012). At the same time, it would be important to use diagnostic interviews to assess “clinical” insomnia and depression. Second, the current study used a cross-sectional design. Without temporal changes, we cannot determine the causal direction between the sleep-related bias and subjective sleep disturbances. A longitudinal study is warranted to establish whether the cognitive bias is, as hypothesized in the cognitive models of insomnia, a vulnerability factor to develop future sleep problems. Third, the non-clinical nature of the current sample may limit the clinical implications of the results. It should be noted, however, that our sample had a fairly high number of individuals with clinically significant levels of sleep disturbances, with 45% scoring above the cut-off of the PSQI. The majority of our sample consisted of university students, who often show a high prevalence of significant sleep problems (Lund, Reider, Whiting, & Prichard, 2010). This shows that it is also important to investigate (vulnerability for) sleep problems in such younger age groups as well, besides patients samples, which typically consist of relatively older adults. Still we believe that further research using clinical samples is warranted to gain more insight into sleep/insomnia cognition. At the same time, a more elaborate sampling (or screening) strategy would be beneficial, as we could not eliminate potential contamination by other factors that influence sleep quality (e.g., sleep apnea).

Despite the above-mentioned limitations, the current study sheds new light on the potential role of intrinsic motivation in sleep-specific cognitive bias and its association with

subjective sleep disturbances. Results clearly show that people who perceive themselves as experiencing a lack of sleep tend to approach sleep-related information, which may cause a sleep-related preoccupation and “effortful” sleep processes (Espie et al., 2006). Future research needs to examine a clinical sample to establish the influences of the motivational factors on sleep disorders.

Acknowledgement

We thank Louise Vanden Poel and Sarah Van den Brande for their assistance in data collection. Keisuke Takano was supported by Humboldt Research Fellowship for Postdoctoral Researchers of the Alexander von Humboldt foundation. Filip Raes was supported by the KU Leuven Research Council grant PF/10/005.

References

Ansfield, M .E., Wegner, D. M., & Bowser, R. (1996). Ironic effects of sleep urgency. *Behaviour Research and Therapy, 34,* 523–531. doi: 10.1016/0005-7967(96)00031-9

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Beck Depression Inventory* (2nd ed.). San Antonio, TX: The Psychological Corporation.

Broomfield, N. M., & Espie, C. A. (2005). Towards a valid, reliable measure of sleep effort. Journal of Sleep Research, 14, 401–407. doi: 10.1111/j.1365-2869.2005.00481.x

Buysse, D. J. (2008). Chronic insomnia. *American Journal of Psychiatry, 165,* 678–686. doi: 10.1176/appi.ajp.2008.08010129.

Buysse, D. J., Reynolds, C. F. 3rd, Monk, T. H., Berman, S. R., Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research, 28,* 193–213. doi:10.1016/0165-1781(89)90047-4

Carney, C. E., Harris, A. L., Moss, T. G., & Edinger, J. D. (2010). Distinguishing rumination from worry in clinical insomnia. *Behaviour Research and Therapy, 48,* 540–546. doi: 10.1016/j.brat.2010.03.004.

Deaner, R. O., Khera, A. V., Platt, M. L. (2005). Monkeys pay per view: adaptive valuation of social images by rhesus macaques. *Current Biology, 15,* 543–548. doi: 10.1016/j.cub.2005.01.044

Espie, C. A., Broomfield, N. M., MacMahon, K. M., Macphee, L. M., & Taylor, L. M. (2006). The attention-intention-effort pathway in the development of psychophysiologic insomnia: a theoretical review. *Sleep Medicine Review, 10,* 215–245. doi:10.1016/j.smrv.2006.03.002

Garner, D. M., Olmstead, M. P., & Polivy, J. (1983). Development and validation of a multidimensional eating disorder inventory for anorexia nervosa and bulimia. *International Journal of Eating Disorders, 2,* 15–34. doi:

10.1002/1098-108X(198321)2:2<15::AID-EAT2260020203>3.0.CO;2-6

Harris, K., Spiegelhalder, K., Espie, C. A., MacMahon, K. M., Woods, H. C., & Kyle, S. D. (2015). Sleep-related attentional bias in insomnia: A state-of-the-science review. *Clinical Psychology Review, 42*, 16–27. doi: 10.1016/j.cpr.2015.08.001.

