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# Sleep-related monitoring on awakening mediates the relationship between insomnia-related interpretive bias and insomnia symptoms using the insomnia ambiguity paradigm

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## Abstract

A number of studies have examined and confirmed the presence of a sleep-related interpretive bias amongst poor sleepers and individuals with insomnia using an insomnia ambiguity task. This study explored possible mechanisms underlying the relationship between interpretive bias and insomnia using the insomnia ambiguity task. More importantly, the possible mediating role of sleep-associated monitoring, sleep preoccupation, sleep anticipatory anxiety and generalized anxiety was also examined. A total of  $N = 176$  participants were stratified into normal sleepers and those displaying insomnia symptoms. Participants completed an online version of the insomnia ambiguity task and questionnaire measures pertaining to sleep and anxiety. Data concerning task response time and time of testing were also collected. Individuals in the insomnia symptom group presented significantly higher sleep-related interpretive bias scores compared to normal sleepers. When sleepiness, sleep-associated monitoring, sleep preoccupation, sleep anticipatory anxiety and generalized anxiety were controlled for, only monitoring on awakening predicted sleep-related interpretive bias. Multiple mediation modelling demonstrated that sleep-associated monitoring on awakening mediated the relationship between interpretive bias and insomnia symptoms. The current outcomes are consistent with previous research, supporting the notion that insomnia is characterized by a disorder-consistent interpretive bias. Furthermore, monitoring for insomnia-consistent cues on awakening appears to mediate group differences in interpretive bias.

## KEYWORDS

cognitive bias, insomnia, interpretation, selective attention, sleep-associated monitoring

## 1 | INTRODUCTION

Cognitive models highlight the role of attentional and interpretive biases for sleep-specific cues in the development and maintenance of insomnia (Espie et al., 2006; Harvey, 2002). Particularly,

the experiences of arousal, distress and negative sleep-related thoughts and beliefs are considered to facilitate the onset of sleep-specific anxiety. This anxiety directs attentional resources towards sleep-related cues related to the internal (e.g., rapid heart rate) and external (e.g., passing car noise) environment (Espie et al., 2006;

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Harvey, 2002). Once a sleep-related cue is detected, those with insomnia are more likely to interpret the cue in a way that confirms their disorder. As cognitive biases of this nature cycle back to further intensify the experience of sleep-specific anxiety, further exploration of possible factors underlying sleep-related biases remains vital (Espie et al., 2006; Harvey, 2002).

An interpretive bias can be observed when people make an inference and deduce a conclusion on an ambiguous and open-ended situation (Gerlach et al., 2020). In the context of psychiatric disorders, the greater tendency to make a disorder congruent, rather than a neutral, interpretations of ambiguous serves as the critical measure of interpretive bias. (Ree & Harvey, 2006). A growing number of studies have examined and confirmed the presence of a sleep-related interpretive bias amongst poor sleepers and individuals with insomnia symptoms using an insomnia ambiguity task (IAT; Ellis et al., 2010; Gerlach et al., 2020; Ree & Harvey, 2006; Ree et al., 2006). After controlling for sleepiness and anxiety, Ree and colleagues (2006) first evidenced that poor sleepers interpreted ambiguous scenarios in a manner consistent with their symptoms when compared with normal sleepers. Although these outcomes have since been replicated in a number of studies sampling poor sleepers (Ellis et al., 2010; Gerlach et al., 2020), Ree and colleagues (2006) failed to extrapolate these findings to individuals with insomnia. Using paradigms other than the IAT, individuals displaying poor sleep are evidenced to forego economic reward to obtain an opportunity to answer sleep-related (rather than eating-related) questions when compared with good sleepers (Takano & Raes, 2018). Examining reaction time, Courtauld and colleagues (2017) found individuals displaying insomnia symptoms to be faster in resolving insomnia-consistent scenarios in a disorder-congruent (rather than benign) manner when compared with normal sleepers. Experimental evidence also shows that individuals with insomnia display an interpretive bias, in that they misperceive their own face as appearing more tired than they physically were, therefore confirming symptoms of their disorder (Akram et al., 2016). Questionnaire studies have likewise found that individuals displaying symptoms of insomnia display a greater propensity to interpret their cutaneous features (i.e., skin, hair and nails) in a manner that is consistent with the presence of a sleep deficit (Gupta et al., 2015; Oyetakin-White et al., 2015), whereas follow-up work determined the relationship between insomnia symptoms and perception of cutaneous features to be mediated by greater reports of sleep-related monitoring on awakening (Akram, 2017).

The examination of possible mediational factors underlying the relationship between disorder-consistent processing of sleep-related information and insomnia using experimental paradigms has only recently been carried out (Gerlach et al., 2020; Zheng et al., 2019). Gerlach and colleagues (2020) evidenced a positive relationship between pre-sleep worry and poor sleep quality, with an increased tendency to choose sleep-related interpretations of ambiguous sentences when using the IAT. However, regression analyses determined suggestive evidence that these outcomes were mediated by trait anxiety but not any objectively determined parameters of sleep continuity (Gerlach et al., 2020). Zheng and colleagues

(2019) determined that individuals with insomnia were more likely to exhibit an attentional bias following the induction of a negative (i.e., autobiographical recall of poor sleep), relative to control (i.e., reading recall), mood state (Zheng et al., 2019). Therefore, the valence and topical focus of an individual's emotional mood state may possibly mediate the relationship between sleep-related cognitive biases and insomnia. The mediational role of anxiety and mood state may further vary based on the topical focus (i.e., whether sleep related or not), intensity, duration and frequency of occurrence, and timing (i.e., whether during the pre-sleep period, on awakening or throughout the day), as highlighted in a recent theoretical perspective (Akram, Barclay, et al., 2018; Akram, Kay, et al., 2018).

