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The effects of attentional bias modification on emotion regulation

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ABSTRACT

Background and objectives: In two experiments, we investigated the effects of Attentional Bias Modification (ABM) on emotion regulation, i.e. the manner in which people influence emotional experiences. We hypothesized that decreases in attentional bias to threat would impair upregulation and improve downregulation of negative emotions, while increases in attentional bias to threat would improve upregulation and impair downregulation of negative emotions.
Methods: Using the emotion-in-motion paradigm (Experiment 1, N = 60) and the visual search task (Experiment 2, N = 58), we trained participants to attend to either threatening or positive stimuli and we assessed emotion intensity while observing, upregulating, and downregulating emotions in response to grids of mixed emotional pictures.
Results: In Experiment 1, the attend positive group reported more positive emotions while merely watching grids of training pictures and the attend threat group showed impaired upregulation of negative affect. In Experiment 2, the attend threat group reported intensified negative emotions for all three instructions, while the attend positive group remained largely stable over time.
Limitations: We cannot unequivocally attribute these changes in emotion regulation to changes in attentional bias, as neither of the experiments yielded significant changes in attentional bias to threat.
Conclusions: By showing that attentional bias modification procedures affect the manner in which people deal with emotions, we add empirical weight to the conceptual overlap between attentional bias modification and emotion regulation.

1. Introduction

Prominent cognitive theories propose that biased cognitive processes play a prominent role in anxiety problems (e.g. Mogg & Bradley, 1998; Williams, Watts, MacLeod, & Mathews, 1997). Compared to non-anxious individuals, anxious individuals are thought to attend more to threatening stimuli in their environment, a finding commonly termed attentional bias. There is now a wealth of empirical evidence for the link between anxiety and attentional bias (for a review, see Bar-Haim, Lamy, Pergamin, Bakermans- Kranenburg, & van IJzendoorn, 2007). In more recent years, research has focussed on the hypothesis that attentional bias causally contributes to the development, maintenance, and/or exacerbation of anxiety (Van Bockstaele et al., 2014). Such a causal relation implies that experimentally induced changes in attentional bias should lead to clinically relevant changes in anxiety.

In a seminal paper, MacLeod, Rutherford, Campbell, Ebsworthy, and Holker (2002) used an adaptation of the visual probe task to train participants to either avoid or attend to threat. In the assessment version of this task, two task-irrelevant cue pictures – typically one threatening and one neutral picture – are shown on opposite locations of the computer screen. After these cues disappear, a target stimulus is presented on either the location of the threatening picture (threat congruent trials) or on the location of the neutral picture (threat incongruent trials). Attentional bias is derived from slower reaction times

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on threat incongruent trials compared to threat congruent trials. MacLeod et al. modified the assessment version of the task by presenting either a majority of threat congruent or a majority of threat incongruent trials. In this manner, they trained one group of participants to attend to the threatening cues, while another group was trained to avoid threat. This attentional bias modification (ABM) procedure resulted not only in changes in attentional bias, but also in changes in anxiety vulnerability: During a stress-inducing task, participants in the avoid threat group reported an attenuated increase in feelings of anxiety and depression as compared to participants in the attend threat group, thus demonstrating the causal effect of attentional bias on stress vulnerability.

ABM has since then been applied in a variety of clinical settings and samples (for reviews, see Clarke, Notebaert, & MacLeod, 2014; Cristea, Kok, & Cuijpers, 2015; Van Bockstaele et al., 2014). Although most early ABM studies in the anxiety domain were successful in reducing both attentional bias and anxiety, more recent studies have struggled to replicate these findings, illustrating that the transfer of changes in bias to changes in anxiety ("far transfer", see e.g. Hertel & Mathews, 2011) is subject to certain boundary conditions. In order to better understand these boundary conditions, a thorough understanding of the mechanisms underlying the transfer of ABM to anxiety is crucial. At present, however, very few studies have investigated how changes in attentional bias lead to changes in anxiety.

One way ABM may reduce anxiety is by improving emotion regulation. Emotion regulation is commonly defined as "the processes by which individuals influence which emotions they have, when they have them, and how they experience and express these emotions" (Gross, 1998, p. 275). Emotion regulation is thus not limited to identifying the emotions one feels at a certain point in time, or even the emotional reactions to a specific event, which is what assessments of anxiety vulnerability after ABM procedures have almost exclusively focused on thus far. Emotion regulation also involves the extent to which people are able to increase or decrease emotional responses according to their goals or needs in a given situation. Dysfunctional emotion regulation has been linked to difficulties to cope with stressful or anxiety provoking events and to the development and maintenance of anxiety disorders (Cisler & Olatunji, 2012; Sheppes, Suri, & Gross, 2015). Some studies have shown that ABM can reduce the frequency of what are typically considered maladaptive emotion regulation strategies, like worry (e.g., Hayes, Hirsch, & Mathews, 2010) and rumination (e.g., Yang, Ding, Dai, Peng, & Zhang, 2015). However, these studies only assessed the frequency of worry and rumination as symptoms of generalized anxiety or depression, and did not specifically examine whether ABM influenced the strength and expression of emotions through its impact on these emotion regulation strategies. According to influential accounts of emotion regulation (e.g. Gross, 1998; Koole, 2009), redirecting attention either towards or away from emotion-provoking aspects of a situation enables people to increase or decrease the intensity of emotions (e.g. Sanchez, Vazquez, Gomez, & Joormann, 2014; van Reekum et al., 2007).

There is a clear conceptual overlap between ABM as a means to reduce anxiety (training people to attend less to threat leads to reduced anxiety vulnerability) on the one hand, and attention deployment as an emotion regulation strategy (attending to positive aspects of a situation helps to reduce the intensity of negative emotions) on the other hand. Although several researchers have noticed this conceptual overlap (e.g. MacLeod & Bucks, 2011; Todd, Cunningham, Anderson, & Thompson, 2012; Wadlinger & Isaacowitz, 2011), the link between ABM and improved emotion regulation skills has thus far remained largely theoretical. In a recent study, Sanchez, Everaert, and Koster (2016) compared the effects of a combination of ABM and interpretation bias training with a no-training control group. They found that larger reductions in attentional bias following the training predicted better instructed downregulation of negative emotions using reappraisal.

In our present two experiments, we aimed to add to this research. We investigated whether ABM training procedures would result in changes in a widely used emotion regulation paradigm in which participants are asked to increase or decrease their emotions (Jackson, Malmstadt, Larson, & Davidson, 2000). In Experiment 1, we used the Emotion-In-Motion paradigm developed by Notebaert et al. (in press) to train people to either attend to threat or attend to positive stimuli. Before and after the training, we assessed attentional bias using the assessment version of the visual probe task and we measured the intensity of negative emotions while watching grids of mixed positive and negative pictures, as well as how well participants were able to increase and decrease the intensity of negative emotions in response to these grids of pictures. If improved emotion regulation is indeed implicated in the emotional effects of ABM, then we expected those in the attend threat group to become better at increasing but worse at reducing their anxiety. Inversely, we expected those in the attend positive group to become worse at increasing but better at reducing their anxiety.

