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Individuals with Clinically Significant Insomnia Symptoms are characterised by a Negative
Sleep-Related Expectancy Bias: Results from a Cognitive-Experimental Assessment

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Abstract

Cognitive models of insomnia consistently suggest that negative expectations regarding the consequences of poor sleep contribute to the maintenance of insomnia. To date, however, no research has sought to determine whether insomnia is indeed characterised by such a negative sleep-related expectancy bias, using objective cognitive assessment tasks which are more immune to response biases than questionnaire assessments. Therefore, the current study employed a reaction-time task assessing biased expectations among a group with clinically significant insomnia symptoms ($n=30$) and a low insomnia symptoms group ($n=40$). The task involved the presentation of scenarios describing the consequences of poor sleep, and non-sleep related activities, which could be resolved in a benign or a negative manner. The results demonstrated that the high insomnia symptoms group were disproportionately fast to resolve sleep-related scenarios in line with negative outcomes, as compared to benign outcomes, relative to the low insomnia symptoms group. The two groups did not differ in their pattern of resolving non-sleep related scenarios. This pattern of findings is entirely consistent with a sleep-specific expectancy bias operating in individuals with clinically significant insomnia symptoms, and highlights the potential of cognitive-experimental assessment tasks to objectively index patterns of biased cognition in insomnia.

An estimated 10%-33% of the population experience symptoms of insomnia at any given point in time (Bartlett, Marshall, Williams, & Grunstein, 2008; Lack, Miller, & Turner, 1988; Olson, 1996). Poor sleep is often accompanied by undesirable symptoms such as daytime fatigue, decreased alertness and concentration, poor memory, lack of motivation or emotional disturbances (Orzel-Gryglewska, 2010). Individuals who experience chronic sleep problems are known to be at an increased risk of developing numerous psychological and physiological conditions. For example, those with insomnia are twice as likely to develop depression (Baglioni et al., 2011), and are at an increased risk of poor physical health (Cheng, Pillai, Mengel, Roth, & Drake, 2015). It is therefore unsurprising that the financial burden of insomnia is extremely high; a conservative estimate placed the direct insomnia-related costs in the United States alone at between \$30 to US\$35 billion per year (Walsh & Engelhardt, 1999) with the more substantial indirect costs (e.g. physical health, accident risk, diminished workplace performance) bringing this estimate closer to \$100 billion (Wickwire, Shaya, & Scharf, 2016). However, despite the significant burden to individuals and society more generally, the factors that underlie the development and maintenance of insomnia remain poorly understood, underscoring the need to enhance current knowledge regarding the mechanisms that underpin insomnia (Morin et al., 2015).

Cognitive models consistently implicate the role of information processing biases in the maintenance of insomnia (Espie, Broomfield, MacMahon, Macphee, & Taylor, 2006; Harvey, 2002). While there has been a key focus on the role of biased attention to sleep-related negative information in recent years (Harris et al., 2015), such models also emphasise the role of biased expectations regarding the negative consequences of poor sleep. For example, Harvey's (2002) cognitive model of insomnia describes a cycle involving dysfunctional patterns of cognition, triggering an autonomic response that heightens arousal and anxiety leading to disruption in sleep onset and/or maintenance. In particular, the model proposes that negative cognitions (operating both during the day and

immediately preceding sleep) concerning the negative daytime consequences of poor sleep can serve to elevate cognitive and physiological arousal and interfere with sleep onset and quality (Harvey, 2002). This model therefore clearly emphasises the influence of negatively biased expectations regarding the outcome of poor sleep as a maintaining factor for insomnia.

Other models, such as Espie et al.'s (2006) attention-intention model, which place greater emphasis on biased attention in insomnia, also acknowledge the potential role of biased expectations regarding the consequences of poor sleep. This has been informed by past findings revealing that the content of pre-sleep cognitions among individuals with elevated insomnia symptoms is consistently characterised by a focus on the anticipated consequences of disrupted sleep, which in turn is associated with longer duration to attain sleep onset (Wicklow & Espie, 2000). This focus on biased expectancies is also reflected in many measures employed in insomnia research. For example, the Dysfunctional Beliefs and Attitudes about Sleep scale (DBAS; Morin, Vallières, & Ivers, 2007) includes items such as: "After a poor night's sleep, I know that it will interfere with my daily activities on the next day" (Item 5).

Despite the apparent consensus about the role of negative expectancies in insomnia, we are aware of no research that has sought to confirm the presence of such a bias among individuals with clinically significant sleep difficulties using an objective cognitive assessment task. Computerised assessments can offer an objective method of evaluating the presence of cognitive biases in insomnia (Espie et al., 2006), and carry the advantage of being comparatively immune to response bias compared to self-report instruments (MacLeod, 1993). These tools can therefore also be useful in providing objective outcome assessments of interventions that seek to specifically target such cognitive processes. Thus, it is crucial to determine whether the self-reported presence of such a bias among individuals with sleep difficulties genuinely reflects the tendency to

spontaneously generate negative expectations regarding the negative consequences of poor sleep.

While no other research we are aware of has sought to directly examine the presence of sleep-specific biased expectations in insomnia, two previous studies have employed computerised cognitive assessment tasks to assess the presence of biased interpretation in insomnia. Ree, Pollit, & Harvey (2006) initially examined whether poor sleepers showed a general, or sleep-specific negative interpretive bias compared to good sleepers. They presented participants with a number of ambiguous scenarios, half of which had an insomnia consistent interpretation, the other half could have been interpreted in a generally negative or benign (sleep-unrelated) manner. The presentation of the scenario was followed by an open-ended response where participants were asked to write down what they thought the sentence was describing, which was then followed by the presentation of two possible interpretations of the sentence. For example the sentence “Angela worried about how she would make it to work the following day” could be followed by “Angela is exhausted vs. Angela had a problem with her car” (Ree et al., 2006, p1360). This study found that the poor sleepers tended to make more negative interpretations overall, but did not show any specific tendency to make more sleep-related interpretations compared to the good sleepers.