The present study further examined possible mechanisms underlying the relationship between a sleep-related interpretive bias and insomnia using an online version of the insomnia ambiguity task (Ree et al., 2006). Based on previous work, we examined the possible mediating role of sleep-associated monitoring, sleep preoccupation, sleep anticipatory anxiety and generalized anxiety (Akram, 2017; Gerlach et al., 2020; Zheng et al., 2019). Previous studies largely grouped participants based on reports of sleep quality, where the measures used to evaluate poor sleep and insomnia may lack specificity or fail to examine insomnia symptoms in the context of the latest diagnostic criteria. As such, the present study employed the Sleep Condition Indicator, a clinical screening tool that examines insomnia symptoms against the DSM-5 criteria for Insomnia Disorder (Espie et al., 2014). Furthermore, a number of prospective confounds were also controlled for. These included levels of sleepiness, task response time, the time at which participants were tested and the presence of other potentially co-occurring physiological sleep disorders. The aim of this exploratory study was twofold: to assess whether individuals presenting insomnia symptoms report greater insomnia-consistent interpretations of ambiguous sentences (i.e., sleep-related interpretive bias scores) compared to normal sleepers (hypothesis 1, hypothesis 2); and to examine whether the presence of an interpretive bias is mediated by sleep-associated monitoring, sleep preoccupation, sleep anticipatory anxiety or generalized anxiety.

## 2 | METHOD

### 2.1 | Participants

Members of the general population were recruited using posters placed around [Sheffield Hallam University] University and social media. In total,  $N = 269$  individuals either began or clicked on a hyperlink to an online survey, delivered using the Qualtrics platform (Qualtrics, Provo, UT). Only complete cases were analysed due to the ethical right to withdraw from the study at any time. Possible duplicate responses were examined based on matching IP addresses, and none were found. In total,  $N = 201$  respondents (mean age =  $34.21 \pm 13.94$ , range 18-78, 78% female) provided complete data. Individuals who reported conducting shift

work, suffered from a disorder of the central nervous system, were currently using medication, which affects sleep, or had a prior head injury or reported symptoms of a sleep disorder other than insomnia were excluded from the analysis ( $n = 34$ , mean age =  $34.92 \pm 13.15$ , range 18–62, 77% female). This resulted in a final sample of  $N = 176$  participants (mean age =  $34.07 \pm 14.12$ , range 18–78, 78% female), who were stratified into normal sleepers and those displaying insomnia symptoms. More specifically,  $N = 109$  normal sleepers (mean age =  $32.67 \pm 14.02$ , range 18–78, 76% female) were identified as scoring  $\geq 17$  on the Sleep Condition Indicator (SCI: Espie et al., 2014), whereas  $N = 67$  individuals scoring  $\leq 16$  on the SCI were stratified into the insomnia symptoms group (mean age =  $36.34 \pm 14.09$ , range 18–78, 82% female). A score of 16 or less on the SCI has identified 'probable insomnia disorder' with an accuracy of 89% [8]. The insomnia symptoms group scored significantly lower on the SCI ( $10.35 \pm 3.70$ ) relative to normal sleepers ( $24.52 \pm 4.55$ ;  $F(1,175) = 461.84$ ,  $p < .001$ ); however, they did not differ in age ( $F(1,175) = 2.80$ ,  $p > .05$ ) or sex ( $\chi(1) = 1.3$ ,  $p > .05$ ). Using G\*Power (Faul et al., 2009), a between-group (i.e., ANOVA) sample size calculation determined that we would require at least 42 participants based on an  $F$  test power of 0.95 and an alpha level of 0.05. Considering this, the present sample size was deemed statistically adequate.

## 2.2 | Questionnaire measures

The sleep condition indicator examined insomnia symptoms (SCI) against the DSM-5 criteria for Insomnia Disorder (Espie et al., 2014). The scale consists of eight items, each scored between 0 and 4, designed to examine insomnia symptomology during the last month. Specifically, questions pertain to sleep onset latency, awakenings during the night, perceived sleep quality, impairment of daytime functioning and symptom persistence. Items are summed to create a total score between 0 and 32, with lower scores indicating greater insomnia symptom severity. Moreover, a score of  $\leq 16$  is reliably evidenced to determine 89% of those with probable insomnia disorder (Espie et al., 2014). Previous large-scale studies show an excellent degree of reliability ( $\alpha = 0.89$ ) and concurrent validity of the SCI (Espie et al., 2012, 2014). Likewise, the current assessment of internal consistency (Cronbach's alpha) yielded a value of  $\alpha = 0.88$ .

Subscales of the SLEEP-50 (Spoomaker et al., 2005) confirmed the absence of: apnea, sleepwalking, narcolepsy, restless legs syndrome/periodic limb movement, and circadian rhythm disorder. Here, participants indicate the extent to which each item is personally applicable over the past month (0 = not at all, 4 = very much). Total scores demonstrated the following:  $\geq 15$  indicates apnea,  $\geq 7$  sleepwalking,  $\geq 7$  narcolepsy,  $\geq 7$  restless legs syndrome/periodic limb movement, and  $\geq 8$  a circadian rhythm disorder. The presence of a sleep disorder based on these cut-off scores determined exclusion.

Two subscales (daytime monitoring for body sensations [DM] and monitoring for body sensations on awakening [WM]) of the the Sleep Associated Monitoring Index (SAMI; Semler & Harvey, 2004a)

examined levels of monitoring behaviour. Specifically, each item is comprised of a 5-point scale where participants indicate applicability over the past month (1 = not at all; 5 = all the time). Mean scores for subscales reflect total subscale scores divided by the number of items in the scale. Each subscale comprised five items. Higher mean scores for each subscale represent increased monitoring for physical cues and sensations attributed to poor sleep. The SAMI has demonstrated good reliability and validity before and after insomnia treatment (Semler & Harvey, 2004b). Assessment of internal consistency yielded a Cronbach's alpha of 0.93 for DM and 0.89 for WM.

The original version of the Anxiety and Preoccupation about Sleep Questionnaire (APSQ) assessed sleep-related worry (Tang & Harvey, 2004). The ASPQ consists of 10 items asking about concerns regarding sleep (e.g., "I worry about the amount of sleep I am going to get every night"), the consequences of poor sleep and control of sleep (e.g., "I put great effort into rectifying my sleep problems"). These items originated from analysis of statements made by insomnia patients (see Borkovec, 1982; Harvey, 2001; Watts et al., 1994). The response for each of the 10 items ranges between 1 (strongly disagree) and 10 (strongly agree). A composite score is created by the summation of all items, where higher scores indicate an increased presence of sleep-related anxiety. Validation of the ASPQ demonstrates a good level of internal consistency ( $\alpha = 0.92$ ) and validity (i.e., convergent, discriminant; Tang & Harvey, 2004; Jansson-Fröjmark et al., 2011). In the current sample, the internal consistency was  $\alpha = 0.94$ .