2. Experiment 1

2.1. Method

2.1.1. Participants

Sixty-one students (46 women, *M* age = 23.90, *SD* = 7.47, range 18–65) participated in this study in exchange for course credits or €15. Students were screened on trait anxiety using the trait version of the State and Trait Anxiety Inventory (STAI-T: van der Ploeg, Defares, & Spielberger, 1980). Because training anxious people to give more attention to threat could have harmful consequences, we excluded extremely high (score $>$ 51) and low (score $<$ 28) trait anxious participants from participating (246 of 309 screened students met this inclusion criterion and were invited to participate). All participants were informed about the general nature of the tasks and stimuli prior to signing an informed consent form. The entire procedure was approved by the ethical committee of the University of Amsterdam.

2.1.2. Materials

We selected a total of 96 threatening and 96 positive pictures from the International Affective Picture System (IAPS: Lang, Bradley, & Cuthbert, 2008). To test generalization across different stimuli and tasks, both threatening and positive pictures were divided in three subsets of 32 pictures each.[1] The first subset was used in the emotion regulation task, the attentional bias assessment task, and the ABM procedure; the second subset was used only in the ABM procedure; the third subset was used only in the emotion regulation task and the attentional bias assessment task. All pictures were cropped and resized to 235 × 235 pixels. For the practice phase of the visual probe task, we selected six neutral pictures from the IAPS, depicting random household objects. For the practice phase of the Emotion-In-Motion task, we used pictures of faces with neutral expressions, including eight male and eight female actors, selected from the Karolinska Directed Emotional Faces database (KDEF; Lundqvist, Flykt, & Öhman, 1998).

2.1.3. Questionnaires

We used the Dutch translation of the State and Trait Anxiety Inventory (STAI-S and STAI-T: van der Ploeg et al., 1980) to measure state and trait anxiety respectively. Both questionnaires consist of 20 4-point Likert items. The STAI-S assesses current levels of anxiety, while

[1] Picture sets were created such that based on the IAPS normative ratings, there were no significant differences between the three threatening subsets on either valence (Set 1: $M = 2.19$, $SD = 0.51$; Set 2: $M = 2.29$, $SD = 0.50$; Set 3: $M = 2.38$, $SD = 0.52$; $F(2, 93) = 1.13$, $p = .33$) or arousal (Set 1: $M = 6.25$, $SD = 0.62$; Set 2: $M = 6.08$, $SD = 0.56$; Set 3: $M = 6.19$, $SD = 0.65$; $F < 1$), nor were there significant differences between the three positive subsets on valence (Set 1: $M = 7.49$, $SD = 0.38$; Set 2: $M = 7.46$, $SD = 0.40$; Set 3: $M = 7.42$, $SD = 0.31$; $F < 1$) or arousal (Set 1: $M = 4.96$, $SD = 0.92$; Set 2: $M = 4.82$, $SD = 1.05$; Set 3: $M = 4.69$, $SD = 1.06$; $F < 1$).

the STAI-T assesses more general levels of anxiety. Cronbach's alphas in this experiment were .91 and .87 for the STAI-S and the STAI-T, respectively.

2.1.4. Attentional bias: visual probe task

We used a visual probe task similar to the one used by Van Bockstaele, Koster, Verschuere, Crombez, and De Houwer (2012) to measure attentional bias pre- and post-training. Each trial in this task started with the presentation of a white fixation cross on a black background, flanked by two grey rectangles (235 × 235 pixels) above and below the fixation cross. After 500 ms, a cue picture (also 235 × 235 pixels) appeared in each of the grey rectangles. The cue pictures remained on the screen for 500 ms, after which they were masked by the grey rectangles for 20 ms and a target stimulus appeared. The target was either an E or an F, and participants were required to respond as fast and accurately as possible to the identity of the target by pressing the A- or the L-key of a standard QWERTY keyboard. As soon as a response was registered, the target was erased, and the next trial started after 500 ms. The task consisted of two crucial trial types. On *threat congruent* trials, the cues consisted of one threatening and one positive picture, and the target appeared on the location of the threatening picture. On *threat incongruent* trials, the cues also consisted of one threatening and one positive picture, but the target appeared on the location of the positive picture. All cue pictures were drawn randomly from Set 1 and Set 3 (see Materials) and were presented equally often, targets were equally often presented in the upper and lower location, and the targets were equally often an E or an F. The task consisted of 2 blocks. In a practice block, consisting of 12 trials with only neutral cues, an error message was shown for 500 ms upon incorrect responding. The test block of the visual probe task consisted of 128 trials, half of which were threat congruent and half were threat incongruent.

2.1.5. Attentional bias modification: emotion-in-motion

The aim of this task was to induce selective attention to threatening or positive pictures. The Emotion-In-Motion task (Notebaert et al., in press) consisted of eight blocks. In each block, eight pictures moved over the screen, changing directions when they made contact with another picture or with the edge of the screen at an angle of reflection that matched the angle of incidence. For participants in the attend threat group, seven out of the eight pictures that were on the screen were always positive, while the target picture was threatening. For participants in the attend positive group, seven distracter pictures were threatening, while the target picture was positive. Participants were instructed to detect the 'odd one out', and track it with the mouse cursor. All pictures, including the target picture, constantly switched to different pictures, while ensuring that no identical pictures were presented twice at the same time. For most of these switches, the valence of each stimulus remained constant (e.g. a threatening picture would switch to another threatening picture), and participants were instructed to keep tracking the odd-valence picture. However, on randomly selected intervals between 5 and 10 s, the pictures changed valence. When this happened, participants were required to relocate and start tracing the new target picture as quickly as possible. There were 60 of these switches per block. For each block, pictures were randomly selected out of a pool of 128 different pictures (64 threatening and 64 positive). Each block lasted for 3 min, and participants were given short breaks as well as basic feedback on their performance in between trials. For each block, the total time that the cursor was over the target picture (tracking score) as well as the average time it took participants to switch between target pictures when they had shifted to a different location (shifting score) was registered. After each block, participants were shown a total score, which was generated by dividing the tracking score by the shifting score, such that the longer a person tracked the target and the faster they switched, the higher their score. Participants were encouraged to beat their high score with every block.

The ABM phase was preceded by a 2-min practice phase, in which participants got acquainted with the basic task requirements. In this phase, we used pictures of faces with neutral expressions. Participants were asked to trace the single male face and ignore the seven distracting female faces.

2.1.6. Emotion regulation task

For the emotion regulation task, we presented complex grids of positive and threatening stimuli to allow for attention to be directed to both positive and threatening parts of the environment. Participants were asked to either just watch, or to up- or downregulate their negative emotions. We created 24 different 4 × 4 grids of pictures. For each grid, we first randomly selected 8 positions that would contain a threatening picture and 8 positions that should contain a positive picture. Next, we randomly assigned pictures of either Set 1 or Set 3 (see Materials) to these locations, resulting in 12 grids containing only pictures of Set 1 ('trained pictures' grids) and 12 grids containing only pictures of Set 3 ('untrained pictures' grids). Each individual picture was used in exactly 3 different grids. Each trial of the emotion regulation task started with a 1s presentation of a white fixation cross on a black background, followed by one of the picture grids for 19s. After the disappearance of the picture grids, participants indicated on two 7-point Likert scales how intensely they experienced anxiety and any positive emotions (1 = not at all; 3 = little; 5 = quite; 7 = very) while viewing the grid.