Acknowledging the potential for the original task to be influenced by response bias, in a follow-up study, Ree and Harvey (2006) implemented a response-time variant of the scenario task. In this task, ambiguous scenarios (potentially sleep-relevant and sleep-irrelevant) were followed by a word or non-word to which they were required to perform a lexical decision to index the relative primed meaning of different interpretations. For example, the scenario “Rosemary tried to disguise the size of her bags” could be followed by the word “shopping” (insomnia-unrelated interpretation) or “eyes” (insomnia-related interpretation; Ree & Harvey, 2006, p252). The results of this study again indicated that

while current sleepiness was associated with the general tendency to impose more negative interpretations, there was no specific tendency for individuals with insomnia to impose sleep-related interpretations.

Of relevance to these findings, while models of insomnia consistently implicate the role of biased expectations in the maintenance of sleep problems, it appears that there is comparatively little emphasis on biased interpretation (Espie et al., 2006; Harvey, 2002). This contrasts with models of anxiety which consistently emphasise a role of biased interpretation favouring negative resolutions of ambiguity (Williams, Watts, MacLeod, & Mathews, 1997). While interpretations involve resolving current emotionally ambiguous information in a negative or benign manner, biased expectations in contrast focus specifically on the future likelihood of negative or benign outcomes. Critically, neither Ree and Harvey (2006) or Ree et al. (2006) included a measure of biased expectations. As such, the absence of sleep-specific biased interpretations among poor sleepers in these previous studies could implicate alternative cognitive processes, such as biased expectations operating in insomnia.

As such, the primary aim of the current study was to determine the presence of biased expectations regarding the negative consequences of poor sleep among individuals with elevated levels of insomnia symptoms in comparison to good sleepers. Given the past findings of Ree and Harvey (2006) and Ree et al. (2006), in addition to the co-occurrence of anxiety and mood problems among individuals who experience sleep difficulties, it is also important to establish the relative specificity of biased expectancies. That is, whether individuals with clinically significant insomnia symptoms show biased expectations toward negative outcomes for a range of scenarios, or whether this is restricted to situations involving poor sleep in particular. Thus, the secondary aim of the current study was to determine if any pattern of biased expectations for negative outcomes represents a general

tendency versus a specific sleep-related pattern of cognition held by individuals with clinically significant insomnia symptoms.

In order to achieve these key aims, we created a task capable of indexing expectancy bias for sleep specific and general information. This task used multiple trials depicting situations where the future probability of a negative or benign outcome is initially indeterminate, before then assessing the relative ease with which individuals can resolve scenarios depicting benign over negative outcomes. To achieve this, we employed an adapted version of Mathews and Mackintosh's (2000) interpretive bias assessment task. In this task, participants are presented with an initial sentence, which is concluded with a word fragment that when resolved renders the scenario negative or positive. For the current study we created scenarios that focus on the potential consequences of poor sleep, in addition to a number of more general scenarios, which could either be resolved in a benign or negative manner. For example the scenario: "If I don't get enough sleep tonight, tomorrow my mind will be...", could be followed by the word fragment 'fu_zy' (fuzzy—negative resolution) or 'f_nct_onal' (functional—benign resolution). Individuals with a more negative expectancy bias would be expected to more readily solve scenarios that are resolved negatively than scenarios that are resolved in a benign manner. Conversely, those with a more benign expectancy bias would be expected to solve scenarios that are resolved in a benign manner more easily than scenarios resolved negatively.

If insomnia is associated with a negative sleep-related expectancy bias, then it is expected that those with high insomnia symptoms will be faster to resolve sleep-related scenarios where the resolution is negative, as opposed to scenarios where the resolution is benign, compared to those with low levels of insomnia symptoms. Furthermore, if biased expectations are restricted to sleep-related information, then it is expected that such a pattern of effects will only be observed for sleep-related scenarios and not scenarios related to more general threat.

Method

Participants

To assess the existence of an expectancy bias in those with high insomnia symptoms, the current study sought to recruit two groups of participants who differed on their levels of insomnia symptoms. Prospective participants ($n = 828$) comprising undergraduate students attending the University of Western Australia and members of the community, were screened on their levels of insomnia symptoms, using the Insomnia Severity Index (ISI; Bastien, Vallieres, & Morin, 2001). Community members registered their potential interest in being involved in this (and other) research conducted through the School of Psychology via response to social media advertising and subsequent completion of screening. Candidate participants with a score of 15 or above on the ISI ($N = 132$; consistent with clinically significant insomnia symptoms; Bastien et al., 2001), were targeted for recruitment to the high insomnia symptoms group. Those with a score of five or lower on the ISI, corresponding to the bottom 20% of scores within the prospective participants ($N = 306$), were targeted for the low insomnia symptoms group. These candidate participants were invited to take part in the study via email. The remainder of the screened sample, with scores falling outside either range, were not contacted for participation. A total of 30 individuals meeting the criteria for 'high insomnia symptoms' ($M_{age} = 22.37$, $SD = 7.90$; 20 female) and 40 individuals meeting the criteria for 'low insomnia symptoms' ($M_{age} = 20.90$, $SD = 6.21$; 22 female) responded and took part in the study. All participants fell within the desired age range of 17-55 years. Figure 1 depicts participant flow through the study.

Materials

Several self-report questionnaires were administered initially to evaluate participants' level of sleep quality and overall emotional susceptibility.