Sleep anticipatory anxiety was assessed using the Sleep Anticipatory Anxiety Questionnaire (SAAQ; Bootzin et al., 1994). Specifically, 10 items examine cognitive and physical arousal while trying to fall asleep at night. Each item is scored on a 4-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). A composite score is created by the summation of all items, where higher scores indicate greater endorsement of negative pre-sleep cognitions. The SAAQ has previously demonstrated an excellent degree of internal consistency ( $\alpha = 0.86$ – $0.92$ ) and acceptable reliability ( $\alpha = 0.78$ – $0.83$ ; Bootzin et al., 1994; Heath et al., 2018; Richdale et al., 2014). In the current sample, the internal consistency was  $\alpha = 0.88$ .

State levels of excessive daytime sleepiness were determined using the Stanford Sleepiness Scale (SSS; Hoddes et al., 1973). The measure consists of a single-item Likert scale, which ranges from 1 (feeling active, vital, alert or wide awake) to 7 (no longer fighting sleep, sleep onset soon, having dreamlike thoughts). Higher scores indicate greater levels of state sleepiness.

Symptoms of anxiety were determined using The Generalized Anxiety Disorder-7 scale (GAD-7; Spitzer et al., 2006). Comprised of seven items, the GAD7 captures core anxiety symptoms as outlined in the DSM-IV/DSM-5. Individual items are scored on a 4-point Likert-type scale and the summation of items determines the total score, ranging between 0 and 28. Higher scores indicate higher levels of anxiety, with scores  $\geq 11$  indicating a possible case of generalized anxiety disorder. The internal consistency in the present study was 0.91.

**TABLE 1** Percentage of responses to each ambiguous sentence split by group status

Ambiguous insomnia-related sentences <sup>a</sup>	Possible response		Percentage (%) of insomnia-consistent endorsements	
	Insomnia consistent	Insomnia inconsistent	Normal sleepers	Insomnia symptoms
Lorraine usually felt the same way when she got into bed at night	Tense	Relaxed	44.0	22.4
Mark thought about sleep that day as much as usual	Often	Rarely	59.6	56.7
Jane's sleep had been this way all her life	Poor	Good	52.3	71.6
Angela worried about how she would make it to work the following day	Exhausted	Car	49.5	64.2
James had a draining problem to fix	Tiring	Plumbing	27.5	38.8
Sam knew how long it would take for him to fall asleep	Slow	Fast	55.0	80.6
Sandra gasped when she woke up and looked in the mirror	Disappointed	Delighted	65.1	73.1
Melinda thought with anticipation about going to sleep that night	Nervous	Eager	40.4	56.7
Jason struggled to get through the afternoon at work	Drowsy	Bored	50.5	73.1
Simon noticed how long it had taken him to relax while lying in bed	Quickly	Slowly	63.3	68.6
While giving her long lecture, Amanda tried to disguise how she felt	Sleepy	Anxious	42.2	43.3
While Jo was lying in bed, the music from next door stirred her emotions	Annoyed	Happy	74.3	86.6
Rebecca had such difficulty with her memory these days	Weary	Elderly	39.4	74.6
Tim felt emotional at the stroke of midnight	Frustrated	Celebration	45.9	68.7
Fogginess made it hard for Julie to get going in the morning	Drowsiness	Weather	65.1	70.1
Rosemary tried to disguise the size of her bags	Eyes	Shopping	65.1	70.1
Paul felt groggy when he woke up in the morning	Tired	Hungover	56.9	73.1
Sandra was very quiet at the party	Sleepy	Shy	11.9	31.3
When he saw her, Aaron knew how Holly had slept	Badly	Well	57.8	77.6
Jo worried that her performance at the morning meeting would be affected	Fatigue	Nervous	41.3	58.2
Sean knew his sleep had affected the quality of his work	Negatively	Positively	74.3	86.6
Tom assumed that he would sleep this way forever	Badly	Well	54.1	80.6
Scott knew why he felt achy when he got out of bed that morning	Insomnia	Flu	31.2	62.7
Alan was always wide awake at this time	Night	Day	61.5	76.1
Adam's usual thoughts came to his mind as he lay in bed	Worrying	Relaxing	65.1	86.6
Helen found it difficult to stay interested in the movie	Sleepy	Bored	34.9	49.3
Geoff noticed how Maggie looked when she got up this morning	Bad	Good	40.4	61.2

<sup>a</sup>Sentences previously validated by Ree et al., 2006.

### 2.3 | Insomnia ambiguity task

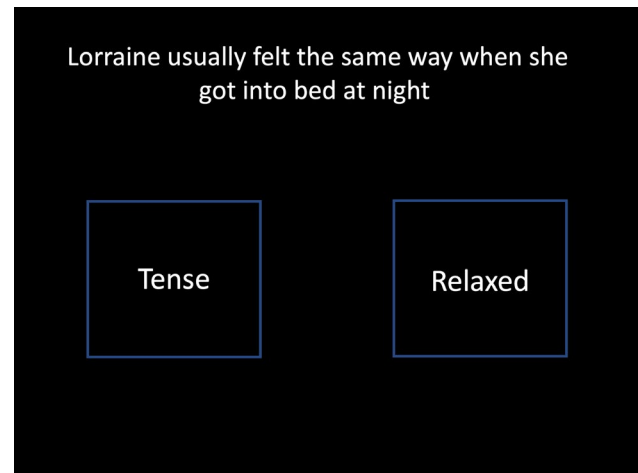
The previously developed Insomnia Ambiguity Task (IAT; Ree & Harvey, 2006) was used in the current study. Specifically, a series of 27 ambiguous sentences were each followed by two possible interpretations, one insomnia consistent and another that was insomnia inconsistent. For example, “Sam knew how long it would take him to fall asleep”: slow (insomnia consistent), fast (insomnia inconsistent). Here, participants were required to decide the content of the ambiguous sentence. The IAT was initially validated by Ree and colleagues (2006). In a pilot study, items were rated by six independent judges to ensure that the two interpretations accompanying each sentence were equally probable, and that one interpretation of each ambiguous sentence was insomnia consistent, whereas the other was not. The final pairs of insomnia-consistent and insomnia-inconsistent target words did not differ in word length or word frequency (Ree & Harvey, 2006). In line with Ellis and colleagues (2010), insomnia-consistent choices were given a score of 1, whereas insomnia-inconsistent choices were given a score of 0. Therefore, sleep-related interpretive bias scores ranged between 0 and 27, where higher scores represent more insomnia-congruent endorsements. All sentences are shown in Table 1.