The emotion regulation task itself consisted of three blocks, each consisting of eight trials (4 grids of Set 1 pictures and 4 grids of Set 3 pictures). In a *watch* block, assessing spontaneous emotion regulation, participants were asked to merely watch the screen and register the intensity of any emotion that they felt while doing so. They were free to look at any picture they wanted. In a *decrease* block, we asked participants to decrease the intensity of any negative emotion that they felt while viewing the screen. They were instructed to not think of things that were completely unrelated to the picture grid. Finally, in an *increase* block, we asked participants to increase the intensity of any negative emotion that they felt in response to the pictures. Participants were asked to not think of things that were unrelated to the grid. In all blocks, participants were told to not close their eyes and to keep looking at the screen. Participants always started with the watch block; the order of the increase and decrease blocks was counterbalanced.

2.1.7. Procedure

Upon arrival in the lab, participants were screened using the STAI-T. If they met the inclusion criterion, they were taken to a sound-proof cubicle where they provided basic demographic information and they completed the STAI-T and the STAI-S. Next, they completed baseline measures of emotion regulation and attentional bias. Participants were then randomly assigned to either the attend threat group or the attend positive group, and they completed the corresponding version of the Emotion-in-Motion task. Just before and after the ABM phase, participants indicated on six separate visual analogue scales how calm, relaxed, content, tense, upset, and worried they felt, allowing us to address immediate mood effects of the ABM phase. To avoid training-induced mood effects, participants performed a filler task after the ABM task. In this task, participants were shown three digits in the centre of the screen, and they were instructed to press the left mouse button when a majority of these digits was odd and to press the right mouse button when a majority was even. After three minutes, the filler task stopped and participants completed the test phase measures of attentional bias and emotion regulation.

2.1.8. Data reduction and outlier analysis

For one participant, the experiment stopped halfway due to a technical error. The data of this participant were completely removed from all analyses. For the emotion regulation task, we calculated mean anxiety and positive emotion intensity scores, separately for each experiment phase and picture set. For the visual probe task, we first calculated percentages of correct responses for baseline and test blocks separately. One participant's percentage correct responses in the baseline assessment was more than 3*SD*s below the sample's average (group $M = 94.11\%$ correct, $SD = 3.61$, cut-off = 83.28% correct, participant's score = 79.69% correct), therefore their baseline attentional bias data were set missing. In line with Van Bockstaele, Salemink, Bögels, and Wiers (2017), we removed trials with errors (baseline: N = 426; test: N = 433) and we removed trials with latencies deviating more than 3*SD*s from the overall mean (baseline $M = 528.03$, $SD = 160.59$, 121 trials removed; test $M = 523.27$, $SD = 284.41$, 53 trials removed). Finally, we removed trials with response latencies deviating more than 3*SD*s from each individual's mean reaction time (baseline: N = 80; test: N = 109). For each phase, we calculated attentional bias scores by subtracting the average reaction time on threat congruent trials from the average reaction time on threat incongruent trials. For the Emotion-In-Motion task, we averaged the scores for the first four blocks versus the last four blocks. For the visual analogue mood scales, we calculated baseline and test phase positive (calm, relaxed, content) and negative (tense, upset, worried) mood scores by averaging participants' responses on the respective scales.

2.2. Results

2.2.1. Baseline group characteristics

At baseline, mean state anxiety was 32.00 ($SD = 7.56$) and trait anxiety was 35.60 ($SD = 7.57$). There were no significant differences between the two training groups on the STAI, both $ts < 1$. Neither state ($r = -0.05$) nor trait anxiety ($r = -0.03$) was significantly correlated with baseline attentional bias, both $ps > .68$.

2.2.2. Effects of ABM on attentional bias

Using a 2 (Experiment phase: baseline vs. test) x 2 (Training group) repeated measures ANOVA, we tested the effects of the ABM procedure on attentional bias. This analysis revealed no significant effects, all $Fs < 1.32$, all $ps > .25$, indicating that the Emotion-In-Motion training failed to induce the expected changes in attentional bias as assessed using the visual probe task. The split half reliabilities of the attentional bias scores were poor (baseline: $r = 0.09$, $p = .50$; test: $r = 0.19$, $p = .15$).

2.2.3. Effects of ABM on emotion regulation

Two separate 2 (Experiment phase) x 2 (Training group) repeated measures ANOVAs on the positive and negative mood scales showed that positive mood decreased significantly, $F(1, 57) = 27.56$, $p < .001$, and negative mood increased significantly, $F(1, 57) = 13.82$, $p < .001$, from baseline to test phase. No effects involving Training group were significant, all $Fs < 1.52$, all $ps > .22$, indicating that the ABM conditions had no differential effects on participants' mood. For the emotion regulation data, we conducted 2 (Experiment phase: baseline vs. test) x 2 (Picture set: trained vs. untrained) x 2 (Training group) repeated measures ANOVAs (see Table 1), separately for anxiety and positive emotion ratings and for each instruction (watch, increase, and decrease). In these analyses, interactions involving Experiment phase and Training group were crucial, as they would indicate that ABM indeed affects emotion regulation. Correlations between anxiety and positive mood ratings were small (ranging between .06 and .35).

For the anxiety ratings with the watch-instruction, this ANOVA yielded a significant main effect of Experiment phase, $F(1, 58) = 8.86$, $p < .005$, with participants reporting more intense feelings of anxiety in the baseline phase ($M = 3.16$, $SD = 1.12$) than in the test phase ($M = 2.76$, $SD = 1.30$). Although the 3-way interaction was marginally significant, $F(1, 58) = 3.67$, $p = .06$, $f = 0.25$,[2] follow-up analyses on each of the picture sets separately revealed only main effects of Experiment phase, both $Fs > 6.38$, both $ps < .05$. The crucial Experiment phase x Training group interactions were not significant, both $Fs < 1.72$, both $ps > .19$, both $fs < 0.18$. For the positive emotion ratings with the watch-instruction, there were significant main effects of Picture set, $F(1, 58) = 4.33$, $p < .05$, and Training group, $F(1, 58) = 5.57$, $p < .05$. These main effects were qualified by a significant 3-way interaction, $F(1, 58) = 4.33$, $p < .05$, $f = 0.27$. Follow-up analyses on each of the two picture sets separately revealed a marginally significant Experiment phase by Training group interaction in Set 1 grids, $F(1, 58) = 3.66$, $p = .06$, $f = 0.25$, while this interaction was not significant in Set 3 grids, $F < 1$. Between-group comparisons on the Set 1 grids revealed no group differences at baseline, $F < 1$, but in the test phase, participants in the attend positive group rated these grids significantly more positive than participants in the attend threat group, $F(1, 58) = 7.68$, $p < .01$, $d = 0.72$.[3] Within group pre/post comparisons revealed no changes in the ratings of participants in the attend positive group, $F < 1$, while participants in the attend threat group reported less intense positive emotions after the training than before, $F(1, 30) = 8.09$, $p < .01$, $f = 0.52$. Hence, positive emotions in response to training pictures decreased from baseline to test in the attend threat group, while they remained stable in the attend positive group.