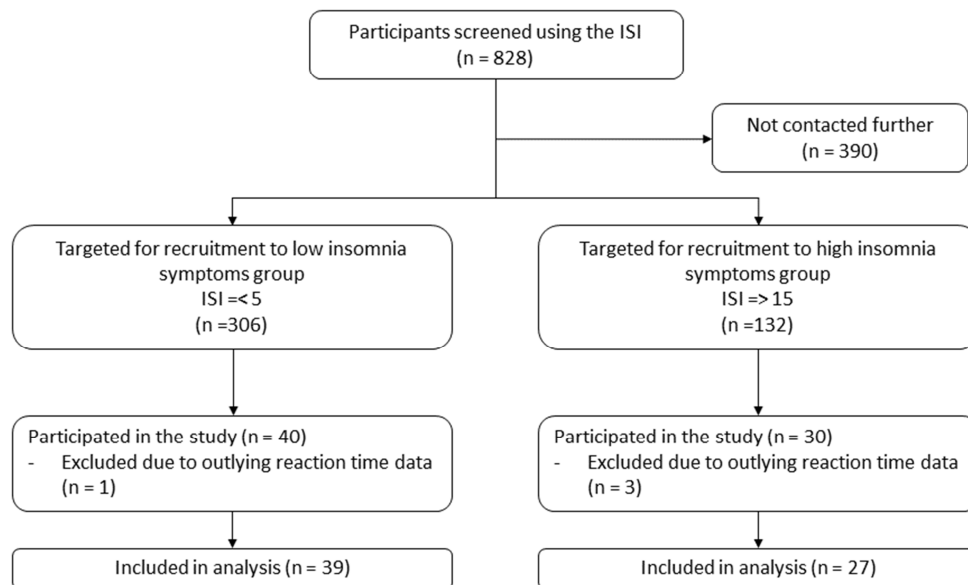


Figure 1. Participant flow through the study (ISI = Insomnia Severity Index).

Insomnia Severity Index (ISI). The ISI (Bastien et al., 2001) is a 5-item self-report measure that specifies a quantitative measure of the degree of severity of sleep difficulties, such as sleep onset and maintenance problems, and interference with daily functioning. The ISI has good internal consistency and concurrent validity ($\alpha = .76$ to $.78$; correlation with sleep diary variables = $.32$ to $.91$; Bastien, et al., 2001). The ISI was used exclusively for the purpose of screening initial participants for potential eligibility in the current study.

Pittsburgh Sleep Quality Index (PSQI). The PSQI (Buysse, Reynolds Iii, Monk, Berman, & Kupfer, 1989) includes seven measures of sleep, including total sleep time, sleep onset latency, and sleep efficiency. The PSQI can differentiate “good” sleepers from “poor” sleepers, with a total score of 5 or above denoting a poor sleeper. It has good internal consistency and reliability for all seven measures (Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002).

Anxiety and Preoccupation about Sleep Questionnaire (APSQ). We employed the APSQ (Tang & Harvey, 2004) to examine sleep-related anxiety between groups. The APSQ is a 10 item measure, with each item being rated on a scale from 1-10 with scores ranging

from 10 to 100. The APSQ has been shown to have high internal consistency ($\alpha = .92$) and good discriminant validity between normal sleepers and those with insomnia disorder ($R^2 = .33-.41$; Jansson-Fröjmark, Harvey, Lundh, Norell-Clarke, & Linton, 2011).

Depression Anxiety Stress Scale (DASS; 21-item). The DASS (Lovibond & Lovibond, 1995) was used to assess general symptoms of emotional vulnerability. As symptoms of depression and anxiety are often comorbid with insomnia it is pertinent to gauge differing levels within groups of those with both high and low insomnia symptoms. The questionnaire comprises three 7-item scales that show good reliability for symptom measures of depression ($\alpha = .90$), anxiety ($\alpha = .79$), and stress ($\alpha = .89$; Crawford, Cayley, Lovibond, Wilson, & Hartley, 2011).

Experimental stimuli. For the expectancy bias assessment task, we created scenarios that described possible outcomes relating to both the consequences of having had a poor night's sleep, as well as more general scenarios depicting the potential consequences of situations that may pose physical or social-related threat. Each scenario was formulated to be emotionally unresolved until the final word, for which two benign and two negative word solutions were devised, only one of which was presented at the end of each scenario. As in Mathews and Mackintosh's (2000) interpretive bias task, the final word was presented as a fragment that the participant was required to solve.

Thirty two sleep-related scenarios were developed, the content of which was guided by the types of maladaptive cognitions known to commonly affect individuals with insomnia (see; Tang & Harvey, 2004). Scenarios were created in relation to several domains relevant to the potential impact of poor sleep, including general performance, work performance, physical health, social performance, mood and general fatigue. For example; "If I have trouble getting to sleep, the following day I will generally...", "st_ug_le" (struggle – negative resolution), or "cop_" (cope – benign resolution).

A further 32 general-threat scenarios were developed, 16 of which were social threat-related, while another 16 were physical threat-related. These scenarios described situations involving potential social and physical threat that could readily be encountered across a range of day to day environments, and work or educational contexts by participants involved in the current study. As such, social threat scenarios depicted common situations involving peer evaluations in work/study environments (e.g. presentations, forgetting people's names, posting personal information on social media), while the physical threat scenarios depicted a range of situations involving risks to health (e.g. injury in sport, skin cancer/sunburn, and interactions with potentially dangerous people and animals). These scenarios included common situations that could be encountered in day-to-day life where expectancies about social or physical threat could be either negative or benign. For example, "By participating in contact sports, I am much more likely to become physically..." "in_ured" (injured – negative resolution) "fi_" (fit – benign resolution). Thus, to the extent that participants automatically generate negative expectations, this should enhance their performance on trials involving negative resolutions compared to trials involving benign resolutions. Conversely, the tendency to automatically generate benign resolutions should instead enhance performance on trials involving benign resolutions compared to trials involving negative resolutions.

