The Effectiveness of Touchscreen-Based Attentional Bias Modification to Thin Body Stimuli on State Rumination

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Ruminative thinking is considered a vulnerability factor for eating disorder symptomatology. Research suggests that attentional bias to body shape stimuli may serve to underpin this maladaptive form of emotion regulation. The current study aimed to determine the direct effect of attentional bias to thin-ideal bodies on state depressive rumination. Additionally, this study sought to evaluate the efficacy of attentional bias modification (ABM) utilising a touchscreen device. A well-established ABM protocol, the modified dot probe task, was used for both attentional assessment and training. Female undergraduate students (*N* = 110) completed an ABM session where attention was trained either towards, or away from, thin-ideal body images. Pre- and post-attentional training, participants completed the dot probe task, as well as a state measure of depressive rumination. Results revealed that the ABM training induced a greater attentional bias to thin-ideal bodies in the attend-thin training condition than in the avoid-thin training condition. Furthermore, induced attentional avoidance of thin-ideal bodies led to a significant reduction in state depressive rumination. The current findings suggest that touchscreen-based ABM is effective in modifying patterns of attentional bias and state depressive rumination.

Keywords: rumination; eating disorders; attentional bias modification; touchscreen.

Characterised by repetitive focus on the causes, experiences, and consequences of dysphoric emotions (Nolen-Hoeksema, 1991), rumination, is considered a vulnerability factor for eating disorder (ED) symptomatology. In support of this notion, large scale meta-analyses provide compelling evidence for an association between this maladaptive form of emotion regulation and ED symptomatology in predominantly non-clinical samples of women (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Smith, Mason, & Lavender, 2018). Thus, this highlights the need to identify mechanisms underpinning a ruminative response style in women in the community.
It has been theorised that biased attentional processing may contribute to a heightened ruminative disposition (Koster, De Lissnyder, Derakshan, & De Raedt, 2011). Despite converging evidence for an association between an attentional bias and rumination in the context of depression (e.g., Donaldson, Lam, & Mathews, 2007; Grafton, Southworth, Watkins, & MacLeod, 2016; Joormann, Dkane, & Gotlib, 2006), few investigators have examined this relationship with respect to body image. A preliminary study found that women with a greater dispositional tendency to ruminate on eating, shape, and weight concerns (i.e., ED-specific rumination) have a heightened tendency to selectively attend to images representing contemporary society’s idealisation of thinness (henceforth ‘thin-ideal’ bodies) (Dondzilo, Rieger, Palermo, Byrne, & Bell, 2017). It is important to acknowledge that although this attentional-linked effect concerns idealised body stimuli, research has shown that individuals with Anorexia Nervosa selectively attend to general and social threat stimuli (Cardi et al., 2015; Cardi, Matteo, Corfield, & Treasure, 2013), as well as ED-relevant threat stimuli (Gilon Mann et al., 2018).

Despite initial evidence for an association between attentional bias to thin-ideal bodies and dispositional ED-specific rumination (Dondzilo et al., 2017), a subsequent study found that an experimentally induced attentional bias to thin-ideal bodies does not serve to influence state ED-specific rumination (Dondzilo, Rieger, Palermo, & Bell, 2018). However, in this same study, participants who were trained to attend to thin-ideal bodies exhibited heightened negative emotional vulnerability, compared with those participants trained to avoid thin-ideal bodies. Thus, given the possibility of a causal association between attentional bias to thin-ideal bodies and state negative affect, and the notion that general rumination (also termed “depressive rumination”) encompasses the tendency to reflect on one’s negative mood and the inability to disengage from
negative thoughts (Nolen-Hoeksema, 1991), it may be inferred that biased attentional processing of thin-ideal bodies leads to changes in state depressive rumination.

