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Assessing the Therapeutic Potential of Targeted Attentional Bias Modification for Insomnia Using Smartphone Delivery

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Cognitive models of insomnia propose that attentional vigilance for threat during the pre-sleep period may play a causal role in insomnia by elevating physiological and psychological arousal to produce a state that is incompatible with the initiation of sleep [1]. Consistent with such theoretical accounts, studies have confirmed that insomnia is associated with patterns of biased attention favouring sleep-related threatening information [2].

Converging research has shown that attentional bias assessment methodologies, such as the attentional probe task, can be converted to attentional bias modification (ABM) tasks. Using such tasks it has been shown that modification of biased attention for threat can achieve therapeutic benefits in conditions where this bias is implicated, including anxiety and mood disorders [3]. Of specific relevance to the current research is the observation that a single session of computer-based ABM can have immediate effects on anxiety and stress reactivity [3]. Therefore, we sought to assess whether targeted delivery of an ABM task during the pre-sleep period could reduce symptoms of insomnia and the cognitive symptoms of pre-sleep arousal.

Invitations were extended to individuals from the University of Western Australia School of Psychology participant pool who had identified worry-related insomnia as a problem (n = 236, n = 41 accepted). Inclusion criteria (met by n = 36) were access to an iPhone, high levels of insomnia symptoms on the Pittsburgh Sleep Quality Index (score ≥5 [4]), completing at least 4 of 5 ABM/control sessions during the study, and consistent accuracy on the attentional probe task (>70%). Participants were randomly allocated to the ABM (n = 18; 12 female) or control condition (n = 18; 15 female).

The study spanned 8 days (7 nights). The first 2 days served as a baseline period in which participants completed self-report measures and wore the sleep monitor, but did not complete the ABM or control task. These initial baseline days were followed by 5 consecutive 'task completion days' in which the participants completed, immediately prior to bed, an ABM task (ABM condition) or a non-training control task (control condition) on their smartphone. Both tasks employed 48 word pairs comprising sleep-related threat words paired with non-threat words. The task format was similar to standard ABM tasks used in prior studies [3], with task parameters adapted for use on an iPhone. On each trial an initial fixation cross was followed by two vertically aligned words, one threatening sleep-related word and one neutral word. After 500 ms the word pair was replaced by a probe appearing in the location of one of the words. The participants discriminated probe identity (horizontally or vertically aligned dots) by tapping the corresponding horizontal or vertical arrow icon at the bottom of the iPhone screen. In the ABM condition, probes always appeared opposite the threat word to encourage attentional avoidance of sleep-related threat. In the control condition and on assessment trials, probes replaced the threat and neutral words with equal frequency, so as not to encourage any pattern of selective attention. On task completion days 1–5, the participants completed 384 trials prior to sleep each night (approx. 15 min). Of these, 288 were ABM/control trials, and 96 were assessment trials randomly dispersed within the latter half of the ABM/control trials. An index of attentional bias to threat was computed across assessment trials in a manner consistent with past studies [3]. Further details of task parameters, stimulus creation, experimental methodology and additional discussion of findings are available in supplementary online material via the following link: http://www.psychology.uwa.edu.au/research/care/research/ClarkePPS).

On the first day of the study, the participants completed the trait version of the State-Trait Anxiety Inventory [5], the Penn State Worry Questionnaire [6] and the Pittsburgh Sleep Quality Index [4], while baseline attentional bias was assessed with 96 trials of the attentional probe assessment task. On all days, the participants completed the cognitive subscale of the Pre-Sleep Arousal Scale [7] prior to sleep (following probe task completion on task completion days). Additionally, we assessed the time taken to fall asleep (sleep onset latency) and the frequency of waking both objectively, with a wireless electrophysiological monitor [8] and subjectively via a sleep diary [9]. The latter also provided ratings of overall sleep quality (from 1 = very bad to 5 = very good). Finally, changes in insomnia-related anxiety between days 1 and 8 were assessed using the Anxiety and Preoccupation about Sleep Questionnaire (APSQ [10]).

