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Validation of a novel Attentional Bias Modification Task: The future may be in the cards.

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Abstract

Attentional bias modification (ABM) is a promising therapeutic tool aimed at changing patterns of attentional selectivity associated with heightened anxiety. A number of studies have successfully implemented ABM using the modified dot-probe task. However others have not achieved the attentional change required to achieve emotional benefits, highlighting the need for new ABM methods. The current study compared the effectiveness of a newly developed ABM task against the traditional dot-probe ABM task. The new person-identity-matching (PIM) task presented participants with virtual cards, each depicting a happy and angry person. The task encourages selective attention toward or away from threat by requiring participants to make matching judgements between two cards, based either on the identities of the happy faces, or of the angry faces. Change in attentional bias achieved by both ABM tasks was measured by a dot-probe assessment task. Their impact on emotional vulnerability was assessed by measuring negative emotional reactions to a video stressor. The PIM task succeeded in modifying attentional bias, and exerting an impact on emotional reactivity, whereas this was not the case for the dot-probe task. These results are considered in relation to the potential clinical utility of the current task in comparison to traditional ABM methodologies.

Keywords: Attentional bias modification; anxiety; cognitive bias; emotional disorders

Validating a novel Attentional Bias Modification Task: The future may be in the cards.

Anxiety disorders are the most common class of mental health problems, affecting an estimated 14-18% of people within their lifetime (Australian Bureau of Statistics, 2008; Kessler, Chiu, Demler, Merikangas, & Walters, 2005). Anxiety disorders severely impact day-to-day activities, and often contribute to social withdrawal (Rubin & Burgess, 2001). In addition to the considerable distress they cause individuals, anxiety disorders pose a huge burden on society with estimates suggesting that they cost the US more than \$42 billion a year (Greenberg et al., 1999).

Cognitive models of psychopathology have long implicated biased attentional processing in anxiety dysfunction (e.g. Mathews & Mackintosh, 1998). This *attentional bias* for threat has been observed using a range of different paradigms, and across a wide range of sub-clinical and clinically anxious populations (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007). One of the most common methods of assessing attentional bias to threat is the dot-probe task (MacLeod, Mathews, & Tata, 1986), which measures attentional distribution between pairs of stimuli that differ in emotional valence, presented simultaneously on a computer screen (e.g. faces or words) for a brief duration (e.g. 500ms). Participants are required to discriminate the identity of a probe that subsequently appears in the location of either the threatening or neutral member of the stimulus pair. An attentional bias to threat is revealed by disproportionate speeding to discriminate probes presented at the location of previously presented threatening stimuli, as compared to probes presented at the location of previously exposed neutral stimuli (MacLeod et al., 1986). Using this and similar paradigms, it has now firmly been established that elevated anxiety is associated with a tendency to preferentially allocate attention towards threatening information (Bar-Haim et al., 2007).

Further research has sought to determine the causal status of biased attention to threat by directly modifying such attentional bias, to assess the consequent impact on anxiety vulnerability. The key feature of attentional bias modification (ABM) paradigms is the introduction of a contingency into the task designed such that successful performance will be enhanced by adoption of the target pattern of attentional selectivity (MacLeod & Clarke, 2013). In the first implementation of this ABM approach, a contingency was introduced in the attentional probe task, such that selectively attending to stimuli of one particular valence would facilitate the probe discrimination response. To encourage greater attentional bias to threat, the probe was always shown at the location of the negative stimulus. In contrast, to encourage attentional bias away from threat, the probe was always presented at the location opposite the threat stimulus (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). The results showed that the intended attentional bias change

was achieved, and that this had a consequent impact on emotional responding to a subsequent stress task. Specifically, when exposed to a stressor following ABM training, participants trained to adopt an attentional bias away from threat show an attenuated elevation of negative emotional state, compared to participants trained to adopt an attentional bias towards threat (MacLeod et al., 2002). This study, and many other subsequent studies employing this same ABM task, have confirmed that attentional bias to threat can be modified in this way (Hakamata et al., 2010), and have shown that when such attentional selectivity is successfully modified, this has a direct impact on emotional vulnerability (Clarke, Notebaert, & MacLeod, 2014; Hakamata et al., 2010; MacLeod & Mathews, 2012). In addition, several studies have shown that attentional bias to threat is significantly reduced after cognitive behavioural therapy (CBT), in a variety of anxious populations (for a review, see Tobon, Ouimet, & Dozois, 2011).

These findings highlighted the possibility that ABM may have significant therapeutic potential, and indeed there is now compelling evidence that this can be the case (Hakamata et al., 2010; MacLeod & Clarke, 2013; Mogoase, David, & Koster, 2014). Several researchers have successfully implemented extended attentional bias training in clinical settings to reduce emotional dysfunction. For example, Amir, Beard, Burns, and Bomyea (2009) delivered 8 sessions of ABM across 4 weeks to individuals with generalised anxiety disorder using the modified dot-probe task. Results showed that at the end of the four weeks, participants who completed the ABM training showed a reduced attentional bias to threat, and a reduction in self-reported and clinician-observed anxiety symptoms as compared to participants who completed a sham training (Amir, Beard, Burns, et al., 2009). Such results have been consistently shown in social anxiety disorder (Van Bockstaele et al., 2014; Woud & Becker, 2014), but also in generalised anxiety disorder (Schmidt, Richey, Buckner, & Timpano, 2009) and paediatric anxiety disorders (Bar-Haim, Morag, & Glickman, 2011; Rozenman, Weersing, & Amir, 2011).

However, not all studies have achieved such therapeutic benefits from delivering this probe-based ABM task (see for example Boettcher, Hasselrot, Sund, Andersson, & Carlbring, 2014; Boettcher et al., 2013; Carlbring et al., 2012; Neubauer et al., 2013; Rapee et al., 2013; Schoorl, Putman, & Van der Does, 2013). It is crucial to note that, whenever change in attentional bias has been assessed, it has consistently been found that the failure to achieve emotional benefits from this ABM procedure has reflected a failure to successfully modify attentional selectivity as intended. In contrast, when the ABM task has proven successful in attenuating attention to threat, so too it has consistently yielded emotional benefits (Clarke, Notebaert, et al., 2014). While this pattern confirms the therapeutic value of effective attentional bias modification, it suggests that the conventional probe-based ABM approach may not be the optimal procedure for achieving such bias

modification. Several studies have modified the dot-probe training task in ways that were hypothesised to enhance attentional training, with mixed results. For example, Bernstein and Zvielli (2014) have added on-line feedback of participants' biased attention to a dot-probe training task, and showed that relative to an active placebo control, this attentional feedback awareness training modified attentional bias to threat and affected the rate of emotional recovery following a stressor. Enock, Hofmann, and McNally (2014) likewise innovated dot-probe ABM by delivering it via participants' smartphones. In spite of the many advantages this approach may offer, the results showed no difference in symptom reduction between participants in the active training conditions as compared to the control conditions. Other researchers have adapted other existing attentional bias assessment task to modify attentional bias (Dandeneau & Baldwin, 2004; Dandeneau, Baldwin, Baccus, Sakellaropoulou, & Pruessner, 2007), however these studies lack an appropriate control condition. Hence one important challenge for ABM research is to find new effective ways of changing patterns of attentional bias. Consequently, many researchers in this burgeoning field have called for the development and validation of new ABM tasks, which may ultimately be deployed in clinical settings (Bar-Haim, 2010; Beard, 2011; Clarke, Notebaert, et al., 2014; Hallion & Ruscio, 2011; Van Bockstaele et al., 2014).