In order to confirm that participants engaged with the content of the scenarios, a comprehension question relating to the initial sleep-related or sleep-unrelated scenario was required. Thus for each scenario, a question with a "yes/no" answer format was developed, which could only be answered correctly if participants had processed the valence of the scenario. For example, the comprehension question following the aforementioned sleep-related scenario is, "Will you find it difficult to manage your daily activities". For the negatively resolved scenario, the correct answer for this is "Yes", and for the scenario resolved in a benign manner, the correct answer would be "No".

Expectancy bias assessment task. Figure 2 provides a schematic depiction of the trial structure of the assessment task. On each trial of the task, scenario presentation occurred in three parts: the sentence stem, the second half of the sentence, and the final fragment. Presenting these components sequentially rather than simultaneously was designed to increase the likelihood that participants would read and comprehend each part of the scenario, rather than attempt to resolve the fragment prematurely. The sentence stem of the scenario was presented for 1000 ms, followed by the second line of the sentence for another 1000 ms, before the word fragment then appeared. Participants were instructed to press the spacebar as soon as they knew the identity of the word fragment. Upon pressing the spacebar, the sentence disappeared with the word fragment remaining, and the participant was required to enter the first missing letter of the fragment. For instance, with the example: “If I have trouble getting to sleep, the following day I will generally...”, “st_ug_le”, the correct missing letter to enter would be “r”. The reaction time to press the spacebar was taken as the critical measure of latency to resolve the scenario on each trial. Relative speeding to resolve negative as compared to benign scenarios provided the dependent measure of expectancy bias.

Upon entering the first missing letter of the fragment, participants received feedback, in the form of the word “Correct” or “Incorrect”, displayed in the centre of the screen for 1000 ms. Each scenario was immediately followed by the relevant comprehension question, presented on one line, which disappeared off screen as soon as “Y” or “N” was pressed. The feedback “Correct” or “incorrect” then appeared centrally onscreen for 1000 ms.

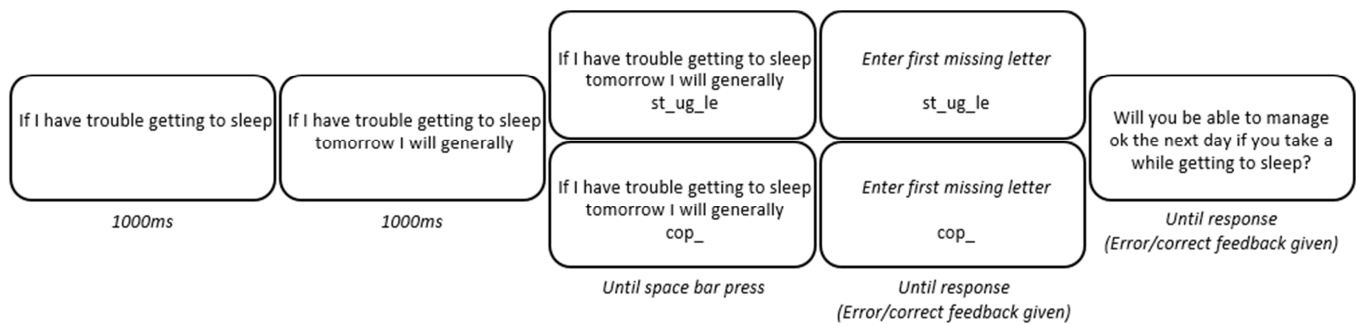


Figure 2. Schematic representation of expectancy bias assessment task showing alternative negative (top) and positive (bottom) resolutions to the scenario. Accuracy feedback not depicted.

The assessment task comprised 64 trials with 32 sleep-related scenarios and 32 general-threat scenarios. Participants only saw each scenario once during the task. Half of the scenarios (of each type – sleep-related/unrelated) in the task were resolved with a negative fragment and half were resolved with a benign fragment. As such, for any given participant each scenario was presented with either its benign resolution or its negative resolution. To balance the presentation of fragments with each scenario across participants, two subsets of 32 scenarios (A and B) were created (with an equal number of each scenario type within each). Fragment allocation was balanced across participants, such that for half the participants, across the 64 assessment trials, Subset A was resolved with a negative fragment and Subset B was resolved with a benign fragment, while for the remaining participants Subset A was resolved with benign fragment and Subset B was resolved with a negative fragment. The 64 scenarios were presented in a randomised order for each participant.

Procedure

The University's human research ethics committee approved all aspects of the current study. Participants were all tested individually by HC or BCM at on-campus research

space within the University of Western Australia, School of Psychology. Upon arrival, participants were initially given information on the requirements of the study and subsequently provided their consent to take part. They then completed all questionnaires in pen and paper form. Participants were then provided verbal instructions on how to carry out the expectancy bias assessment task. They were encouraged to solve the word fragments as quickly as possible without compromising accuracy. The task was then. The expectancy bias assessment task was delivered on a Windows PC using Inquisit software (Inquisit 4.0.8, 2015), and presented to participants on a high resolution 22.5 inch monitor with attached keyboard for recording responses. Participants were presented with additional onscreen instructions, and instructed to press the spacebar to start the task when ready. After completing all 64 trials, participants were debriefed as to the purpose of the study. All components of the study were conducted within a single session that was completed within approximately 45 minutes.

Results

Preparation of Reaction Time Data

The accuracy of fragment resolution was high with a mean overall accuracy of 89%. Reaction time (RT) data was prepared in accordance with recommendations from Ratcliff (1993). Trials with incorrect responses were removed (11% of data). Additionally, to minimise the influence of outlying data, RTs greater than 3 *SDs* away from each participant's own mean, for each trial type, were also excluded (1.5% of data).