In light of the above, the purpose of the current study was to extend the findings of Dondzilo et al. (2018) and determine whether selective attentional processing of thin-ideal bodies serves to influence state levels of depressive rumination in young women. In order to examine this potential causal association, it is necessary to directly alter attentional biases via a well-established training procedure termed attentional bias modification (ABM; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). Importantly, this procedure has been shown to be effective in modifying attentional biases in an eating disorders context (Cardi et al., 2015). Building on this research methodology, a further objective of the current study was to provide “proof-of-principle” with respect to whether attentional biases can be successfully altered using a modern touchscreen device. Given the growing evidence base indicating that ABM can yield therapeutic benefits (MacLeod & Clarke, 2015), combined with the fact it is brief and requires minimal literacy, ABM is considered a prime candidate for smartphone-based interventions (Dennis & O’Toole, 2014). There is a paucity of research, however, examining the efficacy of smartphone-based ABM interventions aimed at building body image resilience. An important consideration regarding the effectiveness of such an intervention is the success of the attentional training itself. Namely, a recent review of ABM-based interventions in anxiety has shown that in most cases ABM only leads to changes in anxiety symptoms if the ABM has successfully been achieved (MacLeod & Clarke, 2015). Thus, to justify the creation of smartphone-based ABM interventions in the body image domain, it is necessary to demonstrate that this approach is successful in inducing the intended attentional change utilising a touchscreen device.
Accordingly, the aims of the current study were to, (1) determine the effectiveness of touchscreen-based ABM in modifying patterns of attentional bias regarding thin body stimuli and, (2) whether ABM training procedures would result in changes in state depressive rumination. Firstly, it was hypothesised that the ABM task would be successful in producing the predicted changes in attentional bias (i.e., young women were trained to either attend towards, or avoid, thin-ideal images). Further, it was anticipated that the two experimental groups would demonstrate opposite patterns of ruminative responses. That is, the participants trained to attend to thin-ideal bodies would experience increased, whereas those trained to avoid thin-ideal bodies would experience reduced, state depressive rumination.

**Method**

**Participants**
The sample consisted of 110 young women ($M_{age} = 19.75; SD = 1.92$; range $= 17-26$), recruited from the undergraduate student population at the University of Western Australia. Participants took part in the study in exchange for course credit. The sample size is consistent with previous work reporting significant effects using a similar study design and sample characteristics (Dondzilo et al., 2018).\(^1\) Ethics approval for this study was granted by the University of Western Australia’s Human Research Ethics Committee.

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\(^1\)A post hoc sensitivity power analysis on the study by Dondzilo et al. (2018) revealed that the sample size employed was large enough to detect significant experimental condition (attend vs. avoid) x time (pre- vs. post-ABM) interactions.
Materials and measures

Stimuli
In line with previous studies assessing attentional bias to thin-ideal bodies by means of the dot probe task, images depicting thin bodies were paired with images depicting cropped sections of abstract art (Dondzilo et al., 2017; Dondzilo et al., 2018). Experimental stimuli comprised the image set employed by Dondzilo et al. (2018), half of which represented thin-ideal bodies (40) while the other half represented abstract art (40). These images differed as a function of their emotional valence, such that thin-ideal bodies were perceived to be affectively positive whereas abstract art was perceived to be affectively neutral. Images of thin bodies were cropped to focus on weight-relevant body regions (i.e., thighs, abdomen, hips, and arms). The bodies were presented in varying perspectives (i.e., front, right side, back, left side) and were predominantly dressed in bathing suits and clothing which emphasised the specific body regions. Additionally, the bodies were estimated to be bordering on underweight, which is consistent with the thin ideal. In line with Dondzilo et al. (2018), 40 stimulus pairs were divided into two subsets: 24 pairs were used at training and the remaining 16 pairs were used at pre- and post-training.

The stimuli were displayed on a 1920 x 1080 CRS Display ++ touchscreen LCD monitor running at 120 Hz, driven by a Dell PC and using Matlab R2013b and the Psychophysics Toolbox (Brainard, 1997) to control stimulus presentations. Participants were seated approximately 50 cm in front of the touchscreen monitor.

Modified dot probe task
In line with the well-established ABM protocol (MacLeod et al., 2002), the modified dot probe task was used for the assessment and manipulation of attentional bias towards thin-ideal bodies. Each trial commenced with the 1,000 ms presentation of a fixation
cross in the centre of the screen. Following this, an image pair was displayed for 500 ms, with one image appearing three degrees to the right, and the other image appearing three degrees to the left, of the central fixation cross. Subsequently, a probe stimulus (i.e., the letter “Q”) was presented in the position previously occupied by one of the images. Participants were required to identify the location of the letter “Q” by directly tapping the “Q” on the touchscreen monitor as quickly and accurately as possible. The speed and accuracy (within 2 degrees of the probe) of this probe detection response was recorded. Upon detection of the participant’s response, the next trial commenced.

In total, 489 trials were presented across the modified dot probe task. Assessment of pre-training attentional bias commenced with nine practice trials, followed by 96 experimental trials. There were 288 attentional training trials and a further 96 post-training trials. The distinction between assessment and training trials is described below.