Harvey, A. G. (2002). A cognitive model of insomnia. *Behaviour Research and Therapy, 40*, 869–893. Doi: 10.1016/S0005-7967(01)00061-4

Harvey, A.G. (2003). The attempted suppression of presleep cognitive activity in insomnia. *Cognitive Therapy and Research, 27*, 593–602. doi:10.1023/A:1026322310019

Harvey, A. G., & Tang, N. K. (2012). (Mis)perception of sleep in insomnia: A puzzle and a resolution. *Psychological Bulletin, 138*, 77–101. doi: 10.1037/a0025730

Jacobson, N. S., Martell, C. R., & Dimidjian, S. (2001). Behavioral activation treatment for depression: returning to contextual roots. *Clinical Psychology: Science and Practice, 8*, 255–270. doi: 10.1093/clipsy.8.3.255

Jones, B. T., Macphee, L. M., Broomfield, N. M., Jones, B. C., & Espie, C. A. (2005). Sleep-related attentional bias in good, moderate and poor (primary insomnia) sleepers. *Journal of Abnormal Psychology, 114*, 249–258. doi: 10.1037/0021-843X.114.2.249

Kingston, R. E. F., Watkins, E. R., & Nolen-Hoeksema, S. (2014). Investigating functional properties of depressive rumination: Insight and avoidance. *Journal of Experimental Psychopathology, 5*, 244–258. doi: 10.5127/jep.038013

Levens, S. M., & Gotlib, I. H. (2010). Updating positive and negative stimuli in working memory in depression. *Journal of Experimental Psychology: General, 139*, 654–664. doi: 10.1037/a0020283.

Lund, H. G., Reider, B. D., Whiting, A. B., & Prichard, J. R. (2010). Sleep patterns and predictors of disturbed sleep in a large population of college students. *Journal of Adolescent Health, 46*, 124–132. doi: 10.1016/j.jadohealth.2009.06.016

Lyubomirsky, S., & Nolen-Hoeksema, S. (1995). Effects of self-focused rumination on negative thinking and interpersonal problem solving. *Journal of Personality and Social Psychology, 69,* 176–190. Doi: 10.1037/0022-3514.69.1.176

MacMahon, K. M. A., Broomfield, N. M., & Espie, C. A. (2006). Attention bias for sleep-related stimuli in primary insomnia and delayed sleep phase syndrome using the dot-probe task. *Sleep, 29,* 1420–1427.

Morin, C. M., Vallières, A., & Ivers, H. (2007). Dysfunctional beliefs and attitudes about sleep (DBAS): validation of a brief version (DBAS-16). *Sleep, 30,* 1547–1554.

Nolen-Hoeksema, S., & Morrow, J. (1991). A prospective study of depression and posttraumatic stress symptoms after a natural disaster: The 1989 Loma Prieta earthquake. *Journal of Personality and Social Psychology, 61*, 115-121. doi:10.1037/0022-3514.61.1.115

Papageorgiou, C., & Wells, A. (2001). Positive beliefs about depressive rumination: development and preliminary validation of a self-report scale. *Behavior Therapy, 32,* 13–26. doi: 10.1016/S0005-7894(01)80041-1

Raes, F., & Hermans, D. (2007). *The revised version of the Dutch Ruminative Response Scale*. Unpublished instrument.

Takano, K., Iijima, Y., Sakamoto, S., Raes, F., & Tanno, Y. (2016). Is self-positive information more appealing than money? Individual differences in positivity bias according to depressive symptoms. *Cognition and Emotion, 30,* 1402–1414. doi: 10.1080/02699931.2015.1068162

Takano, K., Iijima, Y., & Tanno, Y. (2012). Repetitive thought and self-reported sleep disturbance. *Behavior Therapy, 43,* 779–789. doi: 10.1016/j.beth.2012.04.002

Tamir, D. I., & Mitchell, J. P. (2012). Disclosing information about the self is intrinsically rewarding. *Proceedings of the National Academy of Sciences, USA, 109,* 8038–8043.

doi: 10.1073/pnas.1202129109

Thomsen, D. K., Mehlsen, M. Y., Christensen, S., & Zachariae, R. (2003). Rumination—relationship with negative mood and sleep quality. *Personality and Individual Differences, 34,* 1293–1301. doi:10.1016/S0191-8869(02)00120-4

Van der Does, A. J. W. (2002b). *Handleiding bij de Nederlandse bewerking van de BDI-II. [Manual of the Dutch version of the BDI-II]*. Amsterdam, the Netherlands: Pearson Assessment.