The ANOVA on the anxiety ratings with the decrease-instruction revealed only a main effect of Experiment phase, $F(1, 58) = 10.59$, $p < .005$, with participants reporting overall less anxiety in the test phase ($M = 2.43$, $SD = 1.18$) compared to the baseline phase ($M = 2.77$, $SD = 1.26$). The main effect of Picture set was marginally significant, $F(1, 58) = 3.57$, $p = .06$, showing that grids composed of Set 1 pictures tended to provoke more anxiety ($M = 2.66$, $SD = 1.18$) than grids composed of Set 3 pictures ($M = 2.55$, $SD = 1.18$). Neither of the crucial interactions involving Experiment phase and Training group were significant, both $Fs < 1.77$, both $ps > .18$, both $fs < 0.18$. A similar pattern of results appeared in the ANOVA on the positive emotion ratings with the decrease-instruction: Ratings in the baseline phase were higher ($M = 2.45$, $SD = 1.22$) than those in the test phase ($M = 2.20$, $SD = 1.10$), $F(1, 58) = 5.68$, $p < .05$, and grids consisting of Set 1 pictures ($M = 2.28$, $SD = 1.09$) were rated less positive than grids consisting of Set 3 pictures ($M = 2.37$, $SD = 1.12$), $F(1, 58) = 4.14$, $p < .05$. Again, neither of the crucial interactions involving Experiment phase and Training group reached significance, both $Fs < 1.90$, both $ps > .17$, both $fs < 0.19$. In sum, the attention training had no differential effects when participants were asked to decrease negative emotions.

For the increase-instruction, the ANOVA on the anxiety ratings yielded a significant main effect of Picture set, $F(1, 58) = 8.95$, $p < .005$, with Set 1 grids ($M = 3.74$, $SD = 1.36$) evoking more anxiety than Set 3 grids ($M = 3.57$, $SD = 1.38$). The main effect of Experiment phase was also significant, $F(1, 58) = 16.67$, $p < .001$, but this effect was qualified by the interaction between Experiment phase and Training group, $F(1, 58) = 5.28$, $p < .05$, $f = 0.30$. Although both groups reported less intense feelings in the test phase compared to the baseline phase, this decrease was larger in the attend threat group, $F(1, 30) = 13.43$, $p < .005$, $f = 0.67$, than in the attend positive group, $F(1, 28) = 3.93$, $p = .06$, $f = 0.37$. No other effects were significant, all $Fs < 2.55$, all $ps > .11$. Finally, the ANOVA on the positive emotion ratings with the increase-instruction yielded no significant interactions involving Experiment phase and Training group, both $Fs < 1$, and no

[2] Effect sizes for within-group differences and interactions were estimated using Cohen's f, with values from 0.10 representing small effects, values from 0.25 representing medium effects and values from 0.40 representing large effects (Cohen, 1992). We calculated f using the following formula: $f = \sqrt{[\eta p^2/(1 - \eta p^2)]}$.

[3] Effect sizes for between-group differences were estimated using Cohen's d, with values from 0.20 representing small effects, values from 0.50 representing medium effects and values from 0.80 representing large effects (Cohen, 1992).

Table 1
Emotion intensity ratings of experiment 1 for different instructions, self-report scales, and picture sets, as a function of training phase and training group.

Instruction	Scale	Picture Set	Pre training				Post training			
			Attend Threat		Attend Positive		Attend Threat		Attend Positive	
			M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Watch	Anxiety	Set1	2.98	1.12	3.44	1.21	2.63	1.23	3.01	1.44
		Set3	2.98	1.17	3.26	1.19	2.40	1.09	3.03	1.47
		Total	2.98	1.09	3.35	1.14	2.52	1.13	3.02	1.43
	Positive	Set1	2.45	1.06	2.66	0.92	1.90	0.92	2.66	1.19
		Set3	2.37	0.91	2.84	0.93	2.20	0.96	2.72	1.15
		Total	2.41	0.94	2.75	0.83	2.05	0.91	2.69	1.14
Decrease	Anxiety	Set1	2.60	1.33	3.03	1.27	2.36	1.17	2.66	1.26
		Set3	2.56	1.32	2.91	1.26	2.15	1.15	2.59	1.24
		Total	2.58	1.28	2.97	1.23	2.25	1.13	2.62	1.23
	Positive	Set1	2.26	1.12	2.56	1.35	1.83	0.96	2.49	1.11
		Set3	2.34	1.20	2.66	1.32	1.99	1.11	2.52	1.20
		Total	2.30	1.12	2.61	1.31	1.91	1.01	2.50	1.13
Increase	Anxiety	Set1	3.97	1.33	3.96	1.49	3.21	1.41	3.85	1.50
		Set3	3.66	1.29	3.95	1.50	3.03	1.31	3.66	1.70
		Total	3.81	1.29	3.95	1.45	3.12	1.34	3.76	1.57
	Positive	Set1	1.70	0.79	1.98	1.15	1.57	0.72	1.81	0.77
		Set3	1.74	0.72	2.03	1.14	1.68	0.77	1.88	0.83
		Total	1.72	0.72	2.01	1.12	1.63	0.72	1.84	0.77

other significant effects, all $Fs < 2.52$, all $ps > .11$.

2.2.4. Post-hoc manipulation check

As our ABM procedure had no effect on attentional bias in the visual probe task, we checked whether participants did learn to attend more to training-congruent pictures during the training by comparing Emotion-in-Motion scores from the first half of the training to those of the second half of the training. A post-hoc 2 (Task half: first vs. second) x 2 (Training group) repeated measures ANOVA revealed a significant main effect of Task half, $F(1, 57) = 8.27$, $p < .01$, $f = 0.38$, indicating that participants performed better in the second half (score $M = 20.79$, $SD = 9.33$) compared to the first half of the task (score $M = 19.04$, $SD = 7.04$). The main effect of Training group was also significant, $F(1, 57) = 4.94$, $p < .05$, $d = 0.57$, indicating that participants in the attend positive group performed better overall (score $M = 22.06$, $SD = 7.98$) than participants in the attend threat group (score $M = 17.71$, $SD = 7.22$). The interaction between Task half and Training group was not significant, $F(1, 57) = 1.39$, $p = .24$, indicating that both groups improved their task performance to a similar extent. Although the overall improved task performance suggests increased attentional allocation to training-congruent stimuli (threatening versus positive) during the training, it cannot be interpreted as our ABM procedure successfully inducing changes in attentional bias.

2.2.5. Power analysis

A post-hoc sensitivity power analysis using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007), given our sample size, the observed correlations between repeated measures, and the conventional value of .80 for minimal statistical power, showed that our sample was large enough to detect Experiment phase by Training group interactions in emotion intensity ratings with minimal Cohen's *f*s ranging from 0.12 to 0.21 (i.e., small to medium effects).