Attentional assessment trials. In the attentional assessment trials (pre- and post-training), the probes appeared equally often in the location previously occupied by the thin body image, and in the location previously occupied by the neutral image. Additionally, the location of the probe (right, left) was randomized. Within each block of attentional assessment trials (pre or post), each image pair was presented six times.

Attentional training trials. In the attentional training trials, the position of the probe stimulus was contingent on the allocated training condition. Specifically, for participants in the attend condition, the probe consistently (100% probability) replaced the previously presented thin body image. For participants in the avoid condition, this contingency was reversed, that is the probe consistently replaced the previously presented neutral (abstract art) image. Each stimulus pair was presented 12 times.
Self-report questionnaires

Depression Anxiety Stress Scales-21 (DASS-21). The DASS-21 (Lovibond & Lovibond, 1995) was employed for the measurement of trait negative affect. This questionnaire consists of 21 items assessing depression, anxiety, and stress symptoms and are measured on a four-point scale ranging from did not apply to me at all to 3 applied to me very much, or most of the time. Scores obtained for each of these items are summed to yield a total score of negative affect, with higher scores indicative of greater disturbance. The Cronbach’s alpha for the total score in the present study was α = .93.

Brief State Rumination Inventory (BSRI). The 8-item BSRI (Marchetti, Mor, Chiorri, & Koster, 2018) was used to assess state depressive rumination. Participants indicated the extent to which each statement described their feelings and thoughts “right now” (e.g., “Right now, I am reflecting about my mood”) on a 100-mm visual analogue scale (VAS) ranging from completely disagree to completely agree. Scores are summed such that higher scores indicate greater depressive rumination. The minimum total score is 0 and the maximum total score is 800. The BSRI has demonstrated excellent reliability and good convergent and discriminant validity (Marchetti et al., 2018). Additionally, it has shown sensitivity to an experimental manipulation of rumination. Cronbach’s alpha for the composite score in the current sample was α = .91 at pre-ABM and α = .93 at post ABM.

Procedure

Each participant was tested individually in a quiet room. After providing informed consent, participants were first asked to complete the BSRI. Participants were given instructions regarding the dot probe task and then completed the assessment trials. Next, participants were randomly assigned to either an attend-thin bodies or avoid-thin bodies
training condition. Following completion of the attentional training trials, they completed the dot probe assessment trials again. Subsequently, participants were requested to complete the BSRI and DASS. Finally, participants’ height and weight were measured for the calculation of BMI. At the end of the session, all participants were fully debriefed and the experimenter monitored all participants for any distress.

**Data reduction**

For the modified dot probe task, the data analysis was based on correct trials only. One participant was excluded due to an overall accuracy rate of less than 75% at post-ABM. The remaining participants displayed exceedingly high accuracy (pre and post-ABM accuracy rates, 99.2% and 97.2%, respectively). In line with previous studies (Dondzilo et al., 2017; Dondzilo et al., 2018), probe detection reaction times (RTs) less than 200 ms or greater than 2.5 standard deviations above each participant’s mean were excluded. Mean probe detection RTs were used to compute an attentional bias index at each time point (pre- and post-training assessment phases) and for each experimental group (attend and avoid). The calculation of an attentional bias index was adapted from the following formula of MacLeod and Mathews (1988): 

\[
\frac{[(\text{right probe/left target} – \text{right probe/right target}) + (\text{left probe/right target} – \text{left probe/left target})]}{2}.
\]

Specifically, the index suggests the degree to which probe detection was facilitated or inhibited by images of thin bodies, such that positive values reflect an attentional bias towards thin-ideal bodies.

**Results**

**Baseline group characteristics**

Experimental groups did not show significant differences on BMI, trait negative affect, and age (all \(ps > .05\); see Table 1). Moreover, there were no significant differences
between experimental groups on attentional bias and state depressive rumination, at baseline (all *ps* > .05; see Figure 1). Although there were no significant correlations between baseline levels of attentional bias and state rumination, nor between these baseline variables and BMI/age (all *ps* > .05), baseline state rumination was found to significantly correlate with trait negative affect (*r* = .63, *p* < .001).

