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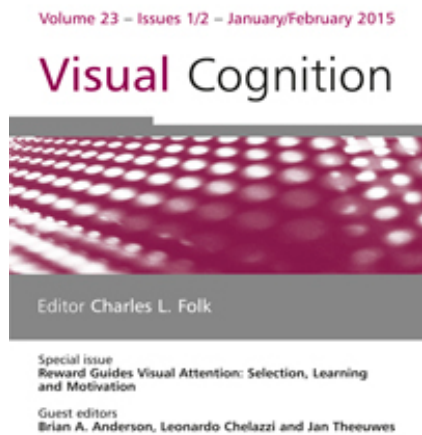
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Money talks in attention bias modification: Reward in a dot-probe task affects attentional biases

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Attention bias modification (ABM) aimed at correcting dysfunctional biases in anxiety patients has met with only mild success. Inspired by recent studies showing large effects of financial reward upon attention shifts, we contrasted effects of traditional dot-probe ABM and reward upon attention biases in a between-subject 2×2 design. Twenty-seven participants in group cognitive behavioural therapy (GCBT) for social anxiety disorder (SAD) were randomly assigned to undergo six sessions of a dot-probe task consisting of ABM or placebo ABM along with random or high reward following neutral stimuli. There was no influence of ABM on participants' attention bias over and above the influence of GCBT. Reward, however, had a strong influence on attention bias. Neither ABM nor reward reduced SAD symptoms over and above the effects of GCBT. The results add to the growing evidence that benefits of ABM through dot-probe training are unreliable but suggest on the other hand that rewarding attention may strongly influence dysfunctional attention biases.

Keywords: Visual attention; Reward; Attention bias; Attention bias modification; Dot-probe task; Social anxiety disorder.

Rewards are environmental stimuli that elicit approach responses and can serve as reinforcers, strengthening learned stimulus-response relationships by increasing their frequency (Schultz, 2006; White, 1989). Rewards have long been known to modulate overt behaviour but recent years have seen increased research into

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their effects on attentional processes. Monetary rewards lead to better overall performance for highly rewarded target colour in a pop-out task and increased trial-to-trial priming for successively repeated targets in the rewarded colour (Kristjánsson, Sigurjónsdóttir, & Driver, 2010). These effects occur even if participants are unaware of the reward schedule and the priming effects even track unpredictable reversals in reward contingencies, indicating that reward has substantial modulation potential on selective attention (Kristjánsson et al., 2010). EEG measures have revealed an enhancement in an attentional selection component (N2pc) when participants respond to a target colour consistently yielding high reward on a pop-out task (Kiss, Driver, & Eimer, 2009) and when effects of attention and reward relevance are dissociated, reward related probes influence responses in extrastriate visual cortex (Buschsulte et al., 2014). The effects of reward contingencies can persist for several days after training (Anderson, Laurent, & Yantis, 2011; Della Libera & Chelazzi, 2009) and can transfer between different types of tasks measuring different attentional orienting systems (bottom-up and top-down; Lee & Shomstein, 2014). In an attentional blink task, previously rewarded faces show resistance to the attentional blink while unrewarded faces do not (Raymond & O'Brien, 2009). Since reward schedules can modify selective attention in the laboratory, an intriguing question is whether these effects can be used to modify dysfunctional attention.

Anxious individuals are more likely than others to have a strong bias to attend to stimuli that they perceive as threatening (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). This bias is thought to play a role in the development and maintenance of anxiety disorders (Heimberg, Brozovich, & Rapee, 2010; Wells & Matthews, 1994). According to cognitive models of social anxiety, attention bias is activated in threatening social situations, causing a shift in attention towards internal perception of performance and potential threats in the environment. This attention bias distorts what individuals learn from their experience about the likelihood and severity of future threat. Such attention biases inhibit the socially anxious individual from correcting pre-existing negative assumptions about threat and their own performance in social situations, causing them to continue feeling anxious in these situations (Clark & Wells, 1995; Heimberg et al., 2010). Attention bias modification (ABM) involves training participants to attend preferentially to non-threatening stimuli. There are many examples in the literature on visual attention of how attention can unconsciously learn relations between stimuli (Fiser & Aslin, 2001; Kristjánsson & Nakayama, 2003; see Kristjánsson, 2006, for review), and presumably attentional bias modification involves a similar learning process, connecting a particular stimulus with one that does not have negative meaning for the participant. Notably for the current study, Chelazzi, Perlato, Santandrea, and Della Libera (2013) propose that such a mechanism might account for the large effects rewards have on visual attention. ABM is usually conducted by presenting a target in the former location or in the proximity of neutral or threatening