2.3. Discussion

In Experiment 1, the Emotion-In-Motion procedure had no demonstrable effect on the visual probe measure of attentional bias, which could be due to the poor reliability of the visual probe task. Although participants' improved performance on the Emotion-In-Motion task over the course of the training suggests that people attended more to threat-congruent information during the training and thus provides some evidence of within-task changes in attention deployment, this was only a post-hoc analysis and it cannot be interpreted as strong evidence for our ABM procedure having effects on attentional bias.

The ABM procedure had some impact on emotion regulation. When asked to merely watch the picture grids, participants in the attend positive group reported more intense positive emotions after training than participants in the attend threat group, although this effect was only significant for grids of pictures that were used during the training. In contrast with our hypothesis, when participants were asked to increase their negative emotions, participants in the attend threat group were *less able* to do so after the training than participants in the attend positive group. As a *post hoc* explanation for this result, the decreased levels of anxiety in the attend threat group could have been the result of increased habituation following extensive exposure to threatening pictures during the training. This interpretation is in line with the emotional processing theory (Foa & Kozak, 1986), according to which attending to threat indeed leads to faster habituation and thus more anxiety reduction (Van Bockstaele, Verschuere, De Houwer, & Crombez, 2010).

In Experiment 2, we used a different and more often used ABM procedure, based on the visual search task with facial stimuli, to investigate the effects of ABM on emotion regulation. Both before and after the ABM procedure, we assessed attentional bias using a visual probe task and we measured emotion regulation in response to grids of happy and angry facial expressions. To improve transfer from the training task to the emotion regulation task and to address generalization to contexts that increasingly differed from the visual search training (a single angry face in a happy crowd versus a single happy face in an angry crowd), we maximized the visual similarities between the training and emotion regulation task and we varied the proportions of happy and angry faces in the emotion regulation task. *A priori*, as in Experiment 1, we expected participants who were trained to attend to angry faces to show stronger increments and smaller reductions of anxiety in response to these grids of facial expressions (especially so in grids containing only one angry face), while people who were trained to attend to happy faces were expected to show smaller increments and stronger reductions of anxiety (especially so in grids containing many angry faces). However, given the unexpected pattern of results in the attend threat group in Experiment 1, we also considered it possible to replicate these findings of Experiment 1 in that people in the attend threat group would show smaller increments of negative affect.

3. Experiment 2

3.1. Method

3.1.1. Participants

Fifty-eight students (37 women, *M* age = 20.53, *SD* = 6.29, range 17–55) of the University of Western Australia completed this study in exchange for course credits. The experiment was run online and all participants were informed about the general nature of the tasks and stimuli prior to signing for informed consent. The entire procedure was approved by the ethical committee of the University of Western Australia.

3.1.2. Materials

For the emotion regulation task (see below), we used pictures of angry and happy facial expressions of 48 actors (24 male, 24 female, 138 × 177 pixels) from the KDEF database (Lundqvist et al., 1998). For the visual search ABM procedure, we used pictures of angry and happy facial expressions of 32 actors (16 male, 16 female, 138 × 177 pixels) from the NimStim Face Stimulus Set (Tottenham et al., 2009). Half of the faces of each emotional expression displayed the emotional expression with an open mouth, while the other half displayed the emotional expression with a closed mouth. For the visual probe task, we used a subset of pictures of angry and happy facial expressions of 24 actors (12 male, 12 female, 239 × 307 pixels) from the NimStim Set, and an additional set of angry and happy facial expressions of 24 actors (12 male, 12 female, 239 × 307 pixels) from the Radboud Faces Database (Langner et al., 2010). Finally, for the practice phase of the visual probe task, we used 4 pictures of neutral facial expressions selected from the NimStim Set.

3.1.3. Questionnaires

As in Experiment 1, we used the STAI to measure state and trait anxiety. Cronbach's alphas in this experiment were .94 and .92 for the STAI-S and the STAI-T, respectively.

3.1.4. Attentional bias: visual probe task

After a 500 ms fixation cross, two face cues (one happy and one angry) of the same actor appeared to the right and left of the fixation cross. The faces remained on the screen for 500 ms, after which they were erased and a target stimulus appeared. Targets consisted of a single arrow pointing up or down, and participants were instructed to respond as fast and as accurately as possible to the direction of the arrow by pressing on the corresponding arrow keys of the keyboard. As soon as a response was registered, the screen was erased and the next trial started 500 ms later. An error message appeared upon incorrect responses and remained on the screen for 3000 ms to discourage incorrect responses. Each of the two measurement blocks (baseline and test phase) consisted of 96 trials, with half of the trials threat congruent and half threat incongruent, and they were preceded by a 12-trial practice phase with neutral face stimuli.

3.1.5. Attentional bias modification: visual search training

Prior to the start of the training, participants were randomly allocated to an attend threat or an attend positive training group. The general appearance of the visual search training was based on the task developed by Dandeneau, Baldwin, Baccus, Sakellaropoulo, and Pruessner (2007). Each trial started with the presentation of a fixation cross for 500 ms. Next, a 4 × 4 grid of faces appeared. In the attend threat group, 15 distracter faces were happy and participants were asked to click as fast as possible with the mouse on the angry target face. In the attend positive group, 15 distracter faces were angry and participants were asked to click as fast as possible on the happy target face. Pictures remained on the screen until a response was registered, after which the screen was erased and the next trial started after 500 ms. Upon incorrect responses, a 3000 ms error message appeared to discourage incorrect responses. The training task consisted of four blocks of 64 trials each, and participants were given the opportunity to have a short break after every 32 trials.

3.1.6. Emotion regulation task

The emotion regulation task was similar to the one used in Experiment 1: In a first block, participants were asked to merely *watch* 4 × 4 grids of face pictures (8 male, 8 female) and after each grid indicated how calm, tense, upset, relaxed, worried, and content they felt on separate 7-point Likert scales (1 = not at all, 7 = very). In a *decrease* block, participants were asked to decrease any negative emotions they felt while viewing the grids. In an *increase* block, we asked participants to increase the intensity of any negative emotions. The order of the decrease and increase blocks was randomized for each participant. Each block consisted of three grids: One grid contained 8 angry and 8 happy faces, one grid contained 15 angry faces and 1 happy face, and one grid contained 1 angry face and 15 happy faces. The grids thus differed in the ratio of angry-happy faces, allowing us to assess generalization of effects to contexts that increasingly differed from the visual search training. Grids were preceded by a 1500 ms instruction cue ("watch", "increase", "decrease") and remained on the screen for 20 s.

3.1.7. Procedure

At the beginning of the experiment, a calibration procedure measured participants' screen pixel-to-cm ratio, which was used to present all visual stimuli in the same size for all participants, independent of screen size and resolution. Next, participants completed the STAI, followed by the baseline measurement of the emotion regulation task and the visual probe task. Participants then completed either the attend threat or the attend positive training task, followed by the test phase assessment of attentional bias and emotion regulation.

3.1.8. Data reduction and outlier analysis

For the visual probe task data, we first calculated error percentages and removed the data of one participant who performed at chance level (43% correct). We also discarded the data of a second participant whose error rate was more than 3*SD*s above the sample's average (group *M* = 96.96% correct, *SD* = 2.99, cut-off = 87.99%, participant's score = 78.65%). Next, we removed errors (N = 279) and trials with latencies deviating more than 3*SD*s from the group mean (*M* = 660, *SD* = 584, N = 37), as well as trials with latencies deviating more than 3*SD*s from each individual's mean reaction time (N = 149). For the remaining data, we calculated baseline and test phase attentional bias scores by subtracting the mean reaction time on threat congruent trials from the mean reaction time on threat incongruent trials.