[Table 1 near here]

**Attentional bias modification**

Attentional bias indices are shown in Figure 1 (top figure). To assess whether the touchscreen-based attentional training procedure was effective in modifying attentional biases regarding thin-ideal bodies, the attentional bias indices were subjected to a 2 (training condition: attend, avoid) × 2 (time: pre-training, post-training) mixed model ANOVA. Results revealed a main effect of time, *F*(1,107) = 7.23, *p* = .008, η² = .06, and a main effect of condition, *F*(1,107) = 9.85, *p* = .002, η² = .08. These main effects were subsumed within a higher-order interaction between training condition and time, *F*(1,107) = 22.95, *p* < .001, η² = .18. Simple effect analyses revealed a significant reduction in attentional bias towards thin-ideal bodies, from pre- to post-training, in the avoid condition, *t*(54) = -6.61, *p* < .001, *d* = -.89, 95% CI [-30.69, -16.40]. Although participants in the attend condition showed an increase in attentional bias for thin-ideal bodies, this change was not significant, *t*(53) = 1.27, *p* = .210, *d* = .20, 95% CI [-.385, 17.08]. Crucially, the two training conditions did not differ significantly in attentional bias at pre-training, *t*(107) = .06, *p* = .954, *d* = .01, 95% CI [-.869, .921], but did differed significantly in attentional bias at post-training, *t*(107) = 4.41, *p* < .001, *d* = .85, 95% CI [16.73, 44.12]. These results indicate that the attentional training successfully
induced differential changes in attentional bias regarding thin bodies in the expected directions.

**Effect of ABM on state depressive rumination**

State depressive rumination scores are shown in Figure 1 (bottom figure). To evaluate the effect of the attentional training on state depressive rumination, a 2 (training condition: attend, avoid) × 2 (time: pre-ABM, post-ABM) mixed model ANOVA was performed.² This analysis revealed no main effect of condition, $F(1,107) = 1.06, p = .306, \eta^2 = .01$. Conversely, there was a main effect of time, $F(1,107) = 6.21, p = .014, \eta^2 = .06$, subsumed within a higher-order interaction between training condition and time, $F(1,107) = 4.03, p = .047, \eta^2 = .04$. Simple effect analyses revealed a significant reduction in rumination from pre- to post-ABM in the avoid condition, $t(54) = -3.23, p = .002, d = -.16, 95\% \text{ CI } [-.50.41, -.11.81]$ but no significant change in rumination across time in the attend condition, $t(53) = -.34, p = .737, d = -.02, 95\% \text{ CI } [-.22.28, 16.57]$. Furthermore, at post-ABM, the two experimental conditions did not differ significantly in their levels of state rumination, $t(107) = 1.39, p = .167, d = .27, 95\% \text{ CI } [-.21.36, 122.28]$. Therefore, it can be suggested that training attention away from thin-ideal images may be associated with the reduction of state depressive rumination, however, it is not more effective as compared to training attention towards thin-ideal images.

[Figure 1 near here]

**Discussion**

The current study sought to evaluate the effectiveness of touchscreen-based ABM in modifying patterns of attentional bias regarding thin-ideal images and state depressive

²Given that baseline state rumination correlated significantly with trait negative affect, negative affect was considered a moderator in the relationship between attentional bias and state rumination. However, there was no evidence for a moderation effect.
rumination. As expected, the ABM was successful in inducing the intended attentional change and, in turn, a change in state depressive rumination. Specifically, participants who were induced to direct attention away from thin-ideal bodies showed reduced state depressive rumination from pre- to post-ABM training.

Findings obtained in the current study were novel in showing that training to direct attention away from thin-ideal images resulted in reduced state depressive rumination in young women. This finding is consistent with theory (Koster et al., 2011) and builds on experimental evidence suggesting that attentional bias serves to influence depressive rumination (Yang, Ding, Dai, Peng, & Zhang, 2015). However, the nature of this relationship was contrary to our prediction that attending to thin-ideal bodies would serve to intensify rumination on depressive themes. One potential explanation for the finding of an effect on depressive rumination for the avoid group, but not for the attend group, is a change in attentional bias in the avoid group only. Given that the attend-thin group showed a change in attentional bias in the expected direction, albeit non-significant, this might suggest that a larger sample would result in a statistically significant change. Future research might also benefit from including control images that offer greater competition in the allocation of attentional resources in comparison to thin-ideal bodies, such as non-thin bodies.

It should also be acknowledged that the current experimental design makes it difficult to disentangle whether the reduction in depressive rumination was due to avoidance of thin-ideal bodies or an attentional bias towards abstract art images, with the latter potentially serving to distract participants from self- or body-focused ruminative thought processes. Thus, future studies should consider the inclusion of control images that, as with the thin-ideal images, are self- or body-relevant. Additionally, the current design does not permit determination of whether the observed
effect was due a decrease in attentional bias in the avoid condition, or due to a maintenance of attentional bias in the attend condition. To make this distinction, future studies are encouraged to include a control group, with no manipulation to attend to or avoid thin-ideal bodies.