Analyses were conducted on indices of sleep-related and sleep-unrelated expectancy bias obtained from the 64 assessment trials. This index was computed in a manner consistent with other assessments of cognitive bias (e.g. Salemink, van den Hout, & Kindt, 2010), by subtracting mean RTs to resolve negative scenarios from mean RTs to

resolve benign scenarios. A higher expectancy bias index score therefore reflects speeding to solve negative over benign scenarios (a more negative expectancy bias), while a lower score reflects speeding to solve benign over negative scenarios (a more benign expectancy bias).

An examination of expectancy bias index scores resulted in four participants being identified as outliers (z -scores $> \pm 3.29$ SD from the mean; Tabachnick & Fidell, 2001). These participants were excluded from the analysis, leaving 66 participants in total (high group $n = 27$). The data were then assessed for normality, which was found to be acceptable (skew $< |2.0|$; kurtosis $< |9.0|$). Average RTs for each group, across negative and benign scenarios, and across sleep-specific and general expectancy scenarios are presented in Table 1.

Table 1

Means and standard deviations of raw reaction times (in milliseconds) to solving negative and benign scenarios across groups.

Scenario type	Resolution	High insomnia symptoms ($n = 27$)		Low Insomnia Symptoms ($n = 39$)	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Sleep-related	Negative	2673.37	(1060.78)	2975.53	(1882.55)
	Benign	3539.41	(1268.82)	3003.64	(1460.74)
Sleep-unrelated	Negative	2065.01	(715.46)	1954.62	(740.73)
	Benign	2244.79	(704.31)	2273.51	(1037.14)

Group Comparisons

Table 2 provides descriptive data of demographic and questionnaire information taken at the time of testing. The groups did not differ according to age (see Table 2) or gender ratio, $\chi^2(1) = .70$, $p = .402$ (Male/Female: high insomnia symptoms group = 9/18, low

insomnia symptoms group = 17/22). As expected, the high insomnia symptoms group showed significantly higher average scores across both sleep-related measures compared to the low insomnia symptoms group. The high insomnia symptoms group also recorded significantly higher average scores on the depression and stress subscales of the DASS, with a slight trend towards significance recorded for the anxiety subscale.

Table 2

Means, Standard Deviations and t-test Comparisons for Age and Questionnaire Measures

	High insomnia symptoms (<i>n</i> = 27)		Low insomnia symptoms (<i>n</i> = 39)		Between Group Comparison	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>t</i> -score	<i>p</i> value
Age	20.97	(6.28)	22.81	(8.21)	1.03	.177
PSQI Scores	10.11	(3.34)	4.51	(1.68)	8.96	< .001
APSQ	58.44	(18.22)	27.74	(16.25)	7.18	< .001
DASS-21						
Depression	16.00	(11.88)	6.62	(8.12)	3.82	< .001
Anxiety	14.52	(9.09)	5.74	(6.84)	4.48	.089
Stress	22.59	(9.80)	8.62	(7.42)	6.59	< .001

Expectancy Bias Data Analysis

In order to test the prediction that those with clinically significant insomnia symptoms hold a negative sleep-related expectancy bias, a two-way repeated measures ANOVA was performed with the between subjects factor of group (high vs. low insomnia symptoms group), and the within subjects factor of expectancy bias type (sleep-related vs. sleep-unrelated). The dependent variable was expectancy bias index scores. A trend toward a significant main effect of group was observed, $F(1,64) = 3.53$, $p = .065$, $\eta_p^2 = .052$, with the

high insomnia symptoms group recording higher expectancy bias index scores ($M = 522.91$, $SD = 742.46$) compared to the low insomnia symptoms group ($M = 173.50$, $SD = 671.77$).

However, this effect was subsumed within a significant two-way interaction between group and expectancy bias type $F(1, 64) = 6.66$, $p = .012$, $\eta_p^2 = .09$. This interaction is depicted in Figure 3.

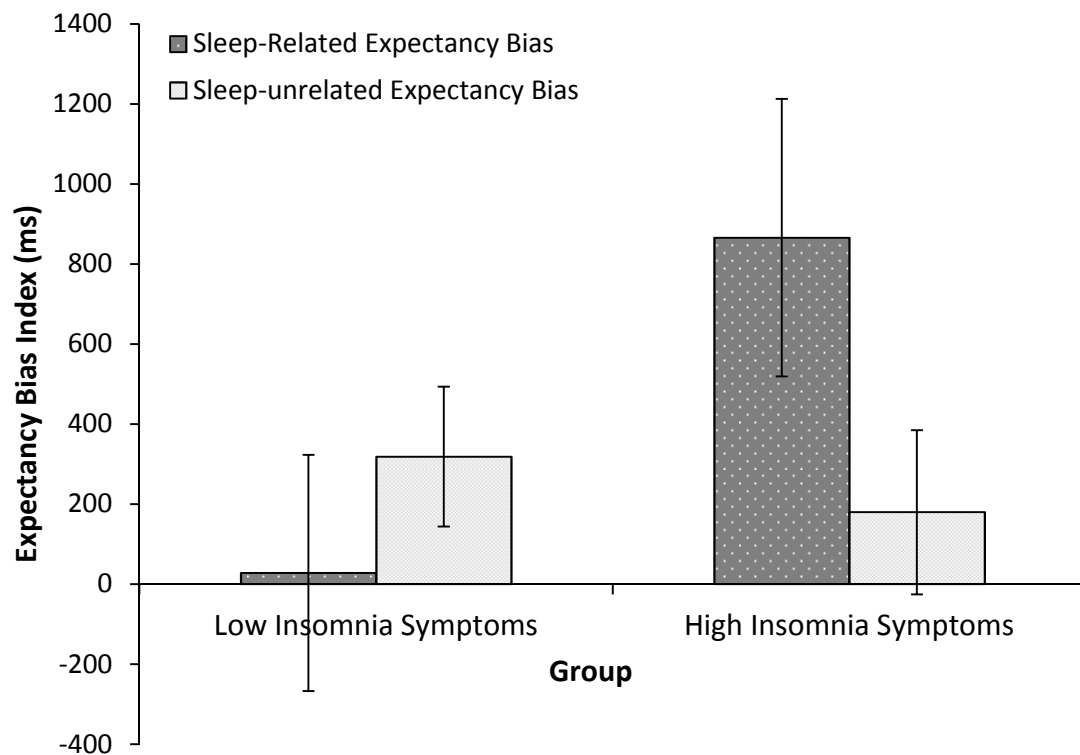


Figure 3. Average expectancy bias index scores ($\pm SE$) across the high and low insomnia symptoms groups for sleep-related and sleep-unrelated (social/physical threat-related) expectancy types. Higher scores indicate faster responses to negative as compared to benign scenarios.