While there has been growing recognition of the importance in moving beyond the dot-probe ABM task, to develop and validate new improved methodologies for directly modifying biased patterns of attentional selectivity, as yet this has not resulted in the expansion of ABM tasks necessary to allow comparison of different approaches. The aim of the current study was to develop a new ABM task, and compare its effectiveness to that of the traditional probe ABM task. This new task was based on the popular card game 'snap', in which a matching judgment needs to be made between two exposed cards. In the current task, this matching response concerned whether faces shown on the two cards were of the same person. In order to be able to train differential attentional responding emotional information, each card presented two faces, each of a different individual, one displaying a happy expression and one displaying an angry expression. To encourage development of an attentional bias away from threat, some participants were required to base their matching response solely on identities of the happy faces. Conversely, to encourage development of an attentional bias towards threat, other participants were instead required to base their matching response solely on the identities of the angry faces. Thus, in line with other ABM tasks, successful task performance would be enhanced by adopting a pattern of processing that favoured greater selective attention towards either the more positive or the more negative information contained in each display (MacLeod & Clarke, 2013).

The two specific aims of the current study were to determine whether this new person identity matching (PIM) ABM task: (i) can produce a change in attentional bias in line with the allocated attentional training condition of equal or greater magnitude to the attentional change elicited by the conventional dot-probe ABM task, and if so, (ii) impacts on emotional vulnerability to an equal or greater degree than does the conventional dot-probe ABM task. To investigate this, participants with mid-range levels of trait anxiety were allocated to one of four conditions: i. Dot-probe ABM configured to encourage attentional bias away from threat (attend-happy), ii. Dot-probe ABM configured to encourage attentional bias towards threat (attend-angry), iii. Person identity matching ABM configured to encourage attentional bias away from threat (attend-happy), iv. Person identity matching ABM configured to encourage attentional bias towards threat (attend-angry). To determine the effectiveness of the ABM tasks in modifying attentional selectivity, attentional bias to threat was measured before and after exposure to the ABM procedure, using the traditional dot-probe attentional bias assessment task. To determine the impact of the ABM tasks on emotional vulnerability, we compared the intensity of negative emotional reactions to a video stressor presented after participants completed these differing ABM conditions.

It was expected that participants who completed the ABM tasks in the attend-happy conditions would show reduced selective attention to the angry faces, post attentional training, than would participants who completed the ABM tasks in the attend-angry conditions. It also was expected that the ABM would impact on emotional vulnerability, evidenced by participants who received ABM in the attend-happy conditions showing attenuated elevation of negative mood state in response to the final video stressor, as compared to participants who instead received ABM in the attend-angry conditions. The validity of our new person identity matching (PIM) ABM task, as a means of modifying attentional bias and altering emotional vulnerability, would be confirmed by the demonstration that it exerts these effects. Moreover, our experimental design also will permits us to appraise whether the impact of this new ABM procedure, on both attentional bias and emotional vulnerability, falls short of, equals, or exceeds, that of the ABM task most widely used by contemporary clinical investigators.

Method

Participants

Participants were community volunteers recruited via university networks. There was no financial or other remuneration for participation. In order to avoid floor or ceiling effects in either attentional bias or emotional reactivity, inclusion criteria required that candidate participants obtained mid-range trait anxiety scores (STAI-T score between 30 and 50), and did not experience a

shift towards more positive mood in response to the video stressor. The final sample consisted of 83 participants. Participants were randomly allocated to one of the following four conditions: Dot-probe ABM attend-happy condition (N=19, 4 male; mean age 20.1 yrs, SD = 4.8; mean STAI-T score = 41.7, SD = 5.5); Dot-probe ABM attend-angry condition (N = 19, 5 male; mean age 19.7 yrs, SD = 6.3; mean STAI-T score = 41.1, SD = 5.3); Person identity match ABM attend-happy condition (N=22, 7 male; mean age 21.0 yrs, SD = 1.5; mean STAI-T score = 39.6, SD = 5.6); and Person identity match ABM attend-angry condition (N = 23, 7 male; mean age 22.8 yrs, SD = 7.6; mean STAI-T score = 41.1, SD = 5.3). There were no significant differences in age, gender ratio or STAI-T trait anxiety score between the 4 groups ($p > .1$).

Materials

Emotional assessment measures

To ensure that included participants were mid-range in terms of trait anxiety, this were measured using the Spielberger Trait Anxiety Inventory, form Y (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). This questionnaire instrument yields a reliable and valid measure of dispositional anxiety (Barnes, Harp, & Jung, 2002; Spielberger et al., 1983).

To assess the emotional reactivity to the video stressor, mood was assessed before and after this stressor using two 11 point (range 0 – 10) mood scales, as in MacLeod et al. (2002). One scale was anchored with the labels happy (0) and Sad (10), while the other was anchored Relaxed (0) and Anxious (10). Participants entered the number corresponding to their current mood. Responses to the two scales were averaged to reflect mood, again as in MacLeod et al. (2002), with higher scores reflecting more negative mood states.

Experimental stimuli

In order to assess and train attentional selectivity for differentially valenced material, photographs of happy and angry faces were presented in the attentional tasks. The face stimuli were selected from the Karolinska Directed Emotional Faces (KDEF) stimulus set (Lundqvist, Flykt, & Öhman, 1998). Original images were cropped to show only the face and the neck. The attentional bias assessment stimulus set consisted of 24 images depicting 12 different individuals (half female, half male) showing both happy and angry expressions. The attentional bias training stimulus set comprised 64 images, depicting 32 different individuals (half male, female), each displaying a happy expression in one image and an angry expression in one image.