### 2.4 | Procedure

Ethical approval was granted by the Sheffield Hallam University Research Ethics Committee, and all participants gave their informed consent before participation. The study was delivered using the Qualtrics online platform. After reading the instructional information, participants completed the IAT. For each trial, the sentences were presented above two possible boxed responses (see Figure 1). Here, two possible interpretations of the same scenario were displayed: a neutral interpretation (i.e., insomnia inconsistent) and a sleep-related interpretation (i.e., insomnia consistent). Participants were required to click the response that they thought was most suited to the content of the ambiguous sentence (as exemplified above). Following the participant's response or 5,000 msec timeout, the next trial began. A total of  $N = 27$  trials were completed in a randomized order, with response-type location counterbalanced. Following the IAT, the SCI, SLEEP-50, SAMI subscales, ASPQ, SAAQ, SSS and GAD-7 were completed. Once complete, participants were debriefed about the nature of the study.

### 2.5 | Statistical analyses

Jamovi (The jamovi project, 2021) was used to conduct statistical analyses of the data. Pearson's bivariate correlations examined possible relationships between measures of sleep-associated monitoring, anxiety and preoccupation about sleep, sleep anticipatory anxiety, sleepiness and generalized anxiety, with total sleep-related interpretive bias scores for the whole sample to assess whether



**FIGURE 1** Example trial from the insomnia ambiguity task (IAT) where the response of ‘tense’ is insomnia consistent and ‘relaxed’ is insomnia inconsistent

these factors influenced interpretation and determine the necessity of controlling for these factors in further analyses. In the case that any associations were significant, these variables were included as covariates in further ANCOVA analysis. Univariate between-groups tests examined group differences in total sleep-related interpretive bias scores, both with and without the inclusion of necessary covariates. Finally, regression-based multiple mediation modelling was used with the MEDMOD plugin for Jamovi (The jamovi project, 2021; Faul et al., 2009), in order to examine the direct and indirect associations between interpretive bias scores and insomnia symptoms, via any significant covariates. Significance was considered at the  $p < .05$  level.

## 3 | RESULTS

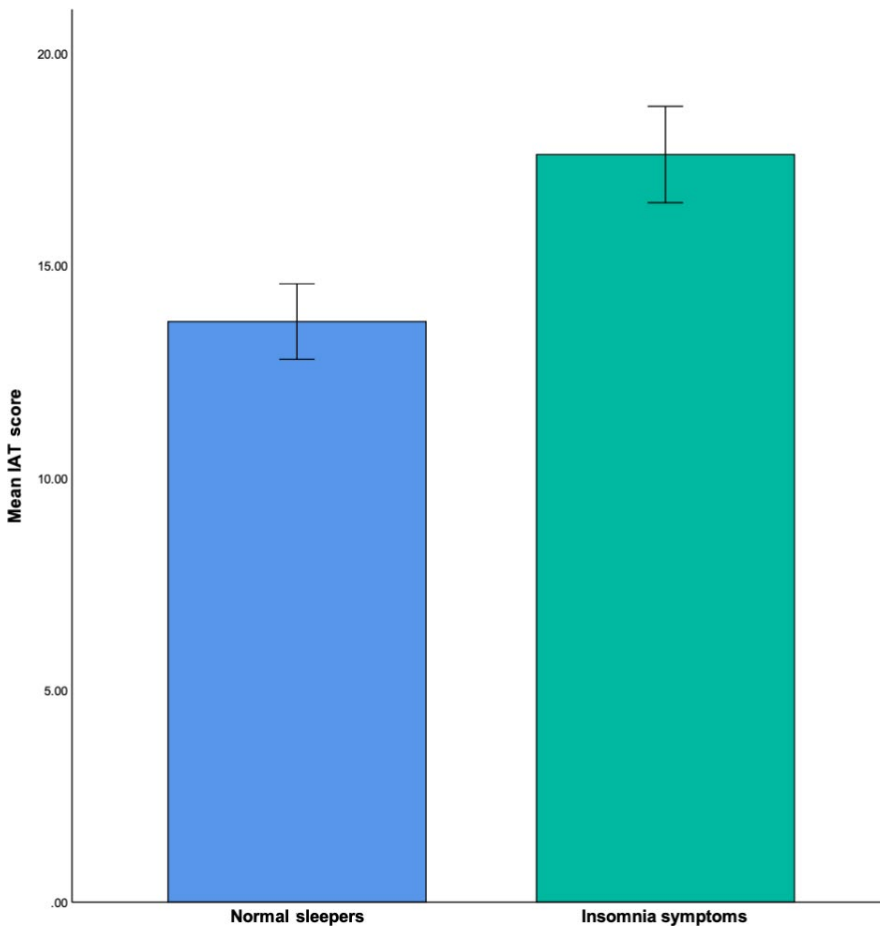
The statistics describing the means and standard deviations of the examined variables are reported in Table 2. The time at which testing took place ( $F(1,175) = 1.01, p = .315$ ) and measures of response time ( $F(1,175) = 1.50, p = .222$ ) did not differ between the normal sleeper and insomnia symptom groups. However, as expected, groups differed in levels of sleepiness ( $F(1,175) = 40.85, p < .001$ ), sleep-associated monitoring on awakening ( $F(1,175) = 35.95, p < .001$ ) and during the day ( $F(1,175) = 40.85, p = .001$ ), anxiety and preoccupation about sleep ( $F(1,175) = 77.04, p < .001$ ), sleep anticipatory anxiety ( $F(1,175) = 80.12, p < .001$ ) and generalized anxiety ( $F(1,175) = 29.83, p < .001$ ).