Follow-up planned comparisons demonstrated that the high and low insomnia symptoms groups significantly differed on the sleep-related expectancy bias index, $t(64) = 2.42$, $p = .018$, with the high group having larger expectancy bias index scores for sleep-

related scenarios than the low group. However, the difference between expectancy bias index scores for the sleep-unrelated scenarios did not approach significance $t(64) = 0.97, p = .338$, indicating that the difference in expectancy bias between groups was restricted to biased expectations for the sleep-related scenarios only.

Comparison of expectancy bias index scores within groups revealed that the high insomnia symptoms group had a significantly higher index score for sleep-related expectancy scenarios as opposed to sleep-unrelated expectancy scenarios, $t(26) = 2.209, p = .036$, however the low insomnia symptoms group did not differ across these two indices, $t(38) = 1.263, p = .214$. Thus, this pattern of effects is entirely consistent with the presence of a sleep-specific expectancy bias among those with clinically significant sleep symptoms that is absent in the good sleepers.

Discussion

The aim of the current study was to determine whether a negative expectancy bias is held by those with high levels of insomnia symptoms, and further, whether any pattern of biased expectations in this group is sleep-specific or generally negative. The results were entirely consistent with the presence of sleep-specific expectancy bias among individuals with clinically significant insomnia symptoms. Specifically, the high insomnia symptoms group displayed a greater negative expectancy bias for sleep-related scenarios compared to the low insomnia symptoms group, however the two groups did not differ in biased expectations for sleep-unrelated expectancy scenarios.

These findings are consistent with theories of insomnia which propose that negative expectancies about the consequences of poor sleep represent a maintaining factor for sleep dysfunction (Harvey, 2002; Espie, et al., 2006). To our knowledge, the current study provides the first evidence using cognitive-experimental tasks to support the presence of sleep-specific biased expectations. As such, this provides important corroborating evidence

for past self-report findings indicating that individuals with high levels of insomnia symptoms hold more negative expectancies about the consequences of poor sleep than those who sleep well (Morin, 1993; Wicklow & Espie, 2000), using a methodology that is comparatively immune to response bias.

Interestingly, we found no evidence to indicate that participants differed in expectancy bias for sleep-unrelated scenarios despite the fact that the high insomnia symptoms group recorded significantly higher levels of depression and stress as compared to the low insomnia symptoms group. This is interesting given the well-established finding that high levels of depression are characterised by biased expectations favouring generally negative outcomes of future events (e.g. Pyszczynski, Holt, & Greenberg, 1987). While the design of the current study does not allow us to draw firm conclusions regarding the directionality of the relationship between insomnia and mood symptoms, the presence of a sleep specific negative expectancy bias, and the absence of more general negative expectancy bias could suggest that the between-group differences in symptoms of depressed mood and stress may be more the product of insomnia symptoms rather than depression or stress per se.

The pattern of effects observed on the current study with biased expectations also contrasts the pattern of past findings on biased interpretation. Specifically, the current study found clear evidence for a sleep-specific expectancy bias in the high insomnia symptoms group, and no evidence of a more general negative expectancy bias. By contrast, both Ree and Harvey (2006) and Ree et al. (2006) found evidence of general biased interpretation for negative information, but no evidence for sleep-specific biased interpretation. This pattern of findings suggest that it is important to clearly distinguish between patterns of biased interpretation and biased expectations in insomnia. One possible account of these findings, is that biased interpretation could, in principle, be associated with other symptoms that co-occur with insomnia (e.g. anxiety and/or

depression) but may not be a feature of insomnia itself. Such a contention could potentially be examined in future research by incorporating a high anxiety/depression control sample, who were also low on insomnia symptoms, and contrast patterns of biased interpretation and expectancies for sleep-specific and general scenarios across groups.

The current results provide clear support for the presence of sleep-specific biased expectations among individuals with elevated symptoms of insomnia. While cognitive models implicate biased expectations regarding the outcomes of poor sleep in the maintenance of insomnia symptoms (Harvey, 2002; Espie, et al., 2006), the current results cannot speak to the causal nature of the relationship between biased expectations and insomnia (Harris et al., 2015). An interesting avenue for future research therefore, will be to examine whether patterns of biased expectancy may proceed and predict the later onset of insomnia, respond to psychological and/or pharmacological intervention, and potentially predict subsequent relapse. The potential causal nature of the relationship between sleep-related expectancy bias and insomnia symptoms may also be experimentally modelled. This could in principle be achieved by specifically targeting biased expectations regarding the negative consequences of poor sleep in treatment and assessing the consequent impact on insomnia symptoms. Conversely, it would also be informative to manipulate sleep quality (or perceptions of sleep quality), to assess whether this in turn contributes to biased sleep-related expectancy.