Stressor task

The stressor task involved exposure to four short video clips, taken from news footage and depicting real-life emergency rescue situations, which have previously been shown to be effective in eliciting negative emotional reactions (Wilson, MacLeod, Mathews, & Rutherford, 2006). The four video clips were presented in a fixed order and had a total duration of 6 minutes, 43 seconds. The videos can be downloaded from the following link:

<http://www.psychology.uwa.edu.au/research/care/research/videostressor>

Experimental Tasks

Dot-probe attentional assessment task. To assess change in attentional bias as a result of the ABM tasks, participants completed assessments of attentional bias before and after completing the ABM tasks. Each trial of this assessment bias task (based on MacLeod et al., 1986) commenced with the presentation of a central fixation cross for 500 msecs. Next, two images were presented simultaneously, one showing a person with a happy emotional expression and the other image showing the same person with an angry emotional expression. The images were 5cm in width and 6.5cm in height, and were spaced 2cm apart along the horizontal axis, while being positioned centrally on the vertical axis. After 500ms the two images disappeared and a probe was presented. This probe consisted of two red dots, which were either aligned horizontally (. .) or vertically (:). Participants were required to respond to the orientation of the probe, by pressing the left mouse button when the dots were aligned horizontally, and the right mouse button when the dots were aligned vertically. Errors triggered a three second feedback delay to encourage accurate responding. The probe was presented in the location previously occupied by the negative image and the location previously occupied by the positive image with equal frequency on each trial. Person identity, image location, probe location, and probe identity were counterbalanced, creating 96 trials. Each trial started with a 500ms fixation cross, followed by the presentation of the images. Next, the probe was presented until response. Trials were separated by a 500ms inter-trial interval.

Dot-probe ABM task. This ABM task was similar to the dot-probe attentional assessment task. However, to encourage development of selective attending to angry or happy faces a contingency was introduced between probe position and the position of each emotional face. This contingency differed between training conditions. Specifically, in the attend-happy condition, probes were presented in the location formerly occupied by the happy face on every trial. In the attend-angry condition, probes were presented in the location formerly occupied by the angry face on every trial. Crossing person identity, picture location, and probe identity created 128 trials. These were each presented three times for a total of 384 trials.

Person Identity Match (PIM) attentional training task. In this task participants were required to assess whether or not the identity of two people matched. Virtual “cards” were created, each with one image depicting a person with a happy expression and a person with an angry expression. Participants were shown two of these cards, one at the bottom of the screen and one at the top of the screen. Participants in the attend-happy condition were required to judge whether or not the person showing the happy expression was the same individual on each of the two presented cards. Conversely, participants in the attend-angry condition were required to judge whether or not the person showing the angry expression was the same individual on each of the two cards. Participants clicked the left mouse button to indicate an identity match, and the right mouse button to indicate an identity mismatch. After the response had been given, the bottom card moved to the top location of the screen, and a new card appeared at the bottom location. Thus, participant judgement always required them to focus their attention on the individuals displaying the target emotion within each of the two presently exposed cards (and ignore the other individuals displayed the alternative emotion), in order to judge whether or not their identity differed. By way of feedback on whether or not the two target identities matched, the border of the card that was moved to the top location turned green to signal a match between the two identities, and turned red if there was a mismatch.

The 64 images of the 32 different identities used in this task were grouped into eight sets (corresponding to eight separate ‘decks’ in the attentional training task) of eight identities with each identity appearing in two sets. Each virtual deck of cards contained 4 different identities (two male, two female). By pairing each identity carrying one expression, with each of the three identities carrying the opposite expression, 24 different cards (trials) were created in each of the eight decks. In each deck, the order of the presentation of the cards was random. Each deck was completed twice, such that (similar to the 384 trials in the dot-probe attentional training task) participants were presented with 384 cards in total. At the end of each deck, participants were given feedback on their number of errors and completion time. To encourage engagement and introduce an additional game-like element to this task, participants were encouraged to try to improve their high score on each deck.

Procedure

Informed consent was obtained from participants, and STAI-T assessment carried out, before the experimental session began. Participants were instructed to sit at a comfortable viewing distance from the computer screen (approximately 60cm), and were given instructions concerning the completion of the attentional assessment task. These instructions emphasised that on each trial

participants should discriminate probe identity as accurately as possible, and press the corresponding mouse button as quickly as they can without compromising accuracy. Following completion of this attentional assessment task, participants then received the instructions for the attentional training task to which they had been assigned. For participants completing the dot-probe ABM task, the instructions remained the same as those given for the attentional assessment task. Participants completing the person identity matching task were informed that they would see two cards presented on screen, each displaying a pair of faces showing differing expressions. They were told that each new card would appear in the lower screen location, and move to the upper location when the next card then was subsequently presented. Participants in the attend-happy condition were instructed that they must decide whether or not the happy individual shown on each new card (appearing in the lower location) was the same person as the happy individual shown on the immediate prior card (now in the upper screen location), and press the right or left mouse button to signal an identity match or mismatch respectively. Participants in the attend-angry condition were instructed that they must decide whether or not the angry individual shown on each new card was the same person as the happy individual shown on the immediate prior card, again pressing the right or left mouse button to signal an identity match or mismatch respectively. After completion of the assigned ABM task, participants again completed the attentional assessment task. Next, they completed mood scales before watching the stressor videos, and again completed these mood scales after viewing these videos. At the end of the session, participants were debriefed about the purpose of the study. The entire experimental session lasted approximately 45 minutes.

Results

Attentional bias assessment data

The attentional assessment data were first examined to ensure that participants were consistently responding correctly and rapidly as instructed. Inspection of reaction times showed one participant to have extremely long average reaction times (> 2 SD above the sample's mean). Data from this participant was not considered in any of the analyses reported below. To further minimise the influence of outlying data points, reaction times on incorrect trials (4.3% of trials), and reaction times above or below 2 SD from an individual's mean reaction time on correct trials (4.4% of remaining trials) were prior to computing indices of attentional bias. For ease of comparison with the norms Cohen (Cohen, 1988), effect sizes for repeated measures were calculated using the formula of Morris and DeShon (2002).

To investigate whether the ABM tasks were successful in inducing a differential attentional bias to threat, attentional bias index (ABI) scores were first computed. For both the pre and post-training attentional assessments, reaction times on trials in which the probe replaced the angry face were subtracted from reaction times on trials in which the probe replaced the happy face. A larger score on this index is indicative a larger attentional bias towards threat. To investigate whether any baseline differences between the 4 groups in attentional bias scores were present, a one-way ANOVA on pre-training bias scores was performed. This confirmed that there were no significant differences in attentional bias at baseline, $F(3,79) = 1.84, p = .15$.