distractors or cues. When the target appears more frequently (or in some cases always) in the former location of a neutral distractor or cue, participants learn (usually without conscious effort) to attend preferentially to neutral stimuli instead of threatening stimuli. Popular paradigms for ABM have been the *dot-probe* (MacLeod, Mathews, & Tata, 1986), *spatial cueing* (Posner, 1980), and *visual search* tasks. ABM has sometimes been reported to correct biases towards threat and subsequently reduce anxiety symptoms (Bar-Haim, 2010; Beard, Sawyer, & Hoffman, 2012).

These attentional modification paradigms have, nevertheless, only met with mild success. Some randomized controlled trials (RCTs) indicate that ABM results in less attention bias and reduced anxiety symptoms (Amir et al., 2009; Heeren, Reese, McNally, & Philippot, 2012; Schmidt, Richey, Buckner, & Timpano, 2009). In Beard et al.'s (2012) meta-analysis, attentional modification using these paradigms had a significant effect on attention bias (Hedge's $g = 0.68$) and a moderate effect on anxiety ($g = 0.48$). More recent RCTs have not shown these benefits of ABM, however (Bunnell, Beidel, & Mesa, 2013; Neubauer et al., 2013; Rapee et al., 2013). Furthermore, ABM as a clinical intervention for adults with anxiety disorders has not yet been tested in clinical settings, which leaves the question of clinical relevance unanswered.

We present results from a randomized controlled trial where we contrast traditional dot-probe ABM with any potential effects of reward upon attention biases among outpatients with social anxiety disorder (SAD) undergoing group cognitive behavioural therapy (GCBT). This is, to our knowledge, the first study to test attention bias modification through reward and also the first study where ABM is tested as an adjunct to CBT in adults with anxiety disorders in a clinical setting. We used a between-subject 2×2 design, contrasting effects of traditional dot-probe ABM with effects of rewarding attention shifts to neutral faces higher than shifts towards threatening faces. Attention bias was measured before and after attention training using a spatial cueing task involving threatening or neutral words (Posner, 1980).

In sum, our first aim was to investigate any potential interaction of the probe task and reward on attention bias. Furthermore, since little is known about the relevance of ABM to clinical practice, our second aim was to measure effects of the probe task and reward on symptom change in SAD patients undergoing GCBT in an outpatient anxiety clinic.

METHOD

Participants

All patients participating in GCBT for SAD at an outpatient anxiety clinic in Iceland from March to May 2011 and from October to December 2012 were invited to take part in the study. All patients had undergone an interview with a

clinical psychologist. Inclusion criterion for participation in the group was meeting DSM-IV criteria for SAD. Participants were asked about their use of alcohol and substances, and were excluded from the study if their use caused problems for them. If participants were taking psychotropic medication they were instructed not to alter the dosage during the group therapy. Thirty-seven participants were recruited and randomly assigned to the four treatment groups. Seven participants dropped out and data from three participants were lost due to an error in the data collection program. Twenty-seven participants completed all six training sessions ($M_{\text{age}} = 28.9$, $SD_{\text{age}} = 9.6$, range 18–56 years, 12 men, 16 women, see Table 1). Participants were compensated with 3000–5000 Icelandic kronas (US\$26–US\$44) in discount from the therapy fee depending on their performance in the attention-training program. The flow of participants through the study is presented in Figure 1. All participants had normal or corrected-to-normal visual acuity. The study was approved by the local IRB and all participants signed an informed consent form.

Equipment

The experimental displays were programmed in C using the VisionShell software library and presented on a 75-Hz CRT controlled by a 400-MHz G4 Apple computer.