Of relevance to the question of the causality between biased expectations and insomnia is whether biased sleep-related expectations can be directly targeted for modification using computerised cognitive training paradigms, and if change in such patterns of cognition then lead to improvements in symptoms of insomnia. This model of seeking to determine the causal role of biased cognition in psychopathology by assessing the emotional consequences of direct bias modification has been successfully implemented in establishing the role of cognitive biases in anxiety (MacLeod & Clarke, 2013). A small

number of recent studies have sought to examine whether targeting biased attention for modification in insomnia may be of potential benefit, with some promising findings (Clarke et al., 2016; Milkins, Notebaert, MacLeod, & Clarke, 2016). Given the potential for cognitive assessment tasks to be reconfigured as bias modification tasks, it is possible that future research could seek to examine whether biased expectancies regarding the negative outcomes of poor sleep are amenable to change via computerised cognitive training tasks. For example, it is conceivable that repeated presentation of scenarios involving only benign outcomes could, in principle lead to a re-training of negative expectations. Whether this pattern of biased cognition can be changed directly, and whether this leads to consequent changes in insomnia symptoms represents an obvious avenue for future research.

While the pattern of effects observed in the current study were consistent with both the current hypotheses and passed theory, it is nevertheless important to acknowledge limitations of the current design. While the present study sought to recruit individuals with elevated levels of insomnia symptoms that may be consistent with clinical levels of insomnia, it is nevertheless the case that these individuals were not clinically diagnosed. Furthermore, while insomnia was assessed to a clinical level, the current screening process did not seek to systematically rule out participants that may have presented with other sleep disorders (e.g. circadian rhythms sleep disorders, sleep apnoea) and as such, the present findings may not be exclusively characteristic of insomnia. Finally, the current sample recruited heavily from the undergraduate student population and as such, the generalisability of the present findings to other populations (e.g. older adults) remains to be seen. Given such limitations it will be important for future research to replicate the pattern of current findings with a clinician assessed sample. Subsequent research could also seek to establish the specificity of sleep-related expectancy bias by systematically comparing its presence in insomnia-specific samples and other sleep disorders that implicate different pathophysiology (e.g. delayed sleep phase syndrome).

In summary, the current findings provide evidence for a sleep-specific negative expectancy bias operating in individuals with clinically significant insomnia symptoms corroborating theoretical and self-report research implicating the presence of negative expectancies regarding the consequences of poor sleep in insomnia. In doing so, this research also highlights the potential of cognitive-experimental assessment tasks to objectively index patterns of biased cognition in insomnia.