Nevertheless, our findings suggest that training to direct attention away from thin-ideal stimuli may serve as a protective mechanism against depressive rumination in young women. This would in turn suggest that attentional biases for thin stimuli could be targeted in interventions designed to build resilience to this maladaptive form of emotion regulation in young women. Moreover, given that the touchscreen method was successful in modifying attentional biases and that this had a consequent impact on depressive rumination, the present findings provide support for the development of ABM-based smartphone interventions in this context. In turn, such an intervention may promote healthy body image, given evidence linking depressive rumination and the emergence of body image and eating disturbances (Naumann, Tuschen-Caffier, Voderholzer, Caffier, & Svaldi, 2015; Naumann, Tuschen-Caffier, Voderholzer, Schäfer, & Svaldi, 2016).

Given the current study was conducted under equivalent conditions to the study by Dondzilo et al. (2018), with the only difference being the response method, it is justifiable to compare the attentional training effect between the two studies. The magnitude of the difference in attentional bias between the two experimental groups at post-ABM was equivalent to a large effect size in the current study (Cohen’s $d = .85$), compared with a medium effect size (Cohen’s $d = .54$) in the study by Dondzilo et al. (2018). Although these different response methods were not directly compared, the notable difference in effect sizes suggests that touchscreen devices may be more effective in modifying attentional processes than the traditional keyboard response.
method (at least as utilised by Dondzilo et al., 2018). One possible explanation is that the probe detection method is more sensitive to individual differences in attentional bias than the probe discrimination method. Further research is necessary to directly compare the efficacy of the touchscreen-based ABM task, in terms of magnitude of change in attention, against that of traditional ABM tasks for both probe detection and discrimination.

In addition to those already noted, there are at least two limitations of the current study that warrant discussion. Primarily, the current measure of state depressive rumination assessed participants’ ruminative thoughts “right now” and thus may not have fully captured this dynamic cognitive process. More precisely, it is unlikely that an individual will be experiencing multiple, and very specific, thoughts at that very moment in time. A potentially more ecologically valid method of assessing state rumination is via a brief breathing focus task where participants are prompted at random intervals to report whether their attention is focused on their breathing, or if at that moment they are experiencing a ruminative thought. This task has recently been used to successfully differentiate between worry and rumination (Hur, Gaul, & Berenbaum, 2019), and thus presents an intriguing avenue for future researchers examining state changes in ruminative thinking. An additional limitation of the current study is that participants were not selected on the basis of displaying either elevated ruminative disposition or eating disorder symptomatology. Thus, it remains uncertain whether individuals vulnerable to developing an eating disorder exhibit the same association between attentional bias regarding thin-ideal bodies and state rumination, as observed in the current sample.

In conclusion, the current study was the first to show that touchscreen-based ABM is successful in modifying attentional biases regarding thin-ideal images.
Furthermore, we showed that this ABM has a subsequent impact on state depressive rumination. Specifically, participants trained to attend away from thin-ideal bodies and toward control images reported a reduction in state depressive rumination from pre- to post-ABM. To investigate whether the effects of the ABM extend beyond the experimental procedure, of benefit would be future research employing longitudinal designs, with the capacity to reveal whether touchscreen-based ABM can lead to sustained reductions in rumination and associated dysfunction.

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Disclosure of interest
The authors report no conflicts of interest.

Data availability statement
The data that support the findings of this study are openly available in figshare at https://doi.org/10.6084/m9.figshare.9722801.v1.

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Table 1. Means (SDs) and statistical comparisons for BMI, age, and trait negative affect across the attend and avoid conditions.

<table>
<thead>
<tr>
<th></th>
<th>Attend (n = 54)</th>
<th>Avoid (n = 55)</th>
<th>Between Condition Comparisons</th>
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<tr>
<td></td>
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<td></td>
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<tr>
<td>BMI</td>
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<td>.24</td>
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<tr>
<td>DASS</td>
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<td>19.35 (10.26)</td>
<td>.59</td>
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<tr>
<td>Age</td>
<td>19.80 (1.85)</td>
<td>19.71 (2.00)</td>
<td>.24</td>
</tr>
</tbody>
</table>

Note. BMI = Body Mass Index (kg/m²); DASS = Depression Anxiety Stress Scale
Figure 1. Means and standard errors for attentional bias indices (above) and state depressive rumination scores (below) for the attend and avoid training conditions at pre- and post-attentional training.