Total sleep-related interpretive bias scores were positively related to levels of sleepiness ( $r = .25, p < .001$ ), sleep-associated monitoring on awakening ( $r = .43, p < .001$ ) and during the day ( $r = .29, p < .001$ ), anxiety and preoccupation about sleep ( $r = .38, p < .001$ ), sleep anticipatory anxiety ( $r = 0.40, p < .001$ ) and generalized anxiety ( $r = 0.28, p < .001$ ).

	Normal sleepers (N = 109)	Insomnia symptoms (N = 67)	F	p	Cohen's d
Interpretive bias score	13.69 ± 4.92	17.63 ± 4.33	29.01	.001*	0.85
Time of test (hh:mm)	15:26 ± 5:25	14:33 ± 6:11	1.01	.315	-
Response time (s)	3.72 ± 0.85	3.87 ± 0.79	1.50	.222	0.18
Insomnia symptoms	34.52 ± 4.55	10.36 ± 3.70	461.84	.001*	5.83
Monitoring: Awakening	2.20 ± 0.83	3.32 ± 0.95	66.87	.001*	1.26
Monitoring: Daytime	2.13 ± 0.93	3.05 ± 1.08	35.95	.001*	0.91
APSQ	28.61 ± 17.29	55.03 ± 22.08	77.05	.001*	1.33
SAAQ	18.44 ± 4.92	25.70 ± 5.44	80.12	.001*	1.40
GAD-7	5.57 ± 5.09	10.11 ± 5.42	29.83	.001*	0.86
Sleepiness	2.46 ± 1.07	3.58 ± 1.25	30.74	.001*	0.96

Note: Insomnia symptoms, Sleep Condition Indicator; Monitoring, Sleep Associated Monitoring Index; APSQ, Anxiety and Preoccupation about Sleep Questionnaire; SAAQ, Sleep Anticipatory Anxiety Questionnaire; GAD-7, The Generalized Anxiety Disorder-7 Questionnaire; Sleepiness, Stanford Sleepiness Scale; hh:mm, response time in hours and minutes.

\*Significant at  $p < .001$ .



**TABLE 2** Means and standard deviations ( $M \pm SD$ ) for normal sleepers and insomnia symptom groups

**FIGURE 2** Bar chart displaying differences in insomnia ambiguity task (IAT) scores between normal sleepers and those presenting insomnia symptoms. Error bars: 95% CI

Between-group univariate analysis of variance (ANOVA) tests demonstrated that individuals in the insomnia symptom group presented significantly higher ( $17.63 \pm 4.33$ ) sleep-related interpretive bias scores compared to normal sleepers ( $13.69 \pm 4.92$ :  $F(1,174) = 29.01, p < .001$ ; see Figure 2). When repeated with levels of sleepiness, sleep-associated monitoring on awakening and during the day, anxiety and preoccupation about sleep, sleep anticipatory anxiety and generalized anxiety as covariates, analysis of covariance (ANCOVA) tests found only monitoring on awakening ( $F(1,162) = 5.73, p = .018$ ), but not group status ( $F(1,162) = 2.69, p = .103$ ), predicted sleep-related interpretive bias (see Table 3). Individual data points are provided in Figure 3.

Based on the outcomes of the ANCOVA analyses, the mediating effect of sleep-associated monitoring was examined using the MEDMOD plugin for Jamovi. Bootstrapping with 1,000 bias-corrected and accelerated resamples and 95% confidence intervals were used, and the Sobel test ( $z$ ) was used to indicate the hypothesized mediation effects. As shown in Table 4, the results demonstrated significant direct effects between interpretive bias scores and group status ( $z = 2.76, p = .006$ ), interpretive bias scores and sleep-associated monitoring ( $z = 6.78, p < .001$ ), and sleep-associated monitoring and group status ( $z = 5.97, p < .001$ ).

In addition, an indirect effect of sleep-associated monitoring was observed between interpretive bias scores and group status ( $z = 4.89, p < .001$ , %mediation = 50.9). Therefore, individuals displaying insomnia symptoms appear to exhibit a greater sleep-related interpretive bias when compared with normal sleepers; this effect appears to be mediated by the extent of monitoring for sleep-related cues, which confirm poor sleep on awakening.

**TABLE 3** Univariate ANCOVA between-groups test with differences in sleep-related interpretive bias as the dependant variable, group status as within-subjects variable and sleep-associated monitoring, anxiety and preoccupation about sleep, sleep anticipatory anxiety, sleepiness and generalized anxiety as covariates

	Mean <sup>2</sup>	F	p
Monitoring: Awakening	121.87	5.73	.018*
Monitoring: Daytime	11.61	0.54	.461
APSQ	0.78	0.04	.849
SAAQ	33.19	1.56	.213
GAD-7	1.79	0.08	.772
Sleepiness	0.88	-0.04	.839
Group status	57.14	2.69	.103

Note:: Monitoring, Sleep Associated Monitoring Index; APSQ, Anxiety and Preoccupation about Sleep Questionnaire; SAAQ, Sleep Anticipatory Anxiety Questionnaire; GAD-7, The Generalized Anxiety Disorder-7 Questionnaire; Sleepiness, Stanford Sleepiness Scale.

\*Signifies at  $p < .05$ .