For the visual search task, we also first calculated error percentages. One participant performed poorly in comparison with the rest of the sample (group *M* = 98.62% correct, *SD* = 3.13, cut-off = 89.23%, participant's score = 78.13%). Because poor performance during the training task is likely to result in no effect on the crucial measures of emotion regulation and attentional bias, we also set this participant's test phase scores of attentional bias and emotion regulation to missing. For the remaining participants, we excluded errors (N = 149), trials with reaction times deviating more than 3*SD*s from the group mean (*M* = 3714, *SD* = 2994, N = 174) as well as trials with reaction times deviating more than 3*SD*s from each individual's mean (N = 214). Finally, we calculated participants' mean latencies of the first versus the second half of the training task. For the emotion regulation task, we calculated baseline and test phase scores of positive (calm, relaxed, content) and negative (tense, upset, worried) mood by averaging the responses on the respective scales, separately for each block (watch, increase, decrease) and each type of grid (8 angry + 8 happy; 15 angry + 1 happy; 1 angry + 15 happy).

3.2. Results

3.2.1. Baseline group characteristics

Baseline state and trait anxiety in our sample were 37.71 ($SD = 10.69$) and 43.66 ($SD = 9.64$), respectively. The two training groups did not differ significantly on either subscale of the STAI, both $ts < 1$. Neither state ($r = -0.09$) nor trait anxiety ($r = -0.02$) was significantly correlated with baseline attentional bias, both $ps > .49$.

3.2.2. Effects of visual search ABM on attentional bias

To examine whether the visual search ABM task successfully induced differential patterns of attentional bias, we used a 2 (Experiment phase: baseline vs. test) x 2 (Training group) repeated measures ANOVA on the visual probe task attentional bias scores. Neither the main effects nor the interaction approached significance, all $Fs < 1.42$, all $ps > .23$, indicating that, as in Experiment 1, the ABM procedure failed to induce the expected changes in attentional bias in the visual probe task. The split half reliabilities of the attentional bias scores were again poor (baseline: $r = -0.03$, $p = .81$; test: $r = -0.01$, $p = .97$).

3.2.3. Effects of ABM on emotion regulation

We analysed the emotion regulation data using 2 (Experiment phase) x 3 (Grid: 8 angry + 8 happy; 15 angry faces + 1 happy; 1 angry + 15 happy) x 2 (Training group) repeated measures ANOVAs, separately for each instruction and for positive and negative mood ratings (see Table 2). Correlations between positive and negative mood ratings were medium to large and negative (ranging between −0.35 and −0.65), indicating a rather strong inverse relation between positive and negative ratings.

For the negative mood ratings with the *watch* instruction, this analysis yielded a significant interaction between Experiment phase and Training group, $F(1, 55) = 4.23$, $p < .05$, $f = 0.28$. Follow-up analyses showed that participants in the attend threat group reported more intense negative emotions after the training compared to before, $F(1, 29) = 7.04$, $p < .05$, $f = 0.49$, while participants in the attend positive group remained stable over time, $F < 1$. All other effects in the main ANOVA were not significant, all $Fs < 2.14$, all $ps > .12$. An identical repeated measures ANOVA on the positive mood ratings after the watch-instruction yielded no significant effects, all $Fs < 1.29$, all $ps > .28$.

For the negative mood ratings with the *decrease* instruction, the interaction between Experiment phase and Training group was again significant, $F(1, 55) = 4.26$, $p < .05$, $f = 0.28$. Participants in the attend threat group became worse at decreasing negative mood following the training, $F(1, 29) = 7.71$, $p < .05$, $f = 0.52$, while participants in the attend positive group remained stable over time, $F < 1$. No other effects in this ANOVA reached significance, all $Fs < 1.78$, all $ps > .17$. For the positive mood ratings, the 3-way interaction was significant, $F(2, 54) = 4.28$, $p < .05$, $f = 0.40$; all other effects were not significant, all $Fs < 1.90$, all $ps > .15$. To follow up on this 3-way interaction, we analysed the positive mood ratings for each grid separately. In the grid with 1 happy face and 15 angry faces and the grid with 8 happy and 8 angry faces, the interactions between Experiment phase and Training group were not significant, both $Fs < 2.26$, both $ps > .13$, both $fs < 0.21$ indicating that the training had no differential effects on positive mood ratings in these two grids. For the grid with 15 happy faces and 1 angry face, the interaction between Experiment phase and Training group was marginally significant, $F(1, 55) = 3.58$, $p = .06$, $f = 0.25$. In line with the results of the negative mood ratings, participants in the attend threat group reported less intense positive emotions after the training compared to before, $F(1, 29) = 6.07$, $p < .05$, $f = 0.46$, while participants in the attend positive group remained stable, $F < 1$. In sum, participants in the attend threat group became worse at decreasing negative emotions, as evidenced by a general impairment to downregulate negative mood (irrespective of the number of angry faces on the screen) as well as a specific impairment to upregulate positive mood when only a single angry face was on the screen.

For the instruction to *increase* negative emotions, the ANOVA on the negative mood ratings again revealed a significant interaction between Experiment phase and Training group, $F(1, 55) = 7.00$, $p < .05$, $f = 0.36$. While participants in the attend threat group became better at increasing negative mood following the training, $F(1, 29) = 10.20$,

Table 2
Emotion Intensity Ratings of Experiment 2 for Different Instructions, Self-Report Scales, and Picture Grids, as a Function of Training Phase and Training Group. Note: 1A15H = 1 angry + 15 happy; 8A8H = 8 angry + 15 happy; 15A1H = 15 angry + 1 happy.