Watkins, E., & Moulds, M. (2005). Positive beliefs about rumination in depression – a replication and extension. *Personality and Individual Differences, 39,* 73–82. doi:10.1016/j.paid.2004.12.006

Wicklow, A., & Espie, C. A. (2000). Intrusive thoughts and their relationship to actigraphic measurement of sleep: Towards a cognitive model of insomnia. *Behaviour Research and Therapy, 38,* 679–693. doi:10.1016/S0005-7967(99)00136-9

Woods, H., Marchetti, L. M., Biello, S. M., & Espie, C. A. (2009). The clock as a focus of selective attention in those with primary insomnia: An experimental study using a modified Posner paradigm. *Behaviour Research and Therapy, 47,* 231–236. doi: 10.1016/j.brat.2008.12.009

Table 1

Descriptive Statistics and Correlations of Questionnaires and Rating Scores in the Pay-Per-View (PPV) Task (N = 58)

	Mean	*SD*	Correlations with		
			PSQI	BDI-II	RRS
PSQI	5.53	2.33	-	-	
BDI-II	9.69	9.31	0.60**	-	
RRS	43.42	11.66	0.53**	0.57**	-
PPV performances					
Self-applicability: “Sleep”	2.61	0.53	0.59**	0.45**	0.39**
Self-applicability: “Eat”	2.30	0.36	-0.06	0.07	0.14
Choice frequency of “Sleep”					
Payoff = -3	0.10	0.20	0.25+	0.16	0.14
Payoff = -2	0.13	0.22	0.35*	0.19	0.24+
Payoff = -1	0.18	0.23	0.28*	0.33*	0.22
Payoff = 0	0.65	0.23	0.08	-0.19	-0.10
Payoff = +1	0.93	0.17	0.01	-0.23+	-0.25+
Payoff = +2	0.95	0.10	-0.19	-0.31*	-0.35*
Payoff = +3	0.95	0.11	-0.16	-0.33*	-0.23+
Average across conditions	0.55	0.09	0.28*	0.00	0.00

Note. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II. RRS = Ruminative Response Scale. ** $p < .01$, * $p < .05$, + $p < .10$.

Table 2

Parameter Estimates for the Multilevel Logistic Model Predicting the "Sleep" response option (N = 58)

	Estimates	*SE*	*t*	95% CI
Intercept (β_{0j})				
Intercept	0.61	0.11	5.68**	[0.39, 0.82]
PSQI	0.35	0.13	2.79**	[0.10, 0.60]
BDI-II	-0.34	0.12	-2.77**	[-0.59, -0.09]
Slope (β_{1j})				
Intercept	2.22	0.21	10.61**	[1.80, 2.64]
PSQI	0.01	0.23	0.06	[-0.45, 0.48]
BDI-II	-0.51	0.23	-2.24*	[-0.98, -0.05]

Note. PSQI = Pittsburgh Sleep Quality Index; BDI-II = Beck Depression Inventory II.