Stimuli and procedure

Attention bias modification. A modified probe task was designed for the study using grey scale facial images of 39 Caucasian Dutch people (20 males) showing neutral expressions (neutral stimuli) or expressions of disgust (threatening stimuli; see Figure 2a). The images were drawn from the *Radboud Faces Database* (Langner et al., 2010). Each trial started with the presentation of a central white fixation cross on a dark grey background. Subsequently, two facial images of the same individual, one neutral and the other threatening ($5.24^\circ \times 5.71^\circ$) were presented for 480 ms above and below the fixation cross, with their centre 3.5° from fixation (see Figure 2b). A white arrowhead (each line 30 arc min) followed;

TABLE 1
Background variables of the sample

	<i>ABM random reward</i> (n = 7)	<i>ABM high reward</i> (n = 9)	<i>Placebo ABM random reward</i> (n = 5)	<i>Placebo ABM high reward</i> (n = 6)
Age	31.7 (12.9)	30.2 (12.2)	35.8 (10.6)	27.3 (7.8)
Gender (% female)	29%	78%	60%	83%

Note. Standard deviations are reported in parentheses

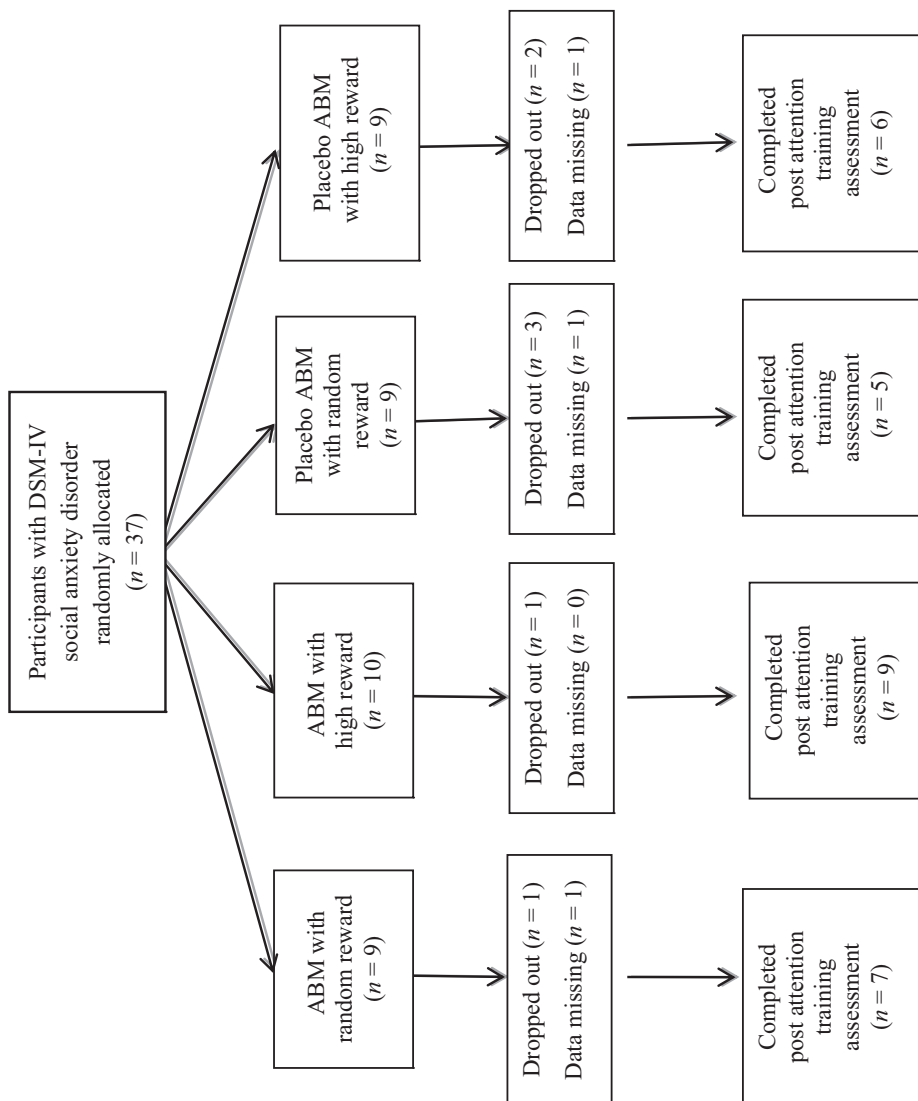


Figure 1. Flow of participants through the study.