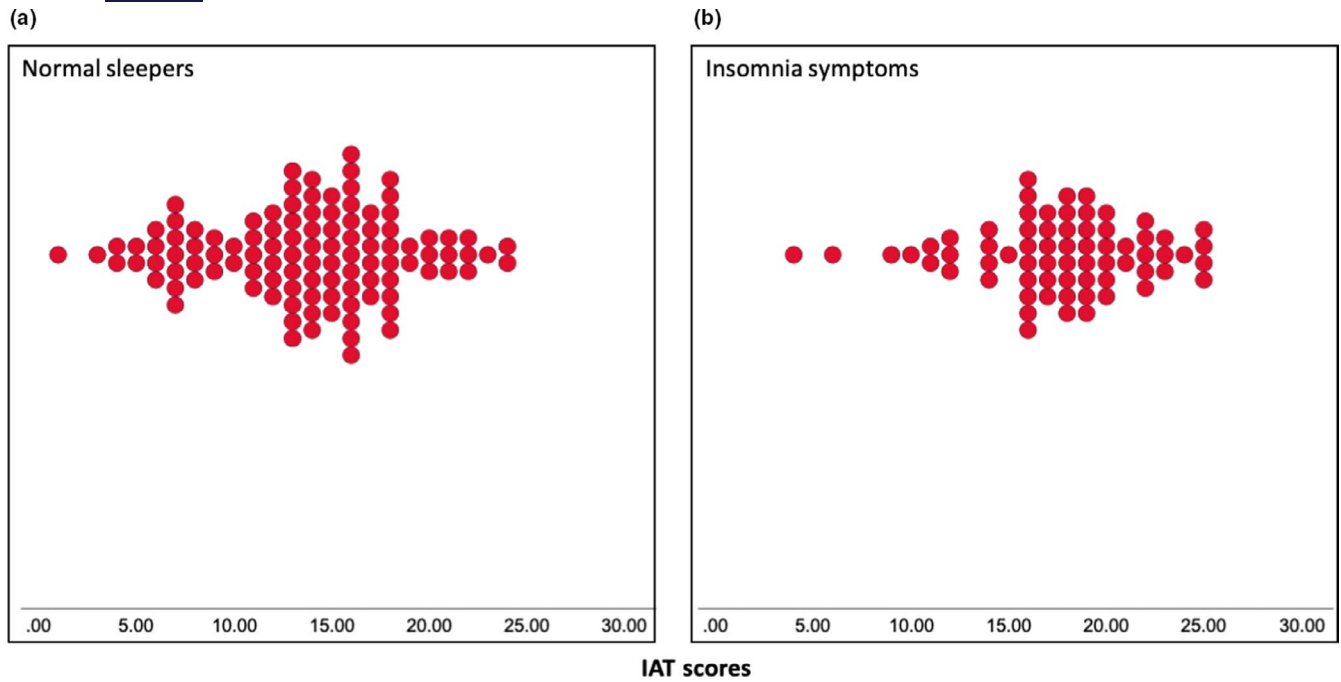
## 4 | DISCUSSION

The present study examined whether individuals presenting insomnia symptoms report greater insomnia-consistent interpretations of ambiguous sentences compared to normal sleepers, and whether the presence of an interpretive bias was mediated by sleep-associated monitoring, sleep preoccupation, sleep anticipatory anxiety and generalized anxiety. In support of our first hypothesis, individuals in the insomnia symptom group displayed a significantly greater tendency to make insomnia-consistent interpretations of ambiguous sentences when compared with normal sleepers. These results are consistent with previous research, supporting the notion that insomnia is characterized by a disorder-consistent interpretive bias (Akram et al., 2016; Ellis et al., 2010; Gerlach et al., 2020; Ree et al., 2006) and providing further support for cognitive models of insomnia (Espie et al., 2006; Harvey, 2002).

Correlational analyses determined that greater interpretive bias scores were positively related to levels of sleepiness, sleep-associated monitoring on awakening and during the day, anxiety and preoccupation about sleep, sleep anticipatory anxiety and generalized anxiety. These outcomes are in line with those of Gerlach and colleagues (Gerlach et al., 2020), who found pre-sleep worry among poor sleepers to be related to an increased tendency to choose sleep-related interpretations of ambiguous sentences. Further, multivariate analysis determined that only increased monitoring for insomnia-consistent cues on awakening predicted group differences in sleep-related interpretive bias scores.

In relation to the second hypothesis, multiple mediation modeling confirmed that although individuals displaying insomnia symptoms appear to exhibit a greater sleep-related interpretive bias when compared with normal sleepers, this effect appears to be mediated by the extent of monitoring for sleep-related cues, which confirm poor sleep on awakening. This may be explained from a cognitive perspective, specifically in terms of biases of attention, which precede and consequently influence insomnia-consistent interpretations (Harvey, 2002). Here, individuals who start the day by examining their bodily sensations and appearance on waking for cues related to poor sleep are likely to self-perpetuate negatively toned cognitive activity, as described in cognitive models of the disorder (Espie et al., 2006; Harvey, 2002) where sleep-related cognition appears to be particularly vulnerable (Akram, 2017; Akram, Kay, et al., 2018; Semler & Harvey, 2005). With that in mind, sleep-associated monitoring on awakening (but not throughout the day) is evidenced to mediate the relationship between negative interpretations of cutaneous body image and symptoms of insomnia (Akram, 2017), whereas qualitative studies indicate that, upon awakening, individuals with insomnia monitor their internal and external bodily environment for cues that confirm a poor night's sleep. Internally, aspects of the body are perceived as sore, heavy and unrefreshed, whereas externally, attention was focused on their (negatively appraised) facial appearance (i.e., heavy eyes, poor complexion). Interestingly,





**FIGURE 3** Data points representing individual insomnia ambiguity task (IAT) scores for participants in the (a) normal sleepers and (b) insomnia symptoms groups

**TABLE 4** Examination of the mediating effect of sleep-associated monitoring, with group status as the dependent variables and interpretive bias scores as the predictor

Mediation estimates							
Effect	Estimate	SE	95% CI estimate		Z	Significance	% mediation
			Lower	Upper			
Indirect (a × b)	0.019	0.004	0.011	0.026	4.89	0.001**	50.9
Direct (c)	0.018	0.004	0.005	0.031	2.76	0.006*	49.1
Total (c + a × b)	0.036	0.004	0.036	0.048	5.94	0.001**	100.0
Path estimates							
	Estimate	SE	95% CI		Z	Significance	
			Lower	Upper			
a: Interpretive bias → sleep monitoring	0.088	0.013	0.062	0.112	6.78	0.001**	
b: Sleep monitoring → group status	0.211	0.035	0.139	0.275	5.97	0.001**	
c: Interpretive bias → group status	0.018	0.006	0.005	0.0310	2.76	0.006*	

Note: Mediation model, 1,000 bootstrap samples. CI, confidence interval; SE, standard error.