** $p < .01$, * $p < .05$.

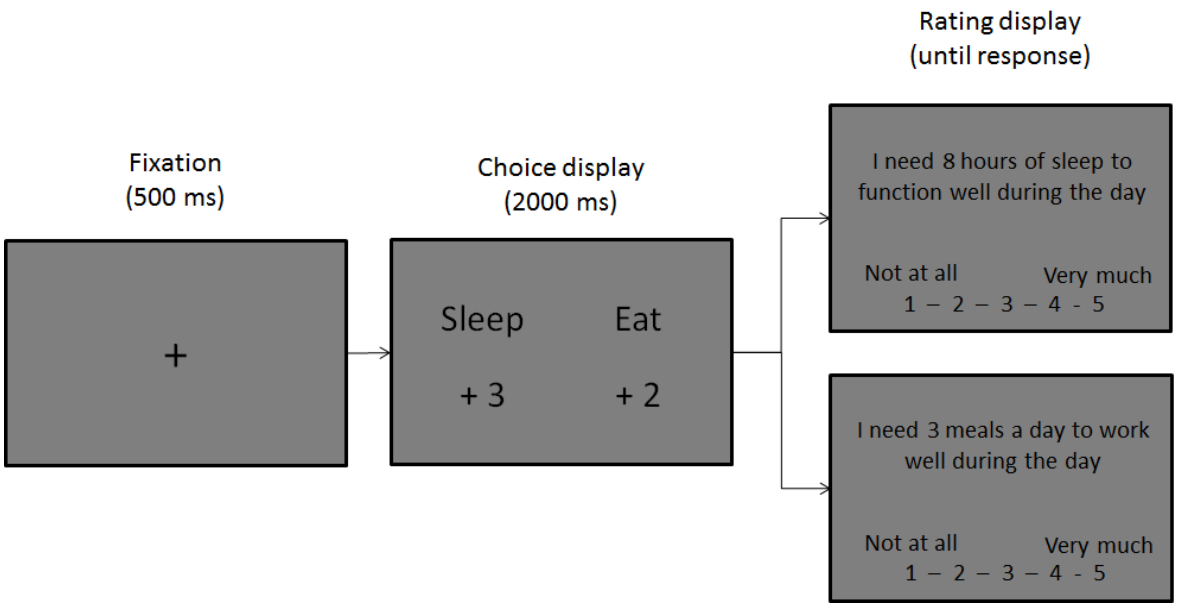

Figure 1

Schematic flow of a single trial of the sleep version of the Pay-per-view task. In the choice display, participants indicated which option they prefer: the left ("sleep" and "+3" points) vs. right ("eat" and "+2" points). If the option where "sleep" was chosen, a question about sleep was displayed in the rating display (top of the "Rating display").

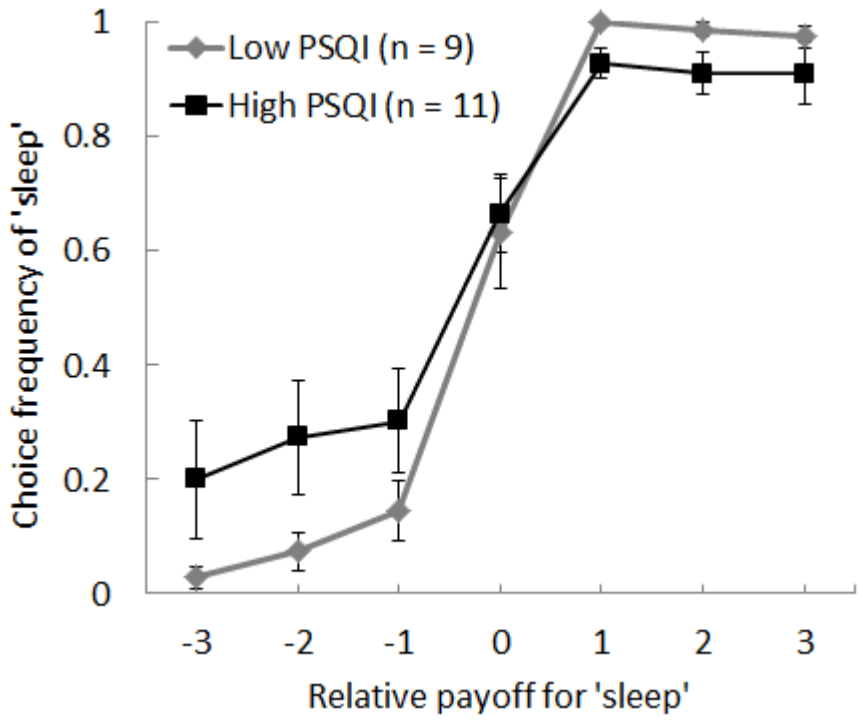

Figure 2. Choice frequency of the "sleep" option as a function of relative payoffs for individuals with higher and lower levels of insomnia symptoms (mean ± 1 *SD*) measured using the Pittsburgh Sleep Quality Index (PSQI). The relative payoff was defined by subtracting the payoff attached to "eat" from that of "sleep."