To assess whether the attend-happy and attend-angry training conditions of each task were able to induce a differential attentional bias to threat, these ABI scores were subjected to a $2 \times 2 \times 2$ mixed methods ANOVA, which considered the within-subject factor Assessment Point (Pre-training versus Post-training), and the between-subjects factors Training Task (Dot-probe versus PIM) and Training Condition (Attend-happy versus Attend-Angry). Successful modification of attentional bias would be reflected in a significant two way interaction between Assessment Point and Training Condition. Superior ABM performance of one task over another would be reflected in a three way interaction, resulting from the greater strength of this simple two way interaction for participants who received the superior ABM task.

The results showed a significant three-way interaction between Assessment Point, Training Task, and Training Condition, $F(1,79) = 4.59, p = .035, \eta^2_p = .06$, and no other significant effects were obtained (all $p > .1$). See Table 1 for an overview of the means. To illuminate the nature of this interaction, the simple two way interaction between Assessment Point and Training Condition was computed separately for each ABM task. For the dot-probe ABM task, this interaction fell short of significance, $F < 1$, indicating that the task was not successful in differentially modifying attentional bias, from pre- to post-training, as function of training condition. In contrast, for the PIM ABM task, there was a significant interaction between Assessment Point and Training Condition, $F(1,36) = 9.34, p = .004, \eta^2_p = .18$. The nature of this interaction was consistent with the attentional training objectives. Specifically, participants in the attend-happy condition displayed reduced attentional bias to threat scores from pre-training to post-training, $t(21) = 2.27, p = .034$, Cohen's $d = 0.66$, whereas participants in the attend-angry condition instead displayed a marginally significant increase in attentional bias to threat scores from pre-training to post-training, $t(22) = 2.05, p = .053$, Cohen's $d = 0.70$. Importantly, following the person identification matching task, but not before, participants in the attend-happy condition showed significantly lower attentional bias to threat scores than did participants in the attend-angry condition, $t(43) = 2.10, p = .041$, Cohen's $d = 0.63$. In summary, therefore, our new person identity matching ABM task successfully modified attentional bias to

threat as intended, and did so more effectively than the conventional probe-based ABM task, which did not significantly modify selective attentional responding to threat.

Emotional vulnerability data

To investigate whether the ABM tasks were successful in inducing differences in emotional vulnerability, as evidenced by emotional reactivity to the stressor, mood scores reported before and after watching the videos were subjected to a 2 x 2 x 2 mixed methods ANOVA, which considered the within-subject factor Assessment Point (Pre stressor versus Post stressor), and the between-subjects factors Training Task (Dot-probe versus PIM) and Training Condition (Attend-happy versus Attend-angry). A differential impact on emotional vulnerability would be reflected in a significant two way interaction between Assessment Point and Training Condition. Again, superior performance of one task over another would be reflected in a three way interaction, resulting from the greater strength of this simple two way interaction for participants who task most capable of influencing emotional vulnerability.

The results revealed a significant main effect of Assessment Point, $F(1,42) = 107.9, p < .001$, $\eta^2_p = .58$, indicating that mood became more negative after exposure to the video stressor as compared to before exposure to this stressor ($M = 4.94, SD = 1.99$ vs $M = 3.58, SD = 1.94$, respectively). Importantly, there was also a significant three-way interaction between Assessment Point, Training Task, and Training Condition, $F(1,79) = 5.75, p = .019$, $\eta^2_p = .07$, which was the only other significant effect to emerge from the ANOVA. See Table 2 for an overview of the means. To decompose this higher order interaction, the simple two way interaction between Assessment Point and Training Condition was computed separately for participants receiving each ABM task. For participants who received the dot-probe ABM task, this interaction was not significant, $F(1,36) = 1.92, p = .17$, $\eta^2_p = .05$, indicating that this ABM variant was not successful in modifying emotional vulnerability. However, for the participants who received the PIM ABM task, there was a significant interaction between Assessment Point and Training Condition, $F(1,43) = 4.27, p = .045$, $\eta^2_p = .09$ ¹. This interaction reflected the fact that although there were no significant group difference before or after the video stressor (both $p > .3$), the magnitude of the change towards a more negative mood was attenuated for in the PIM attend-happy condition, compared to participants in the PIM attend-angry condition, ($1.30, SD = 1.1$ vs. $2.15, SD = 1.6$ respectively), $t(43) = 2.07, p = .045$, Cohen's $d = 0.62$. Therefore, our new PIM task successfully modified emotional reactivity to the video stressor as

¹ As foreshadowed, these analyses do not include participants who showed a shift towards more positive mood in response to the video stressor. By including those participant who did not experience the videos as stressful, this effect would have been reduced below significance, $F(1,83) = 1.87, p = .175$. In the dot-probe training conditions, including these participants does not change the non-significance of this interaction, $F < 1$.

intended, and did so more effectively than the conventional probe-based ABM task, which did not significantly influence emotional reactivity.

Discussion

The aim of the current study was to evaluate the capacity of a new attentional bias modification (ABM) task to alter selective attentional responding to emotional information, and to influence emotional vulnerability. This new task involved making matching judgements between the identities of faces showing either happy or angry expressions, when these faces appeared in displays that also included faces showing the opposite emotional expression. The training condition designed to encourage attentional selectivity towards more positive information required participants to selectively focus on the happy faces when judging identity match, whereas the training condition designed to encourage attentional selectivity towards more negative information required participants to selectively focus on the angry faces when judging identity match. Results showed that this new person identity matching (PIM) ABM task was effective in modifying attentional bias as indexed by the attentional probe task. At the end of PIM task, participants who had completed it in the attend-happy condition showed reduced attentional bias to threat as compared to participants who had completed it in the attend-angry condition. This change in attentional bias affected by the PIM task is particularly encouraging, as this represents transfer to an attentional bias assessment task that is distinct from the parameters of the attentional bias training task. Moreover, the change in bias had a subsequent effect on emotional vulnerability, evidenced by the fact that participants who completed this new ABM task in the attend-happy condition showed an attenuated shift towards a more negative mood in response to the subsequent stressor, as compared to participants who instead completed it in the attend-angry condition.

In contrast, the conventional dot-probe ABM task failed to induce the intended attentional change in the present study. This adds to existing evidence that the intended attentional bias modification is not always achieved using this dot-probe training task (Carlbring et al., 2012; Clarke, Browning, Hammond, Notebaert, & Macleod, 2014; Clarke, Notebaert, et al., 2014; Dahl & Dahl, 2010; Hakamata et al., 2010; Morris & DeShon, 2002; Neubauer et al., 2013; Teo, Lerrigo, & Rogers, 2013). Given the present failure of the dot-probe ABM task conditions to induce differential change in attentional bias, it is unsurprising that dot-probe ABM task condition also did not differentially influence emotional reactivity to the stressor. This is consistent with our prior observation that ABM procedures only affect emotional vulnerability when they successfully modify attentional responding to threat information (Clarke, Notebaert, et al., 2014).