Instruction	Scale	Grid	Pre training				Post training			
			Attend Threat		Attend Positive		Attend Threat		Attend Positive	
			M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Watch	Negative	1A15H	1.93	1.23	2.51	1.33	2.69	1.46	2.51	1.22
		8A8H	2.07	1.14	2.44	1.32	2.30	1.20	2.37	1.45
		15A1H	2.24	1.10	2.67	1.57	2.74	1.20	2.43	1.44
		Total	2.08	0.89	2.54	1.19	2.58	1.08	2.44	1.22
	Positive	1A15H	4.66	1.38	4.38	1.51	4.50	1.36	4.47	1.32
		8A8H	4.47	1.36	4.27	1.64	4.50	1.54	4.30	1.43
		15A1H	4.41	1.45	4.57	1.42	4.23	1.20	4.49	1.21
		Total	4.51	0.99	4.41	1.27	4.41	1.17	4.42	1.11
Decrease	Negative	1A15H	2.18	1.09	2.27	1.22	2.49	1.22	2.31	1.48
		8A8H	2.00	0.88	2.38	1.47	2.79	1.48	2.12	1.18
		15A1H	2.17	1.12	2.35	1.56	2.41	1.11	2.21	1.29
		Total	2.11	0.87	2.33	1.28	2.56	1.09	2.21	1.21
	Positive	1A15H	4.54	1.31	4.59	1.35	3.92	1.35	4.70	1.42
		8A8H	4.81	1.25	4.63	1.32	4.34	1.35	4.72	1.18
		15A1H	4.33	1.11	4.96	1.41	4.47	1.26	4.69	1.49
		Total	4.56	1.04	4.73	1.19	4.24	1.16	4.70	1.26
Increase	Negative	1A15H	2.60	1.39	2.68	1.51	3.32	1.47	2.65	1.43
		8A8H	2.54	1.24	2.56	1.24	3.02	1.36	2.70	1.55
		15A1H	2.27	1.24	3.10	1.69	3.01	1.46	2.54	1.18
		Total	2.47	0.92	2.78	1.21	3.12	1.22	2.63	1.19
	Positive	1A15H	4.00	1.53	4.31	1.37	3.79	1.37	4.27	1.46
		8A8H	3.90	1.23	4.36	1.58	4.11	1.14	4.31	1.38
		15A1H	4.14	1.52	4.14	1.47	4.13	1.41	4.42	1.54
		Total	4.01	1.08	4.27	1.11	4.01	1.11	4.33	1.32

$p < .005$, $f = 0.59$, participants in the attend positive group remained stable, $F < 1$. Although no other effects in the ANOVA reached significance, all Fs < 2.84, all ps $> .09$, the 3-way interaction was marginally significant, $F(2, 54) = 2.59$, $p = .08$, $f = 0.31$, suggesting that the Experiment phase by Training group interaction may have differed between different grids. Exploratory analyses on each of the grid types separately revealed that the Experiment phase by Training group interaction was not significant in the grid with 15 happy faces and a single angry face, $F(1, 55) = 2.54$, $p = .12$, or in the grid with 8 happy and 8 angry faces, $F < 1$. However, in the grid with 15 angry faces and a single happy face, the interaction was significant, $F(1, 55) = 10.53$, $p < .005$, $f = 0.44$, indicating that participants in the attend threat group became better at increasing negative mood following training, $F(1, 29) = 6.92$, $p < .05$, $f = 0.49$, while participants in the attend positive group tended to get worse at increasing negative mood, $F(1, 26) = 3.88$, $p = .06$, $f = 0.39$. For the positive mood ratings, no effects approached significance, all Fs < 1.22, all ps $> .27$. In sum, the results of the increase instruction indicate that participants in the attend threat group responded with more intense negative mood following the training, especially so when many angry faces were present. Inversely, participants who had been trained to find happy faces in such angry crowds responded with less intense negative emotions to these grids.

3.2.4. Post-hoc manipulation check

Given the lack of change in attentional bias in the visual probe task, we checked whether participants became better at finding their target emotional faces during the training by comparing reaction times in the first versus the second half of the visual search task. This analysis revealed significant main effects of Task half, $F(1,55) = 21.00$, $p < .001$, $f = 0.62$, and Training group, $F(1, 55) = 21.11$, $p < .001$, $d = 1.22$. While the main effect of training group indicated that finding angry faces ($M = 3089$, $SD = 527$) was easier than finding happy faces ($M = 3827$, $SD = 680$), the main effect of Task half illustrated that participants in both groups became better at finding the face displaying their target emotion (first half: $M = 3553$, $SD = 787$; second half: $M = 3329$, $SD = 671$). The interaction between Task half and Training group was not significant, $F < 1$. Like in Experiment 1, these results suggest that participants became gradually better at finding training-congruent emotional faces, yet they cannot be interpreted as our ABM procedure successfully inducing changes in attentional bias.

3.2.5. Power analysis

A post-hoc sensitivity power analysis showed that our sample was large enough to detect Experiment phase by Training group interactions with minimal Cohen's fs ranging from 0.18 to 0.23. Our sample was thus large enough to detect medium sized effects but was too small to detect also small effects.

3.3. Discussion

The main aim of Experiment 2 was to further address the interplay between ABM and emotion regulation using a visual search ABM procedure. Although we again failed to induce or detect the expected pattern of attentional bias in the visual probe task, the ABM procedure did have marked effects on emotion regulation. Participants in the attend threat group reported more intense negative mood following the training during all three instructions and they reported less intense positive mood when asked to decrease negative emotions in the grid with a single angry face amidst 15 happy faces (i.e., the grid similar to the ones they had seen during the training). Mood ratings of participants in the attend positive group remained largely stable over time, although they did show a marginal decrease in negative mood when asked to increase negative emotions while viewing the grid with a single happy face amidst 15 angry faces (i.e., again, the grid similar to the ones they had seen during the training). The effects of the attend threat group were largely in line with our hypotheses, showing stronger increments and smaller reductions of negative mood following training. Nevertheless, the results of Experiment 2 are not in line with those of Experiment 1, where we found the attend threat group to be more emotionally unresponsive (overall less intense emotions).

4. General discussion

The main goal of the present line of experiments was to investigate the hypothesis that changes in emotion regulation underlie the effects of ABM on anxiety and emotional responsiveness to stress. To do so, we conducted two separate experiments in which we assessed the effects of two different ABM procedures on a standard emotion regulation paradigm in which people were asked to merely watch emotional pictures or to increase or decrease their negative emotions in response to these pictures. In Experiment 1, we failed to observe the expected change in attentional bias following the ABM procedure, but we did find effects of the training on emotion regulation on pictures that were used in the training. Participants in the attend positive group reported more intense positive emotions while merely watching grids of these pictures than participants in the attend threat group and participants in the attend threat group were less able to increase their anxiety levels than participants in the attend positive group when prompted to do so. In Experiment 2, we again failed to observe the expected change in attentional bias following a the ABM procedure, but again the training did have an effect on emotion regulation measures. For all three instructions, participants in the attend threat group reported more intense negative mood after the training than before. Negative mood ratings of the attend positive group remained largely stable over time, with the exception of a tendency to become worse at increasing negative emotions in response to grids similar to the ones that were used in their training.

An important issue in both experiments concerns our failing to detect or confirm a change in attentional bias in the visual probe task. In the absence of changes in attentional bias, we cannot attribute any between-group differences in emotion regulation to differential patterns of attentional bias. Such lack of training effects on attentional bias measures is not an isolated finding (Clarke et al., 2014; MacLeod & Grafton, 2016). One possible explanation relates to the poor reliability of the visual probe task as a measure of attentional bias (Schmukle, 2005; but see De Schryver, Hughes, Rosseel, & De Houwer, 2016). It is possible that our ABM procedures were in fact successful in inducing the expected patterns of attentional bias, but that our visual probe task outcomes were too much distorted by random measurement error to pick up these changes. Some support for this explanation follows from the fact that the Emotion-in-Motion scores of participants in Experiment 1 did improve over the course of the training, as did the search speed of participants in Experiment 2. This may indicate that the ABM procedures did affect the intended attentional processing of threat, although it must be noted that these results were exploratory and may also reflect task-specific practice effects.