\*Significant at < .01, \*\* < .001

sleep-related monitoring throughout the day was reported to be more of an opportunistic behaviour (Akram, Kay, et al., 2018). Semler and Harvey (2005) found that the promotion of sleep-misperception upon awakening using false feedback (i.e., indicating that subjects had slept more poorly than they actually had) subsequently distorts the perception of daytime deficit in those with insomnia. On days

following false feedback (that their sleep obtained was poor), negative thoughts, sleepiness, monitoring for sleep-related threat and use of safety behaviours were all greater when compared to days when the same participants received false positive feedback (that sleep quality was good; Semler & Harvey, 2005). Given the current and previous outcomes, targeting and reducing sleep-associated

monitoring on awakening may theoretically eliminate one source of maintenance in insomnia by extinguishing the tendency to interpret ambiguous cues as consistent with a poor night's sleep, which perpetuates the negative thought cycle proposed by cognitive models of insomnia (Espie et al., 2006; Harvey, 2002). Likewise, as highlighted by Ree and Harvey (2006), correcting disorder-consistent interpretive biases in insomnia may serve to augment cognitive behavioural treatments.

Several strengths and limitations of the current study should be noted. A number of potential confounding variables were controlled for. Notably, levels of sleepiness, task response time and the time at which participants were tested. The cross-sectional nature of the study leaves the outcomes vulnerable to inflation bias between variables and limits definitive conclusions about causal relationships. The present sample comprised mostly female participants in the insomnia group, possibly limiting generalizability to males. However, it is relevant to note that women are more likely than men to be diagnosed with insomnia (Zhang & Wing, 2006). Moreover, although a clinical screening tool was used to examine insomnia symptoms against the DSM-5 criteria, the current outcomes cannot be extrapolated to individuals meeting diagnostic criteria for insomnia. However, we employed additional screening to exclude participants presenting with co-occurring physiological sleep disorders. Employing a general population sample may be considered a practical step towards the identification of factors mediating interpretive bias in the context of insomnia. Indeed, symptoms of and primary mechanisms underpinning insomnia exist along a continuum (Ellis et al., 2010). Here, although the same processes are expected in a general population and clinical samples, they diverge in severity. Therefore, the present effects may be stronger in those meeting the criteria for insomnia disorder. Finally, although the use of a behavioural task may be considered a strength of the current study, the IAT remains vulnerable to a possible response bias.

Nevertheless, this study provides additional evidence that the experience of insomnia symptoms is associated with a disorder-consistent interpretive bias. More crucially, we highlight the role of monitoring for insomnia-consistent cues on awakening, which appears to accentuate levels of sleep-related interpretive bias.

#### CONFLICT OF INTEREST

No conflicts of interest are declared in relation to this paper.

#### AUTHOR CONTRIBUTIONS

The experiment was designed and conceived by UA. Data were collected by UA, EB, CH and VO. An initial version of the manuscript was written by UA. Following, input was sought from ADR. All authors approved the final version of the manuscript.

#### DATA AVAILABILITY STATEMENT

Data will be made available on reasonable request.

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#### REFERENCES

- Akram, U. (2017). Sleep associated monitoring on awakening mediates the relationship between cutaneous body image dissatisfaction and insomnia symptoms. *Sleep Science*, 10, 92.
- Akram, U., Barclay, N. L., & Milkins, B. (2018). Sleep-related attentional bias in insomnia: Time to examine moderating factors? *Frontiers in Psychology*, 9, 2573. <https://doi.org/10.3389/fpsyg.2018.02573>
- Akram, U., Ellis, J. G., Myachykov, A., & Barclay, N. L. (2016). Misperception of tiredness in young adults with insomnia. *Journal of Sleep Research*, 25(4), 466–474. <https://doi.org/10.1111/jsr.12395>
- Akram, U., Kay, S., & Fonquerine, Z. (2018). Qualitative examination of daytime monitoring and selective attention in insomnia. *Sleep and Vigilance*, 2(2), 149–155. <https://doi.org/10.1007/s41782-018-0049-6>
- Bootzin, R., Shoham, V., & Kuo, T. (1994). Sleep anticipatory anxiety questionnaire: A measure of anxiety about sleep. *Sleep Research*, 23, 188.
- Borkovec, T.D. (1982). Insomnia. *Journal of Consulting and Clinical Psychology*, 50, 880–895. <https://doi.org/10.1037/0022-006X.50.6.880>
- Courtauld, H., Notebaert, L., Milkins, B., Kyle, S. D., & Clarke, P. J. (2017). Individuals with clinically significant insomnia symptoms are characterised by a negative sleep-related expectancy bias: Results from a cognitive-experimental assessment. *Behaviour Research and Therapy*, 95, 71–78. <https://doi.org/10.1016/j.brat.2017.05.010>
- Ellis, J., Gardani, M., & Hogh, H. (2010). Priming affects poor sleepers but not normal sleepers on an insomnia ambiguity task. *Journal of Sleep Research*, 19(1-Part-I), 27–30. <https://doi.org/10.1111/j.1365-2869.2009.00792.x>
- Espie, C. A., Broomfield, N. M., MacMahon, K. M., Macphie, L. M., & Taylor, L. M. (2006). The attention-intention-effort pathway in the development of psychophysiological insomnia: A theoretical review. *Sleep Medicine Reviews*, 10(4), 215–245. <https://doi.org/10.1016/j.smrv.2006.03.002>
- Espie, C. A., Kyle, S. D., Hames, P., Cyhlarova, E., & Benzeval, M. (2012). The daytime impact of DSM-5 insomnia disorder: Comparative analysis of insomnia subtypes from the great British sleep survey. *The Journal of Clinical Psychiatry*, 73(12), 1478–1484.
- Espie, C. A., Kyle, S. D., Hames, P., Gardani, M., Fleming, L., & Cape, J. (2014). The Sleep Condition Indicator: A clinical screening tool to evaluate insomnia disorder. *British Medical Journal Open*, 4(3), e004183. <https://doi.org/10.1136/bmjopen-2013-004183>
- Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G\*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, 41, 1149–1160. <https://doi.org/10.3758/BRM.41.4.1149>
- Gerlach, F., Ehring, T., Werner, G. G., & Takano, K. (2020). Insomnia-related interpretational bias is associated with pre-sleep worry. *Journal of Sleep Research*, 29(1), e12938. <https://doi.org/10.1111/jsr.12938>
- Gupta, M. A., Gupta, A. K., & Knapp, K. (2015). Dissatisfaction with cutaneous body image is directly correlated with insomnia severity: A prospective study in a non-clinical sample. *Journal of Dermatological Treatment*, 26, 193–197. <https://doi.org/10.3109/09546634.2014.883060>
- Harvey, A. G. (2001). I can't sleep, my mind is racing! An investigation of strategies of thought control in insomnia. *Behavioural and Cognitive Psychotherapy*, 29(1), 3–11. <https://doi.org/10.1017/S1352465801001023>