Several factors could have contributed to the greater success of the new PIM ABM task, as compared to the conventional dot-probe ABM task. First, in the PIM ABM task participants must necessarily process the emotional valence of the stimuli in order to execute the task. In contrast, participants are able to perform the conventional dot-probe ABM task without the need to process stimulus valence, and so may less reliably register the differing valence of the presented stimuli. However, the success of the procedure to change attentional selectivity depends on participants registering the link between stimulus valence and probe location. Therefore, inconsistency in the degree to which participants process stimulus valence plausibly could translate into inconsistency in the degree to which the procedure induces attentional change. It is therefore possible that the conventional dot-probe ABM task may be non-optimal because it does not necessitate the processing of stimulus valence, and that the need to process the emotional tone of the stimuli in our new PIM task accounts for its greater success in modifying attentional responding to threat. Second, the PIM task was designed to be more game-like by representing the stimuli and trials to participants in the format of playing cards and giving participant a score at the end of each completed 'deck'. This may have enhanced engagement with and concentration on the task. In addition, this type of 'block' feedback has been shown to enhance learning in simple repetitive tasks (e.g. Liu, Doshier, & Lu, 2014). Therefore, the added feedback given to participants in the PIM training task may have improved the type of learning that was encouraged through this task, and contributed to the consequent effects on emotional vulnerability. Given the novelty of this task, future research could investigate whether the PIM task also affects other cognitive biases or processes (such as decision-making), and examine if these other cognitive processes also contribute to change in subsequent emotional vulnerability.

The promising results from the current study highlight the scope for the development of new ABM tasks. Whereas the traditional dot-probe training task is a computerised, reaction time based, target discrimination task, other tasks may adapt a variety of task conditions which may make them more suitable for implementation in different contexts. For example, self-paced tasks like the PIM task may be more suitable for implementation in specific populations for which task requirement might vary widely, such as children and older adults (Brand & Jolles, 1987; Cerella, 1985; Fry & Hale, 1996). Among children, the prevalence rates for anxiety disorders range from 5.7 to 17.7%, making them the most common form of psychopathology in this age group (Costello & Angold, 1995). Children with elevated levels of anxiety have been shown to display an attentional bias to threat (Bar-Haim et al., 2007), that is amenable to modification (Bar-Haim et al., 2011). Anxiety disorders are also highly prevalent in older adults (10-20), with generalised anxiety disorder the most frequently diagnosed anxiety disorder in this population (Byers, Yaffe, Covinsky, Friedman,

& Bruce, 2010). Research has shown that the anxiety-linked cognitive bias is similar in older and younger adults (Fox & Knight, 2005; Murphy & Isaacowitz, 2008), however to our knowledge, no research has implemented specific ABM in older samples. Future research can investigate whether self-paced ABM tasks such as the PIM are equally effective and better suited than traditional reaction time ABM tasks in these populations with varying processing speeds and speed of motor execution.

Future research may also usefully examine whether newly developed ABM tasks are more acceptable to patients than the conventional dot-probe task. The dot-probe task was the very first ABM task ever developed. It was delivered in a single-session design aimed at addressing the question of whether attentional bias causally contributes to anxiety vulnerability. The likelihood that the very first task ever created to modify attentional bias will prove to be the best means of achieving this seems highly improbable. Indeed, ABM training using the dot-probe paradigms has been labelled 'confusing' and 'repetitive', which may reduce acceptability of the task, and negatively affect attritions rates when implemented in multisession treatments (Beard, 2011). There is huge potential to implement effective new ABM tasks in a wide range of clinical settings. The tasks can be implemented within therapy sessions, or patients can be encouraged to practise the training in their own social settings either in-between therapy session, or after completion of therapy to maintain therapeutic gains. Future research which implements new ABM tasks into clinical settings should aim to examine and compare the acceptability of these new tasks in relation to conventional dot-probe ABM, to investigate which task is most suitable for clinical implementation.

Future research could also aim to develop ABM tasks that can be delivered in ways that would facilitate transfer of training from the ABM task to real world situations in which bias change is likely to be most therapeutic. Such enhancement of transfer could be obtained by actually delivering the training as an integral component of people's interactive, complex, real world experiences. One way in which this can be realised is to enhance the accessibility of the ABM task by delivering it via smartphones (e.g. Enock et al., 2014). Conversely, other tasks may readily lend themselves to potential delivery without the use of a computer. For example, for the PIM task this would simply require using printed versions of the virtual cards that were currently displayed on the computer screen. There is plentiful research in both adults and children showing that heightened anxiety is associated with increased social isolation (Chou, Liang, & Sareen, 2011; Dahl & Dahl, 2010; Modin, Ostberg, & Almquist, 2011; Teo et al., 2013). In addition, research has shown people with mental health issues are particularly vulnerable to engage in problematic computer use (Kraut et al., 1998). Therefore, developing ABM tasks that do not rely on computers and that incorporate a social aspect could represent a major advancement in terms of the accessibility, acceptability, and

effectiveness of ABM. Future research could thus usefully examine whether computer-free ABM tasks are equally effective as computerised tasks.

Finally, in addition to the need for more research into the development of new and effective ABM tasks, more research is also needed to develop new attentional bias assessment tasks that have better psychometric properties than the dot-probe task. Indeed, the Spearman-Brown corrected split-half reliability for the dot-probe assessment task in the current study was only .1, which is consistent with the low rates of reliability reported in other ABM studies that have sought to examine this (Enock et al., 2014; McNally, Enock, Tsai, & Tousian, 2013).

Moreover, card-based ABM approaches of this nature offer the potential to implement ABM in a social session using dyads of participants. For example, given the association between anxious parents and anxious children (Grover, Ginsburg, & Jalongo, 2005), this task could potentially represent an ideal 'homework' task that children being treated for anxiety disorders could play with their parents. As in the traditional game of snap, the two players could alternate laying out a new card, and they would make a matching judgment based on the identities of people carrying one particular facial expression. Given that matches occur less often than mismatches, the first person to notice a match would win and collect all the cards that have been laid out. This way, a pattern of attentional selectivity is encouraged while also encouraging social interaction. The effectiveness of this version of the PIM task can be examined in a similar manner to the current study, by assessing change in attentional bias and impact on emotional vulnerability.