Another possible explanation for the lack of training effects on the attentional bias measures relates to the different tasks that we used to induce changes in attentional bias (Emotion-in-Motion, visual search task) and the visual probe task that we used to assess attentional bias. While both our ABM tasks consisted of relatively complex displays with multiple stimuli, the visual probe assessment was more static and less complex, with only two emotionally relevant stimuli simultaneously on the screen. Also, in both ABM tasks, the emotional stimuli were task-relevant: Participants were instructed to find and/or follow an emotionally significant target stimulus. In the visual probe task, the positive/negative stimuli were task-irrelevant, as participants only needed to respond to letters or arrows. It is possible that more extensive training is needed to allow the training-induced pattern of selective attention to overcome such between-task variations and generalize to different settings (Van Bockstaele et al., 2012, 2017).

Even though we cannot attribute group differences in emotion regulation to changes in attentional bias, exposure to alternative training contingencies is still the most likely cause for differences in emotion regulation. A priori, we expected people in attend threat groups to become better at increasing and worse at decreasing negative emotions, while we expected the opposite for participants in attend positive groups. The emotion regulation results of our two experiments were not entirely consistent. The expected pattern of results was only partially present in Experiment 2, especially so in the attend threat group. In contrast, the results of Experiment 1 were not in line with the results of Experiment 2 nor with our initial hypotheses, suggesting that attending to threat could also result in habituation, leading to overall less intense emotions. As such, the results of Experiment 1 are in line with studies where participants in both attend and avoid threat groups showed decreases in anxiety (e.g. McNally, Enock, Tsai, & Tousian, 2013; Van Bockstaele et al., 2011).

One of the main differences between our experiments and the broad ABM literature is that we explicitly asked participants to regulate (i.e., to increase or decrease) their emotions. ABM research to date has predominantly assessed emotional changes following training naturally, without interference (e.g. report how anxious you feel at this moment), equivalent to our watch instruction (for an exception, see Sanchez et al., 2016). Our results show that modifying attention deployment using ABM training not only influences these natural emotional responses to stimuli, but also affects participants' ability to *alter the intensity* of their emotions when prompted to do so. Distinguishing between these instructions may help to explain some of the inconsistencies in the ABM-field (for reviews, see Clarke et al., 2014; Van Bockstaele et al., 2014). Individual variations in the extent to which people spontaneously attempt to influence or regulate their emotions in stressful situations may differentiate between ABM studies with versus without significant emotional impact. As such, differentiating between emotion experience and emotion regulation is likely to move the ABM field forward, and thus enhance the benefits of ABM as a therapeutic intervention.

Our study also has implications for emotion regulation research. As pointed out by MacLeod and Bucks (2011), emotion regulation research has relied largely on explicit instructions to adopt a certain regulatory strategy. For instance, a recent meta-analysis on the effectiveness of different emotion regulation strategies included only studies in which people were explicitly instructed to adopt specific strategies (Webb, Miles, & Sheeran, 2012). Given the growing interest in implicit or automatic emotion regulation (e.g. Gyurak, Gross, & Etkin, 2011; Koole & Rothermund, 2011), developing methods to influence such implicit emotion regulation is imperative. Our study is among the first to empirically demonstrate that ABM procedures can serve as implicit emotion regulation training procedures (Todd et al., 2012). Elaborating on this idea, interpretation bias modification (IBM) procedures, in which people are trained to interpret emotional ambiguity in a non-threatening way (Hirsch, Meeten, Krahé, & Reeder, 2016), show substantial conceptual overlap with the idea of (re)appraisal, which involves changing the way one thinks about stimuli in order to change the emotional intensity that they evoke. Given this conceptual overlap, IBM procedures may serve as implicit or automatic (re)appraisal training procedures, and the emotional effects of IBM could in part be driven by improved (re)appraisal and thus improved emotion regulation (Sanchez et al., 2016).

Despite these implications, several limitations need to be taken into account. The absence of change in attentional bias in the visual probe task implies that we cannot convincingly attribute changes in emotion regulation to changes in attentional bias. This lack of training effects in the visual probe task is a relatively common problem in ABM studies (e.g., see Clarke et al., 2017; Everaert, Mogoaşe, David, & Koster, 2015), as is the lack of transfer from specific ABM procedures to other measures of attentional bias (Van Bockstaele et al., 2012, 2017). Developing better or improving existing paradigms to assess and change attentional bias will likely reduce some of the inconsistencies in the attentional bias domain (e.g. Dodd, Vogt, Turkileri, & Notebaert, 2017; Notebaert, Clarke, Grafton, & MacLeod, 2015; Sigurjónsdóttir, Sigurðardóttir, Björnsson, & Kristjánsson, 2015). Also, operationalizing attentional bias in terms of reaction time variability (e.g., Iacoviello et al., 2014) or eye-movements (e.g., Armstrong & Olatunji, 2012, but see Waechter, Nelson, Wright, Hyatt, & Oakman, 2014) may lead to more reliable and better estimates of attentional bias (for a detailed discussion of reliability issues in measuring attentional bias, see Rodebaugh et al., 2016). Related to this, our results were inconsistent as to whether or not training effects generalized to new stimuli. In Experiment 1, we only found group differences in emotion regulation for pictures that were used during the training, while in Experiment 2 the effects did generalize to new stimuli. A plausible explanation for this difference is the large similarity between the stimuli used in the training and in the emotion regulation task in Experiment 2 (all facial expressions), while the stimulus sets in Experiment 1 were more diverse (IAPS pictures).

Another limitation is our exclusive focus on self-reported emotion intensity, omitting physiological responses or overt behaviour. Although these different response systems often show substantial overlap (e.g. Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005), this is not always the case (e.g. Mauss, Cook, & Gross, 2007). In addition, because we only assessed emotion intensity after the regulation instruction had been given, we cannot preclude the possibility that some pictures or grids evoked more or less intense emotions to begin with. Related to this, the emotion intensity ratings in Experiment 2 showed that the face pictures evoked only low levels of negative emotions, potentially hampering the further downregulation of negative affect. Including multiple measures of emotion intensity at multiple time points and using more intense stimuli will allow for a more fine-grained understanding of the effects of automatic attention allocation on emotion and emotion regulation. We also did not explicitly instruct participants on how to regulate their emotions. Although we theoretically expected the training to influence mainly attention deployment strategies, it is possible that some participants used reappraisal or other strategies. Finally, the effects of training on the emotion regulation paradigms were not consistent across our two experiments. More research is needed to fully uncover the boundary conditions of the interplay between induced changes in attention and emotion regulation.

These limitations notwithstanding, our research does add empirical weight to the conceptual overlap between attentional bias modification and attention deployment as an emotion regulation strategy. Therefore, the further synergy between the emotion regulation framework and the cognitive bias modification account is likely to improve our understanding of emotions as well as our attempts to change them.

Data availability statement

The original data that were used in Experiment 1 and Experiment 2 are accessible in the following Open Science Framework data deposit: osf.io/q5hsz.

Conflicts of interest

All authors acknowledge that they have exercised due care in ensuring the integrity of the work. Further, none of the original material contained in the manuscript has been submitted for consideration nor will any of it be published elsewhere except in abstract form in connection with scientific meetings. We have no conflicts of interest to disclose.

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