Participants in the ABM and control groups did not differ significantly in gender ($p > 0.10$), age or any baseline measures, with the exception of sleep quality (table 1). All daily measures were subjected to an ABM condition (ABM/control) by probe task day (1–5) mixed model ANOVA. Results revealed main effects of the ABM condition showing that, compared to those in the control

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Table 1. Comparison of participant characteristics, mean baseline daily measures and mean probe task daily measures between active ABM and control groups

	ABM condition	Control condition	Comparison		
			t	p	d
Participant characteristics					
Age	19.89±2.95	18.33±2.06	1.83	0.08	0.61
Trait Anxiety Inventory	50.00±8.68	54.72±8.36	1.66	0.11	0.55
Penn State Worry Questionnaire	51.11±6.07	53.78±8.21	1.11	0.28	0.37
Pittsburgh Sleep Quality Index	18.16±11.64	14.00±6.87	1.31	0.20	0.44
Baseline day measures					
Pre-sleep arousal	20.94±4.59	24.44±6.49	1.87	0.07	0.62
Sleep quality	2.47±0.55	3.06±0.59	3.08	0.01*	1.03
Sleep onset latency – monitor	41.46±25.17	46.00±32.99	0.46	0.64	0.15
Number of wakings – monitor	2.29±1.49	2.65±2.46	0.53	0.60	0.18
Sleep onset latency – diary	28.94±15.57	36.49±26.07	1.05	0.29	0.35
Number of wakings – diary	1.94±1.40	1.76±1.13	0.50	0.68	0.14
Attentional bias index	–14.8±22.8	–5.01±27.66	1.17	0.25	0.39
Task completion day measures					
Pre-sleep arousal	17.56±6.66	22.46±7.63	2.45	0.02*	0.68
Sleep quality	3.43±0.77	2.91±0.95	3.34	<0.01*	0.60
Sleep onset latency – monitor	31.34±22.70	53.48±42.95	2.65	0.01*	0.64
Number of wakings – monitor	1.76±1.07	3.05±2.07	2.34	0.02*	0.78
Sleep onset latency – diary	29.50±31.40	39.22±42.55	1.02	0.31	0.26
Number of wakings – diary	1.42±1.24	1.16±1.04	0.69	0.49	0.23
Attentional bias index	7.65±29.64	–0.58±19.01	0.99	0.33	0.33

Results are means ± SD. * $p < 0.05$.

condition, subjects in the ABM condition reported significantly lower pre-sleep arousal (on the cognitive subscale of the Pre-Sleep Arousal Scale) and better overall sleep quality (a reversal of the baseline difference). Additionally, electrophysiological monitor measures showed that those in the ABM condition fell asleep faster and woke less often during the night compared to controls. No other significant main effects or interactions were observed (all $F < 1.7$, all $p > 0.15$; see table 1 for means and between-group differences).

Changes in sleep-related anxiety (APSQ) were assessed via a condition (ABM/control) by assessment time (pre-/post-assessment) mixed model ANOVA, which showed a significant interaction effect, $F(1, 34) = 5.44$, $p = 0.03$, $\eta^2 = 0.16$. This interaction was carried by a significant decrease in APSQ scores from pre-assessment (mean = 61.61, SD = 18.00) to post-assessment time points (mean = 40.72, SD = 13.38) in the ABM group, $t = 3.86$, $p < 0.01$, $d = 1.32$, that did not approach significance for the pre-assessment (mean = 61.50, SD = 17.88) to the post-assessment time (mean = 56.17, SD = 14.34) in the control group, $t = 1.36$, $p = 0.19$, $d = 0.33$. In summary, as compared to the control condition, participants who completed ABM training reported less pre-sleep arousal, fell asleep faster, woke less often during the night, reported a better overall sleep quality and showed significant reductions in sleep-related anxiety from before to after the 5-day programme.

Although these effects are entirely consistent with the positive effects of ABM on relevant sleep measures, we did not also observe any significant change in attentional bias. While this may represent a genuine absence of bias change, the consistency of effects across separate sleep measures suggests that ABM was having the intended effect. It is possible therefore that iPhone-based assessment coupled with the relatively small sample size may not have been sufficient to detect bias changes. Indeed, a post hoc power analysis suggests that in order to detect a medium-sized between-group effect in attentional bias it would be necessary to recruit a sample with more than 50 participants.

Overall, these results suggest that attentional bias modification targeting vigilance for sleep-related threat during the pre-sleep period has the capacity to reduce cognitive arousal and improve insomnia symptoms, providing a crucial step towards establishing a novel intervention for insomnia. Given the small sample size, replication with a larger sample will be crucial before it is possible to draw firm conclusions about potential benefits of ABM for insomnia. Nevertheless the results provide encouragement that targeted ABM could be used not only as a potential treatment for insomnia, but also with other conditions that implicate attentional bias (and consequent anxious arousal), as being acutely problematic at specific points in time. These findings therefore not only highlight a novel target for ABM in insomnia, but also a novel method of ABM by targeting acute rather than enduring change in attentional bias.

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Disclosure Statement

All authors report no conflicts of interest.

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