Future research could also examine the effectiveness of the PIM task in clinical settings using a multi-session design similar to already existing multi-session ABM studies (Amir, Beard, Taylor, et al., 2009). In clinical settings, a no-contingency control condition can be implemented, in which participants perform the matching judgments based on the identities of the happy people on half the decks, and based on the identities of angry people in the other half of decks. This way, no selective attentional allocation to stimuli of one particular valence is encouraged (MacLeod & Clarke, 2013). Research could examine the effectiveness of such multi-session PIM training on change in anxiety symptoms (self-reported and clinical-rated), and change in social isolation (e.g. using the De Jong Gierveld Loneliness Scale, Gierveld & Tilburg, 2006).

Of course, the current study is not without its limitations. For example, although we consider it plausible that this game-like person identity matching ABM task would likely be more engaging for participants than the conventional probe-based ABM task, this was not explicitly tested. Future research could usefully investigate this issue by including self-report measures to examine whether the present task is associated with improved participant acceptability. A second issue concerns the

pattern of effects in the emotional vulnerability data in the PIM training task. Although the pattern of results was consistent with our predictions, showing a greater shift towards more negative mood in the attend-angry condition than in the attend-happy condition, there were no significant between-group differences in mood either before or after the stressor. The mood ratings show that the video clips employed in the current study were experienced as only mildly stressful, and a number of participants did not experience an increase in negative affect at all. Therefore, future research replicating these results could consider using stressor tasks that are better able to evoke elevations in negative mood, in order to maximise the opportunity for individual differences in emotional vulnerability to be assessed. A third limitation is that the conventional dot-probe ABM task did not modify attentional selectivity in the present study. This is despite the fact that participants in the PIM training conditions showed a non-significant pre-training difference in attentional bias which needed to be reversed in order to obtain the observed post-training group difference. Even though the absence of such difference in the dot-probe task conditions could have made it easier to detect a change in attentional bias, such change was not observed. Similarly, it is unlikely that the lack of effect on emotional vulnerability in the dot-probe training conditions is due to a ceiling effect, as the mood scales still permitted substantial movement from the baseline scores. However, this lack of effects means we cannot exclude the possibility that our new PIM task may be no more effective than the probe-based ABM approach when the latter does succeed in modifying attentional bias. However, we can take encouragement from the current findings that the PIM task did produce the intended impact on selective attentional responding to threat, and exerted a consequent effect on emotional vulnerability. Future research can now build on this finding, by determining whether the PIM task is capable of reliably producing more robust changes in attentional bias and emotional vulnerability than conventional probe-based ABM across differing contexts, including clinical settings, and whether it will prove more acceptable to patients. To facilitate such future research, we have made the programming script for the PIM task available for download from the following link <http://www.psychology.uwa.edu.au/research/care/research/PIM>.

In conclusion, we have introduced and validated a promising new attentional bias modification task, here termed the person identity matching (PIM) task, which has proven capable of directly modifying selective attentional responding to emotional information, with associated consequences in terms of altered emotional vulnerability. In the present study, the performance of this new ABM task compares very favourably with that of the best established ABM task, both in terms of attentional and emotional impact. This new task has the potential to be implemented in a range of contexts, in ways that may enhance the future clinical benefits that can be obtained from attentional bias modification approaches. We hope these positive findings may encourage other

researchers to experiment with the creation of novel ABM methods, that can be compared in terms of their relative efficacy, in order to continuously improve our capacity to therapeutically modify the patterns of attentional selectivity that underpin emotional vulnerability and dysfunction .

ACCEPTED MANUSCRIPT

References

- Amir, Nader, Beard, Courtney, Burns, Michelle, & Bomyea, Jessica. (2009). Attention modification program in individuals with generalized anxiety disorder. *Journal of Abnormal Psychology*, 118(1), 28-33.
- Amir, Nader, Beard, Courtney, Taylor, Charles T., Klumpp, Heide, Elias, Jason, Burns, Michelle, & Chen, Xi. (2009). Attention training in individuals with generalized social phobia: A randomized controlled trial. *Journal of Consulting and Clinical Psychology*, 77(5), 961-973.
- Australian Bureau of Statistics, ABS. (2008). National Survey of Mental Health and Wellbeing: Summary of Results, 2007.
- Bar-Haim, Yair. (2010). Research review: Attention bias modification (ADM): A novel treatment for anxiety disorders. *Journal of Child Psychology and Psychiatry*, 51(8), 859-870. doi: <http://dx.doi.org/10.1111/j.1469-7610.2010.02251.x>
- Bar-Haim, Yair, Lamy, Dominique, Pergamin, Lee, Bakermans-Kranenburg, Marian J., & van Ijzendoorn, Marinus H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, 133(1), 1-24. doi: <http://dx.doi.org/10.1037/0033-2909.133.1.1>
- Bar-Haim, Yair, Morag, Inbar, & Glickman, Shlomit. (2011). Training anxious children to disengage attention from threat: a randomized controlled trial. *Journal of Child Psychology and Psychiatry*, 52(8), 861-869. doi: 10.1111/j.1469-7610.2011.02368.x
- Barnes, Laura L., Harp, Diane, & Jung, Woo Sik. (2002). Reliability generalization of scores on the Spielberger State-Trait Anxiety Inventory. *Educational and Psychological Measurement*, 62(4), 603-618. doi: 10.1177/0013164402062004005
- Beard, Courtney. (2011). Cognitive bias modification for anxiety: Current evidence and future directions. *Expert Review of Neurotherapeutics*, 11(2), 299-311. doi: <http://dx.doi.org/10.1586/ern.10.194>
- Bernstein, Amit, & Zvielli, Ariel. (2014). Attention Feedback Awareness and Control Training (A-FACT): Experimental test of a novel intervention paradigm targeting attentional bias. *Behaviour Research and Therapy*, 55, 18-26. doi: 10.1016/j.brat.2014.01.003
- Boettcher, Johanna, Hasselrot, Jonas, Sund, Erik, Andersson, Gerhard, & Carlbring, Per. (2014). Combining Attention Training with Internet-Based Cognitive-Behavioural Self-Help for Social Anxiety: A Randomised Controlled Trial. *Cognitive Behaviour Therapy*, 43(1), 34-48. doi: 10.1080/16506073.2013.809141
- Boettcher, Johanna, Leek, Linda, Matson, Lisa, Holmes, Emily A., Browning, Michael, MacLeod, Colin, . . . Carlbring, Per. (2013). Internet-Based Attention Bias Modification for Social Anxiety: A Randomised Controlled Comparison of Training towards Negative and Training Towards Positive Cues. *Plos One*, 8(9). doi: e7176010.1371/journal.pone.0071760
- Byers, A. L., Yaffe, K., Covinsky, K. E., Friedman, M. B., & Bruce, M. L. (2010). High occurrence of mood and anxiety disorders among older adults: The national comorbidity survey replication. *Archives of General Psychiatry*, 67(5), 489-496.
- Carlbring, Per, Apelstrand, Maria, Sehlin, Helena, Amir, Nader, Rousseau, Andreas, Hofmann, Stefan, & Andersson, Gerhard. (2012). Internet-delivered attention bias modification training in individuals with social anxiety disorder - a double blind randomized controlled trial. *BMC Psychiatry*, 12(1), 66.
- Chou, K. L., Liang, K., & Sareen, J. (2011). The Association Between Social Isolation and DSM-IV Mood, Anxiety, and Substance Use Disorders: Wave 2 of the National Epidemiologic Survey on Alcohol and Related Conditions. *Journal of Clinical Psychiatry*, 72(11), 1468-1476. doi: 10.4088/JCP.10m06019gry
- Clarke, Patrick J. F., Browning, Michael, Hammond, Geoff, Notebaert, Lies, & Macleod, Colin. (2014). The Causal Role of the Dorsolateral Prefrontal Cortex in the Modification of Attentional Bias:

- Evidence from Transcranial Direct Current Stimulation. *Biol Psychiatry*. doi: 10.1016/j.biopsych.2014.03.003
- Clarke, Patrick J. F., Notebaert, Lies, & MacLeod, Colin. (2014). Absence of evidence or evidence of absence: reflecting on therapeutic implementations of attentional bias modification. *BMC Psychiatry*, 14(1), 8.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd Ed. ed.). Hillsdale, NJ: Erlbaum.
- Costello, E.J., & Angold, A. (1995). Epidemiology. In J.S. March (Ed.), *Anxiety disorders in children and adolescents*. New York: Guilford Press.
- Dahl, C. A. F., & Dahl, A. (2010). Lifestyle and social network in individuals with high level of social phobia/anxiety symptoms: a community-based study. *Social Psychiatry and Psychiatric Epidemiology*, 45(3), 309-317. doi: 10.1007/s00127-009-0069-6
- Dandeneau, Stephane D., & Baldwin, Mark W. (2004). The Inhibition Of Socially Rejecting Information Among People With High Versus Low Self-Esteem: The Role Of Attentional Bias And The Effects Of Bias Reduction Training. *Journal of Social and Clinical Psychology*, 23(4), 584-602. doi: <http://dx.doi.org/10.1521/jscp.23.4.584.40306>
- Dandeneau, Stephane D., Baldwin, Mark W., Baccus, Jodene R., Sakellaropoulou, Maya, & Pruessner, Jens C. (2007). Cutting stress off at the pass: Reducing vigilance and responsiveness to social threat by manipulating attention. *Journal of Personality and Social Psychology*, 93(4), 651-666. doi: 10.1037/0022-3514.93.4.651
- Enock, Philip M., Hofmann, Stefan G., & McNally, Richard J. (2014). Attention Bias Modification Training Via Smartphone to Reduce Social Anxiety: A Randomized, Controlled Multi-Session Experiment. *Cognitive Therapy and Research*, 38(2), 200-216. doi: 10.1007/s10608-014-9606-z
- Fox, L. S., & Knight, B. G. (2005). The effects of anxiety on attentional processes in older adults. *Aging & Mental Health*, 9(6), 585-593. doi: 10.1080/13607860500294282
- Gierveld, Jenny De Jong, & Tilburg, Theo Van. (2006). A 6-Item Scale for Overall, Emotional, and Social Loneliness: Confirmatory Tests on Survey Data. *Research on Aging*, 28(5), 582-598. doi: 10.1177/0164027506289723
- Greenberg, P. E., Sisitsky, T., Kessler, R. C., Finkelstein, S. N., Berndt, E. R., Davidson, J. R. T., . . . Fyer, A. J. (1999). The economic burden of anxiety disorders in the 1990s. *Journal of Clinical Psychiatry*, 60(7), 427-435.
- Grover, Rachel L., Ginsburg, Golda S., & Ialongo, Nick. (2005). Childhood Predictors of Anxiety Symptoms: A Longitudinal Study. *Child Psychiatry and Human Development*, 36(2), 133-153. doi: 10.1007/s10578-005-3491-3
- Hakamata, Yuko, Lissek, Shmuel, Bar-Haim, Yair, Britton, Jennifer C., Fox, Nathan A., Leibenluft, Ellen, . . . Pine, Daniel S. (2010). Attention Bias Modification Treatment: A meta-analysis toward the establishment of novel treatment for anxiety. *Biological Psychiatry*, 68(11), 982-990. doi: <http://dx.doi.org/10.1016/j.biopsych.2010.07.021>
- Hallion, LS, & Ruscio, AM. (2011). A meta-analysis of the effects of cognitive bias modification on anxiety and depression. *Psychol Bull*, 137(6), 940 - 958.
- Kessler, R. C., Chiu, W. T., Demler, O., Merikangas, K. R., & Walters, E. E. (2005). Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry*, 62(6), 617-627. doi: 10.1001/archpsyc.62.6.617
- Kraut, R., Patterson, M., Lundmark, V., Kiesler, S., Mukopadhyay, T., & Scherlis, W. (1998). Internet paradox - A social technology that reduces social involvement and psychological well-being? *American Psychologist*, 53(9), 1017-1031. doi: 10.1037//0003-066x.53.9.1017
- Liu, Jiajuan, Doshier, Barbara, & Lu, Zhong-Lin. (2014). Modeling trial by trial and block feedback in perceptual learning. *Vision Research*, 99(0), 46-56. doi: <http://dx.doi.org/10.1016/j.visres.2014.01.001>