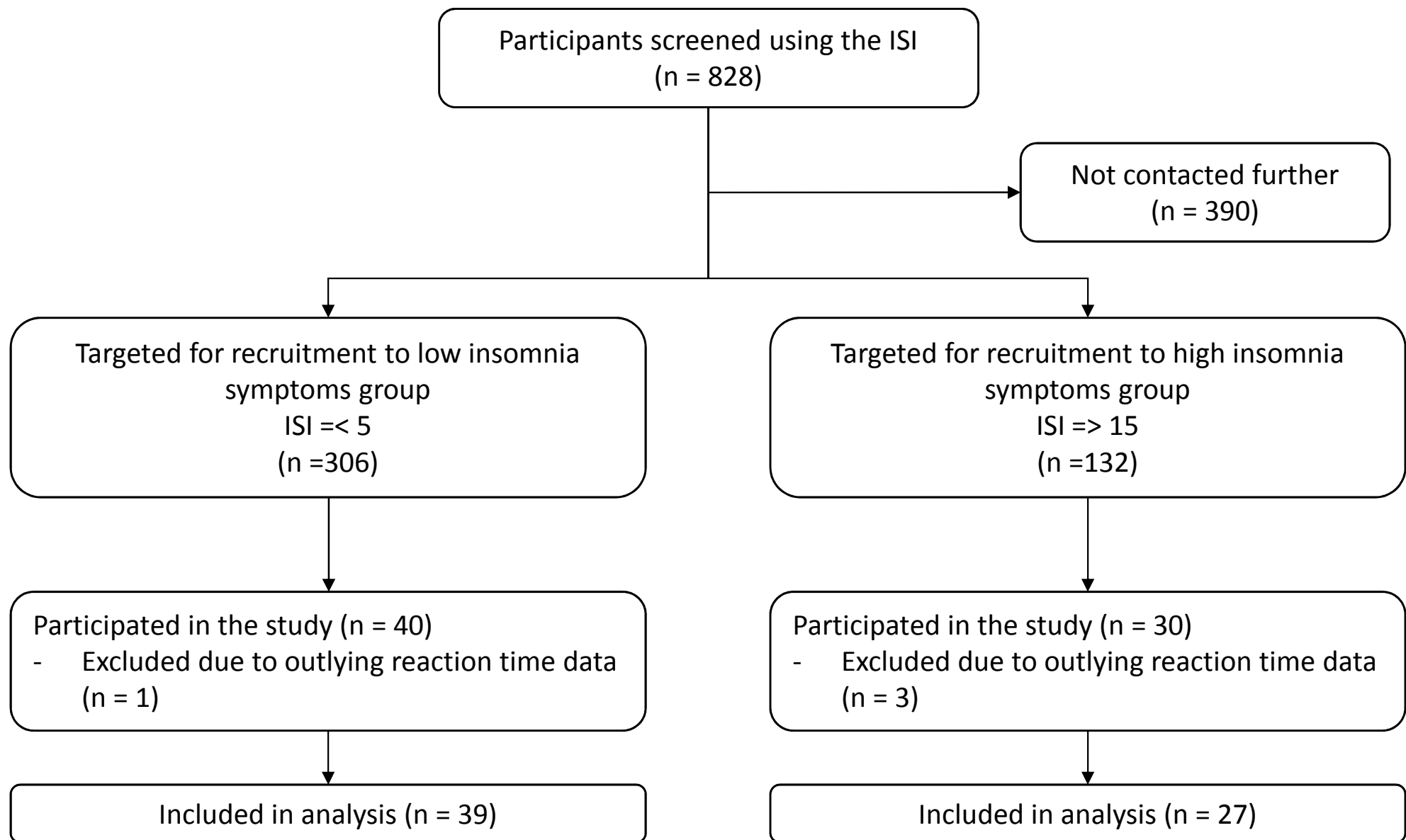
Acknowledgements

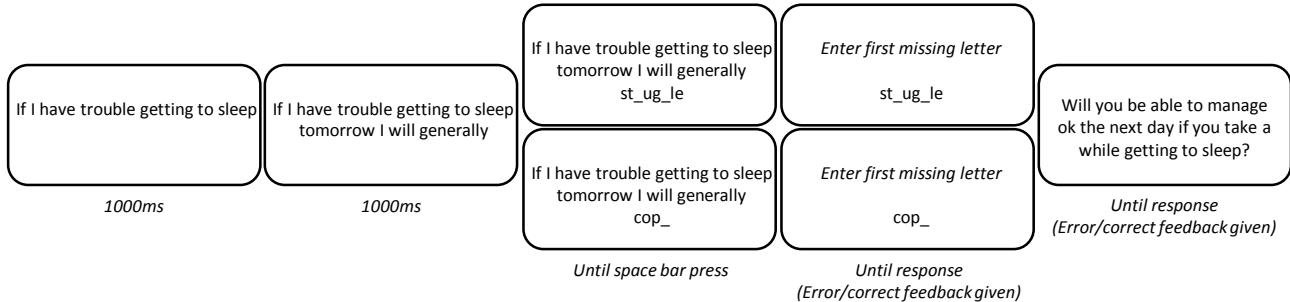
Lies Notebaert is supported by an Australian Research Council Grant DP140103713

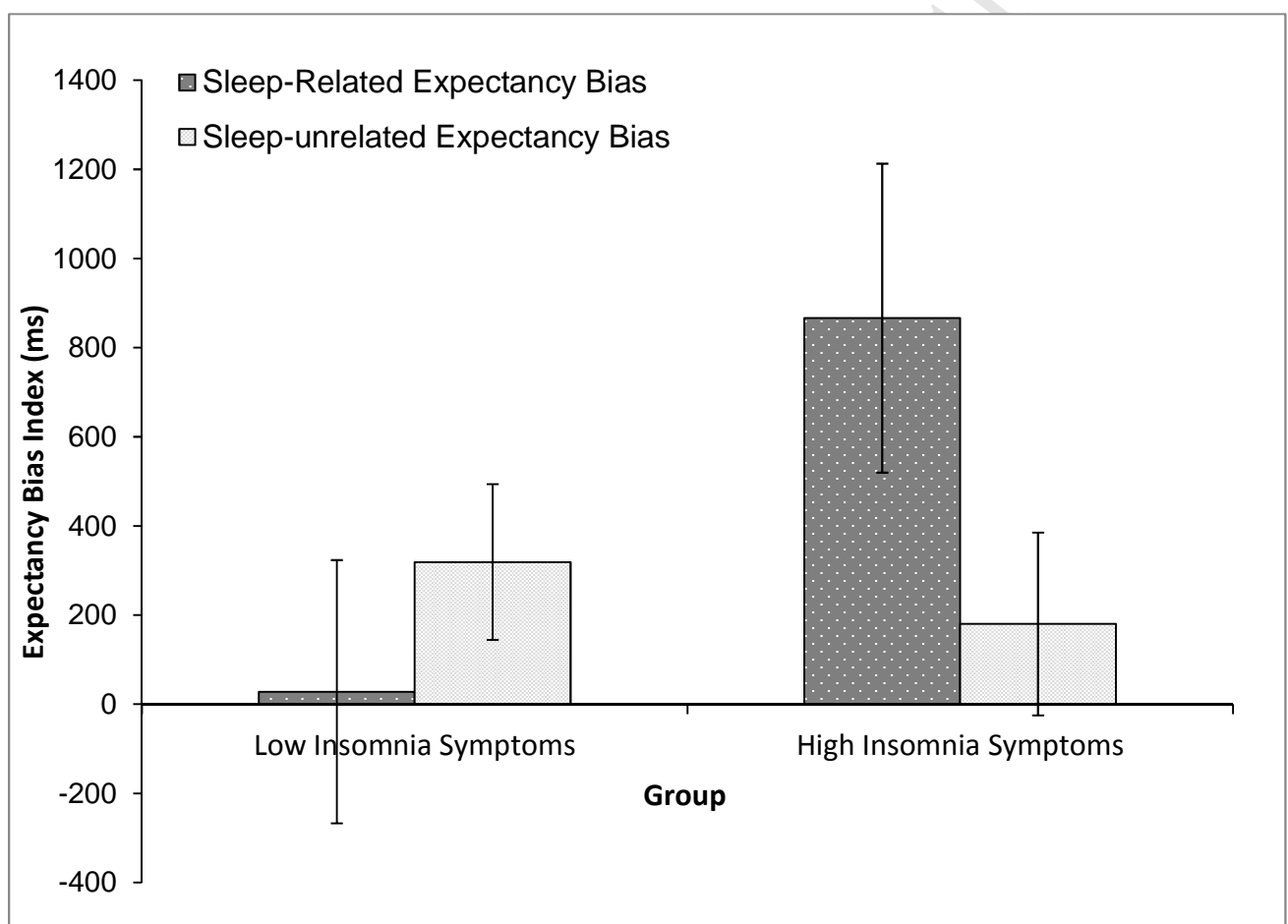
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- Insomnia is thought to be underpinned by a sleep-specific negative expectancy bias
- This has not yet been assessed with an objective measure
- A cognitive-experimental assessment is used to assess expectancy bias in insomnia
- The high insomnia symptoms group showed a sleep-specific negative expectancy bias
- Confirms the presence of sleep-specific biased expectations operating in insomnia