- Harvey, A. G. (2002). A cognitive model of insomnia. *Behaviour Research and Therapy*, 40(8), 869–893. [https://doi.org/10.1016/S0005-7967\(01\)00061-4](https://doi.org/10.1016/S0005-7967(01)00061-4)
- Heath, M., Johnston, A., Dohnt, H., Short, M., & Gradisar, M. (2018). The role of pre-sleep cognitions in adolescent sleep-onset problems. *Sleep Medicine*, 46, 117–121. <https://doi.org/10.1016/j.sleep.2018.03.002>
- Hoddes, E., Zarcone, V., Smythe, H., Phillips, R., & Dement, W. C. (1973). Quantification of sleepiness: A new approach. *Psychophysiology*, 10(4), 431–436. <https://doi.org/10.1111/j.1469-8986.1973.tb00801.x>
- Jansson-Fröjmark, M., Harvey, A. G., Lundh, L. G., Norell-Clarke, A., & Linton, S. J. (2011). Psychometric properties of an insomnia-specific measure of worry: The anxiety and preoccupation about sleep questionnaire. *Cognitive Behaviour Therapy*, 40(1), 65–76. <https://doi.org/10.1080/16506073.2010.538432>
- Oyetaquin-White, P., Suggs, A., Koo, B., Matsui, M. S., Yarosh, D., Cooper, K. D., & Baron, E. D. (2015). Does poor sleep quality affect skin ageing? *Clinical and Experimental Dermatology*, 40, 17–22. <https://doi.org/10.1111/ced.12455>
- Ree, M. J., & Harvey, A. G. (2006). Interpretive biases in chronic insomnia: An investigation using a priming paradigm. *Behavior Therapy*, 37(3), 248–258. <https://doi.org/10.1016/j.beth.2006.03.002>
- Ree, M. J., Pollitt, A., & Harvey, A. G. (2006). An investigation of interpretive bias in insomnia: An analog study comparing normal and poor sleepers. *Sleep*, 29(10), 1359–1362. <https://doi.org/10.1093/sleep/29.10.1359>
- Richdale, A. L., Baker, E., Short, M., & Gradisar, M. (2014). The role of insomnia, pre-sleep arousal and psychopathology symptoms in daytime impairment in adolescents with high-functioning autism spectrum disorder. *Sleep Medicine*, 15(9), 1082–1088. <https://doi.org/10.1016/j.sleep.2014.05.005>
- Semler, C. N., & Harvey, A. G. (2004a). Monitoring for sleep-related threat: A pilot study of the Sleep Associated Monitoring Index (SAMI). *Psychosomatic Medicine*, 66(2), 242–250. <https://doi.org/10.1097/01.PSY.0000114870.50968.90>
- Semler, C. N., & Harvey, A. G. (2004b). An investigation of monitoring for sleep-related threat in primary insomnia. *Behaviour Research and Therapy*, 42(12), 1403–1420.
- Semler, C. N., & Harvey, A. G. (2005). Misperception of sleep can adversely affect daytime functioning in insomnia. *Behaviour Research and Therapy*, 43(7), 843–856. <https://doi.org/10.1016/j.brat.2004.06.016>
- Spitzer, R. L., Kroenke, K., Williams, J. B., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. *Archives of Internal Medicine*, 166(10), 1092–1097. <https://doi.org/10.1001/archinte.166.10.1092>
- Spoormaker, V. I., Verbeek, I., van den Bout, J., & Klip, E. C. (2005). Initial validation of the SLEEP-50 questionnaire. *Behavioral Sleep Medicine*, 3(4), 227–246. [https://doi.org/10.1207/s15402010bsm0304\\_4](https://doi.org/10.1207/s15402010bsm0304_4)
- Takano, K., & Raes, F. (2018). Subjective sleep disturbances are associated with intrinsic motivation toward sleep-related thinking. *Behaviour Research and Therapy*, 100, 30–36. <https://doi.org/10.1016/j.brat.2017.11.002>
- Tang, N. K., & Harvey, A. G. (2004). Correcting distorted perception of sleep in insomnia: A novel behavioural experiment? *Behaviour Research and Therapy*, 42(1), 27–39. [https://doi.org/10.1016/S0005-7967\(03\)00068-8](https://doi.org/10.1016/S0005-7967(03)00068-8)
- The jamovi project. (2021). jamovi (Version 1.6) [Computer Software]. Retrieved from <https://www.jamovi.org>
- Watts, F. N., Coyle, K., & East, M. P. (1994). The contribution of worry to insomnia. *British Journal of Clinical Psychology*, 33(2), 211–220. <https://doi.org/10.1111/j.2044-8260.1994.tb01115.x>
- Zhang, B., & Wing, Y. K. (2006). Sex differences in insomnia: A meta-analysis. *Sleep*, 29(1), 85–93. <https://doi.org/10.1093/sleep/29.1.85>
- Zheng, S., Feng, J., Lin, R., Yan, Y., Zhang, R., Huang, H., Wang, J., & Huang, R. (2019). The impact of negative mood state on sleep-related attentional bias in insomnia. *Journal of Sleep Research*, 28(2), e12748. <https://doi.org/10.1111/jsr.12748>

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