- Lundqvist, D., Flykt, A., & Öhman, A. . (1998). The Karolinska Directed Emotional Faces - KDEF. CD ROM from Department of Clinical Neuroscience, Psychology section, Karolinska Institutet.
- MacLeod, Colin, & Clarke, Patrick J. F. (2013). Cognitive Bias Modification: A New Frontier in Cognition and Emotion Research. In M. D. Robinson, E. R. Watkins & E. Harmon-Jones (Eds.), *Handbook of Cognition and Emotion* (pp. 540-562). New York: Guilford.
- MacLeod, Colin, & Mathews, A. (2012). Cognitive Bias Modification Approaches to Anxiety. *Annual Review of Clinical Psychology*, 8(1), 189. doi: 10.1146/annurev-clinpsy-032511-143052
- MacLeod, Colin, Mathews, Andrew, & Tata, Philip. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology*, 95(1), 15-20.
- MacLeod, Colin, Rutherford, Elizabeth, Campbell, Lyn, Ebsworthy, Greg, & Holker, Lin. (2002). Selective attention and emotional vulnerability: Assessing the causal basis of their association through the experimental manipulation of attentional bias. *Journal of Abnormal Psychology*, 111(1), 107-123. doi: 10.1037/0021-843X.111.1.107
- Mathews, Andrew, & Mackintosh, Bundy. (1998). A cognitive model of selective processing in anxiety. *Cognitive Therapy and Research*, 22(6), 539-560. doi: 10.1023/a:1018738019346
- McNally, Richard J., Enock, Philip M., Tsai, Cynthia, & Tausian, Mona. (2013). Attention bias modification for reducing speech anxiety. *Behaviour Research and Therapy*, 51(12), 882-888. doi: 10.1016/j.brat.2013.10.001
- Modin, B., Ostberg, V., & Almquist, Y. (2011). Childhood Peer Status and Adult Susceptibility to Anxiety and Depression. A 30-Year Hospital Follow-up. *Journal of Abnormal Child Psychology*, 39(2), 187-199. doi: 10.1007/s10802-010-9462-6
- Mogoase, C., David, D., & Koster, Ernst H.W. (2014). Clinical Efficacy of Attentional Bias Modification Procedures: An Updated Meta-Analysis. *Journal of Clinical Psychology*, epub ahead of print.
- Morris, S. B., & DeShon, R. P. . (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychological Methods*, 7, 105-125.
- Murphy, Nora A., & Isaacowitz, Derek M. (2008). Preferences for emotional information in older and younger adults: A meta-analysis of memory and attention tasks. *Psychology and Aging*, 23(2), 263-286. doi: 10.1037/0882-7974.23.2.263
- Neubauer, Karolin, von Auer, Maxie, Murray, Eileen, Petermann, Franz, Helbig-Lang, Sylvia, & Gerlach, Alexander L. (2013). Internet-delivered attention modification training as a treatment for social phobia: A randomized controlled trial. *Behaviour Research and Therapy*, 51(2), 87-97. doi: 10.1016/j.brat.2012.10.006
- Rapee, Ronald M., MacLeod, Colin, Carpenter, Leigh, Gaston, Jonathan E., Frei, Jacqueline, Peters, Lorna, & Baillie, Andrew J. (2013). Integrating cognitive bias modification into a standard cognitive behavioural treatment package for social phobia: A randomized controlled trial. *Behaviour Research and Therapy*, 51(4-5), 207-215. doi: 10.1016/j.brat.2013.01.005
- Rozenman, Michelle, Weersing, V., & Amir, Nader. (2011). A case series of attention modification in clinically anxious youths. *Behaviour Research and Therapy*, 49(5), 324-330. doi: <http://dx.doi.org/10.1016/j.brat.2011.02.007>
- Rubin, K.H., & Burgess, K. (2001). Social withdrawal. In M.W Vasey & M.R. Dadds (Eds.), *The developmental psychopathology of anxiety* (pp. 407-434). Oxford, UK: Oxford University Press.
- Schmidt, Norman B., Richey, J., Buckner, Julia D., & Timpano, Kiara R. (2009). Attention training for generalized social anxiety disorder. *Journal of Abnormal Psychology*, 118(1), 5-14.
- Schoorl, Maartje, Putman, Peter, & Van der Does, Willem. (2013). Attentional Bias Modification in Posttraumatic Stress Disorder: A Randomized Controlled Trial. *Psychotherapy and Psychosomatics*, 82(2), 99-105. doi: 10.1159/000341920
- Spielberger, C, Gorsuch, R, Lushene, R, Vagg, P, & Jacobs, G. (1983). *Manual for the State-Trait Anxiety Inventory STAI (Form Y): Self-evaluation questionnaire*. Alto: Ca: Consulting Psychologist Press.

- Teo, A. R., Lerrigo, R., & Rogers, M. A. M. (2013). The role of social isolation in social anxiety disorder: A systematic review and meta-analysis. *Journal of Anxiety Disorders*, 27(4), 353-364. doi: 10.1016/j.janxdis.2013.03.010
- Tobon, Juliana I., Ouimet, Allison J., & Dozois, David J. (2011). Attentional bias in anxiety disorders following cognitive behavioral treatment. *Journal of Cognitive Psychotherapy*, 25(2), 114-129.
- Van Bockstaele, B., Verschuere, B., Tibboel, H., De Houwer, J., Crombez, G., & Koster, E. H. (2014). A review of current evidence for the causal impact of attentional bias on fear and anxiety. *Psychol Bull*, 140(3), 682-721. doi: 10.1037/a0034834
- Wilson, Edward, MacLeod, Colin, Mathews, Andrew, & Rutherford, E. M. (2006). The causal role of interpretive bias in anxiety reactivity. *Journal of Abnormal Psychology*, 115(1), 103-111. doi: 10.1037/0021-843x.115.1.103
- Woud, Marcella L., & Becker, Eni S. (2014). Editorial for the Special Issue on Cognitive Bias Modification Techniques: An Introduction to a Time Traveller's Tale. *Cognitive Therapy and Research*, 38(2), 83-88. doi: 10.1007/s10608-014-9605-0

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Table 1. Attentional bias index scores (in ms) for participants in the PIM and dot-probe ABM attend-happy and attend-angry conditions.

	Dot-probe training				PIM training			
	Attend Happy		Attend Angry		Attend Happy		Attend Angry	
	N = 19		N = 19		N = 22		N = 23	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Pre-training ABI	1.36	39.2	2.74	30.1	10.3	35.7	-12.5	27.2
Post-training ABI	11.0	43.9	4.54	51.7	-11.6	30.5	6.9	28.1

Table 2. Mood data for participants in the PIM and dot-probe ABM attend-happy and attend-angry conditions.

	Dot-probe training				PIM training			
	Attend Happy		Attend Angry		Attend Happy		Attend Angry	
	N = 19		N = 19		N = 22		N = 23	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Pre stressor neg. mood	3.95	1.89	4.31	1.53	3.34	1.90	2.72	2.08
Post stressor neg. mood	5.13	2.09	5.11	1.57	4.64	2.12	4.87	2.17

Figure Captions

Figure 1. Example of PIM task display (not to scale). For participants in the attend-happy condition, these two cards would require a match response, as the same person is showing the happy expression in the two cards. For participants in the attend-angry condition, these two cards would require a mismatch response. (NB. In accordance with publication guidelines, these images are not from the KDEF database).

Highlights

- Attentional bias modification (ABM) is a promising therapeutic tool which aims to change patterns of attentional selectivity associated with heightened anxiety.
- The current study compared the effectiveness of a newly developed ABM task against the traditional dot-probe ABM task.
- This new ABM task succeeded in significantly modifying attentional bias, and exerting a consequent impact on emotional reactivity to a stressor.
- The validation of this new task in comparison to established ABM techniques represents a critical step in enhancing the clinical utility and efficacy of attentional bias modification as an intervention.