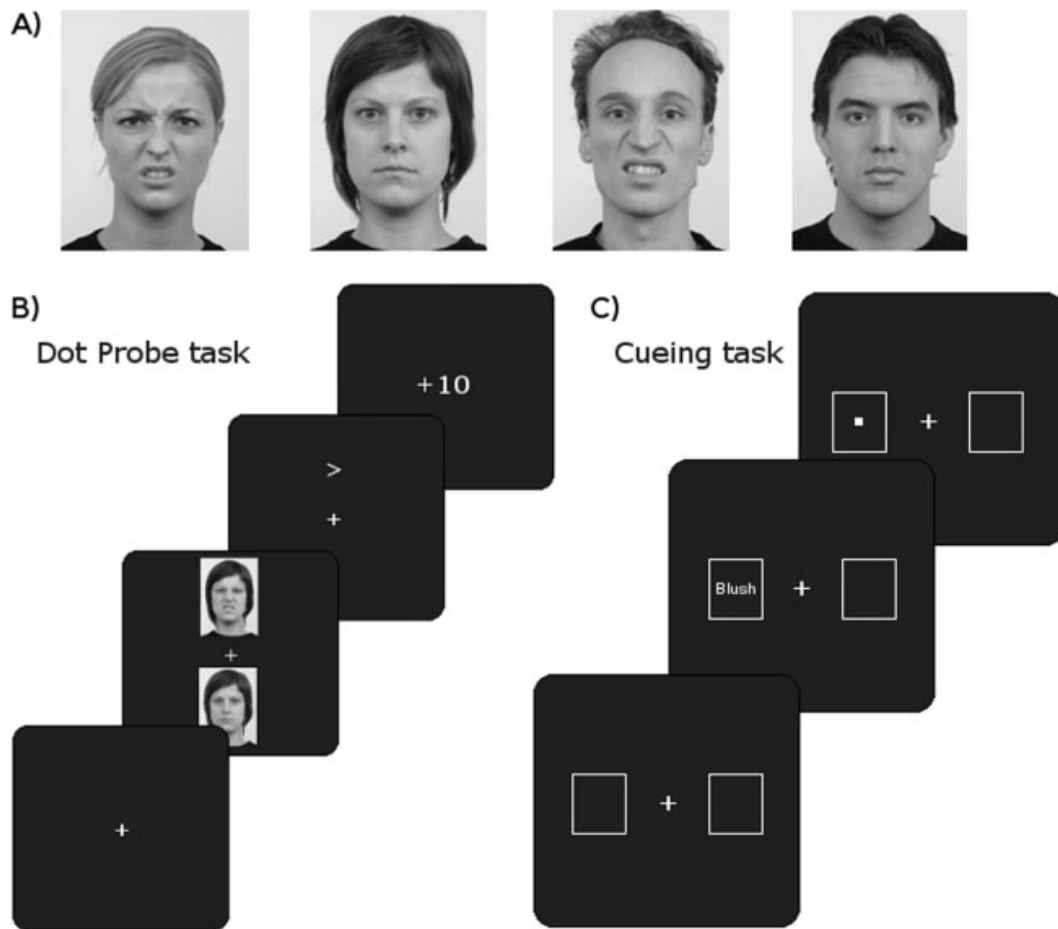


Figure 2. Examples of the faces used and the paradigms used to measure (Cueing task) and modify (Probe task) attention biases. (A) Four examples of faces, two of each gender and two with each expression (neutral or disgust). (B) The Probe task: Two faces were presented for 480 ms following initial fixation, followed by an arrow at one of the locations and an indication of points earned. (C) The Cueing task: A word cue was presented for 601 ms, immediately followed by the target at either the cued or uncued location.

presented either where the neutral or threatening face had appeared. Participants judged (by keypress) whether the arrow pointed to the left or right.

Auditory feedback on whether the answer was correct or incorrect was given at the end of each trial along with feedback on how many points the participant gained. The auditory feedback for high reward (10 points) was a high pitch “ka-ching” sound reminiscent of a slot machine sound but for low reward (1 point) a 65 HZ sinusoidal tone (duration 600 ms) was heard. For wrong answers (0 points) a 55 HZ sinusoidal tone was heard. Participants were told that the points represented monetary reward that would accumulate and they would receive in the form of a reduced fee for treatment.