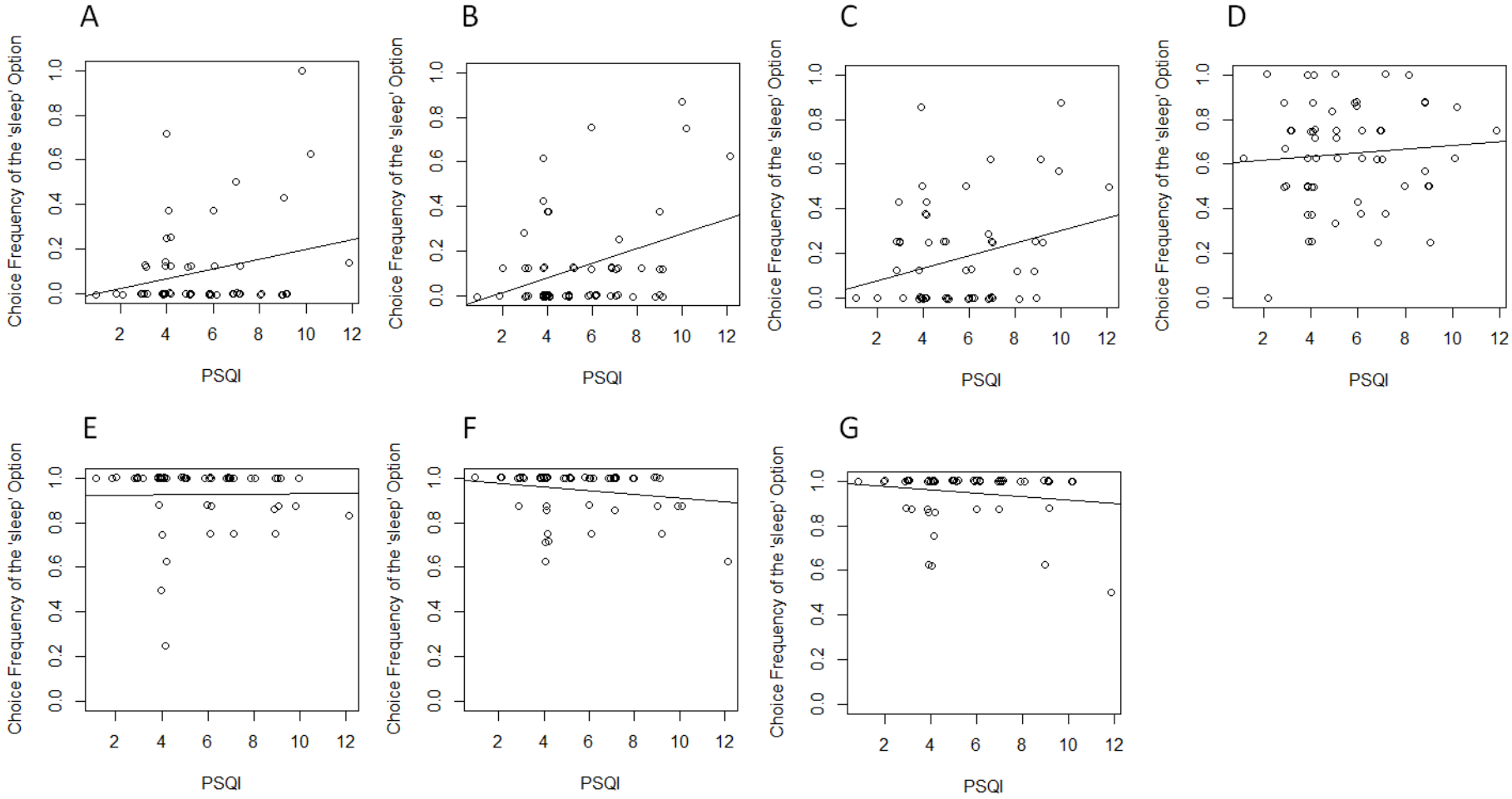

Figure 3. Choice frequency of the "sleep" option as a function of Pittsburgh Sleep Quality Index (PSQI) scores (N = 58). Each panel corresponds to the relative-payoff condition of -3 to +3 points (Panels A-G). Plotted values were jittered by a small amount of random noise.