Participants were randomly assigned to one of four different treatment conditions: (i) *ABM with high reward*, (ii) *ABM placebo with high reward*, (iii) *ABM with random reward* and (iv) *ABM placebo with random reward* (see Table 2). All correct answers were rewarded with 1 point (low reward) or 10 points (high

TABLE 2
The 2 × 2 design of the study

<i>Treatment condition</i>	<i>Target position</i>	<i>Reward level</i>
ABM + high reward	Target appears 75% of times behind a neutral face and 25% of times behind a threatening face	High reward: 75% of times target appears behind a neutral face (Low reward: 25% of times) High reward: 25% of times target appears behind a threatening face (Low reward: 75% of times)
ABM placebo + high reward	Whether target appears behind neutral or threatening face, is random	High reward: 75% of times target appears behind a neutral face (Low reward: 25% of times) High reward: 25% of times target appears behind a threatening face (Low reward: 75% of times)
ABM + random reward	Target appears 75% of times behind a neutral face and 25% of times behind a threatening face	Reward is random, not contingent on facial expression
ABM placebo + random reward	Whether target appears behind neutral or threatening face, is random	Reward is random, not contingent on facial expression

reward). The probability of high reward as a function of facial expression depended on which treatment condition participants were assigned to. In all treatment conditions, reward level and target position were *independently manipulated* so there was no contingency between ABM and reward resulting in all participants receiving approximately the same total reward.

Group cognitive behavioural therapy for social anxiety disorder. This group therapy consisted of 10 weekly two-hour sessions and a follow-up session four weeks later. Eight to 12 patients attend each group with two psychologists leading the sessions. The therapy is based on Clark et al.'s (2006) version of group treatment. It consists of psychoeducation about social anxiety and CBT, and the use of cognitive restructuring and behavioural experiments in social situations in and between sessions (Viðar, Ludvígsdóttir, Davíðsdóttir, Jónsdóttir, & Smári, 2011).

Attention bias measure. A modified cueing task (see Figure 2c) was used to measure attention bias using eight words (Icelandic), four socially threatening and four neutral words matched on length and appearance. Each trial started with the presentation of two white frames ($4.95^\circ \times 4.95^\circ$) at the left and right of fixation (centre of the square 4.5° from fixation). A cue, a neutral or threatening word, appeared in one of the frames 1100 to 1500 ms later (randomly determined) for 601 ms followed immediately by a small white square (30×30 arc

min) either in the cue frame (if the cue was valid) or in the opposite frame (when the cue was invalid). Participants judged (by keypress) whether the square appeared to the left or right.

Social anxiety measures. SAD symptoms were measured using the *Social Interaction Anxiety Scale* and the *Social Phobia Scale* (SIAS & SPS; Mattick & Clarke, 1998). Each scale comprises 20 items. Together they assess the main fears and avoidance behaviour of SAD, interaction fears (SIAS) and performance fears (SPS). The Icelandic translations have been shown to have good psychometric properties ($\alpha > 0.80$; Ólafsdóttir, 2012).

Procedure

Nineteen participants were recruited during the 10-week period of the GCBT, but eight participants were recruited after their last session. All participants underwent the computerized attention-training *Probe task* (214 trials) six times over a period of six weeks. In the beginning of the first and after the last experimental session, participants completed the *Cueing task* (160 trials) that measured their attention bias and SAD symptom severity was assessed with the SPS and the SIAS. Each session took 10–15 minutes.

RESULTS

Error trials and trials with response times ± 3 SDs for each participant were excluded from analyses.

Attention bias

Each participant's attention bias index was calculated based on the results from the cueing task, performed before and after the six-week attention-training period. Attention bias was indexed by differences in validity effects (shorter response times (RT) when the cue is valid) on threatening and neutral trials ($\text{Attention bias} = (\text{RT}_{\text{invalid threat}} - \text{RT}_{\text{valid threat}}) - (\text{RT}_{\text{invalid neutral}} - \text{RT}_{\text{valid neutral}})$). A positive attention bias index indicates delayed disengagement from threat and a negative attention bias index indicates avoidance of threat (Fox, Russo, Bowles, & Dutton, 2001). Changes in attention bias measured with the cueing task are presented in Figure 3. Participants' attention biases indices before and after the six week attention training period were assessed with a $2 \times 2 \times 2$ (ABM [training, placebo] \times Reward [high reward neutral, random] \times Time [pre, post]) mixed model analysis of covariance (ANCOVA) comparing the effects of ABM and reward on attention bias over time. To account for the different timepoints participants were recruited at (eight out of 27 after the last GCBT

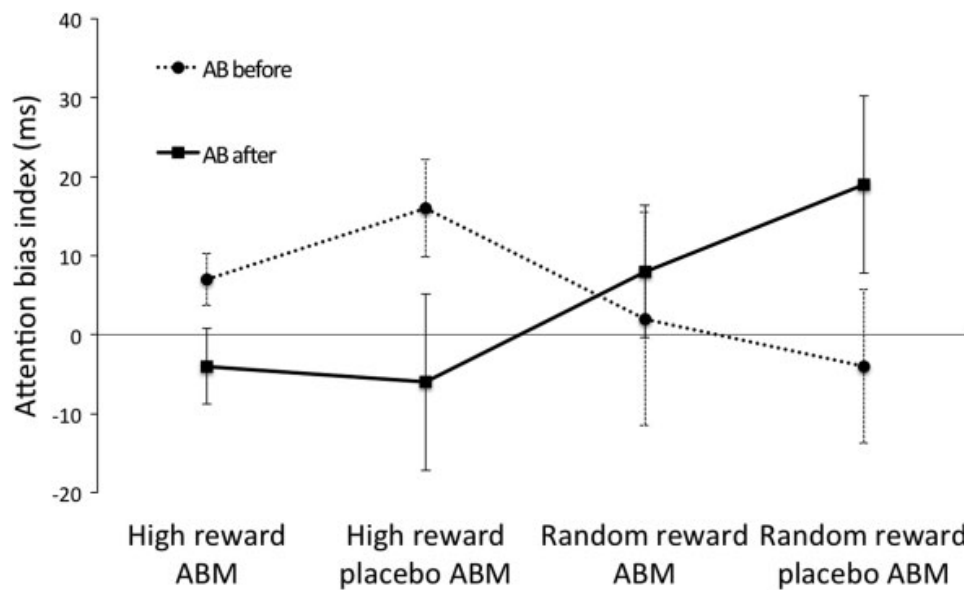


Figure 3. Attention bias (AB) before and after six week attention training for the four experimental groups. Attention bias index < 0 indicates avoidance of threat and > 0 indicates delayed disengagement from threat. Participants receiving training with high reward changed from having a severe threat focus to mild avoidance focus (Fox et al., 2001). Error bars show the standard errors of the mean.

session), the number of months from participants' final GCBT session until the first attention training session was included as a covariate. The ANCOVA results are shown in whole in Table 3, most importantly showing a strong Reward \times Time interaction, $F(1, 22) = 7.765$, $p = .011$, $\eta_p^2 = .261$. No other effects or interactions were significant. A follow-up analysis of the Reward \times Time interaction indicates that pre-training attention bias did not differ for participants receiving training with high reward for neutral stimuli and participants receiving random reward, $F(1, 25) = 1.763$, $p = .196$, $\eta_p^2 = .066$. Post-training attention biases in those same participants did, on the other hand, differ significantly, $F(1, 25) = 4.60$, $p = .042$, $\eta_p^2 = .155$. In sum, there were no effects of ABM training

TABLE 3

Results from a mixed model analysis of covariance comparing the effects of ABM and reward on attention bias over time

Source of variance	Sum of square	Mean square	F	df	p	η_p^2
Time	119.69	119.69	0.249	1	0.623	0.011
Time \times Time since GCBT	569.34	569.34	1.185	1	0.288	0.051
Time \times ABM	108.10	108.10	0.225	1	0.640	0.010
Time \times Reward	3730.45	3730.45	7.765	1	0.011	0.261
Time \times ABM \times Reward	1133.33	1133.33	2.359	1	0.139	0.097
Error	10568.92	480.41		22		

on participants' attention bias over and above the effects of GCBT. Reward, on the other hand, had a strong influence on attention biases toward threat. Participants receiving training with high reward changed from having a threat focus to a mild avoidance focus.

Social anxiety symptoms

Changes in social anxiety symptoms measured with SIAS and SPS are presented in Figure 4. Participants' combined scores of SIAS and SPS before and after the six-week attention-training period were subjected to a $2 \times 2 \times 2$ (ABM [training, placebo] \times Reward [high reward neutral, random] \times Time [pre, post]) mixed model analysis of covariance (ANCOVA) comparing the effects of ABM and reward on social anxiety symptoms over time. The number of months from participants' final CBGT session until the first attention training session was included as a covariate. The results showed a significant main effect of time ($F(1, 22) = 28.21, p < .01$) showing that social anxiety symptoms decreased during GCBT but no other effects or interactions were significant (the complete ANCOVA results are presented in Table 4). In sum, there was no effect of ABM training or reward on participants social anxiety symptoms over and above the effects of GCBT.

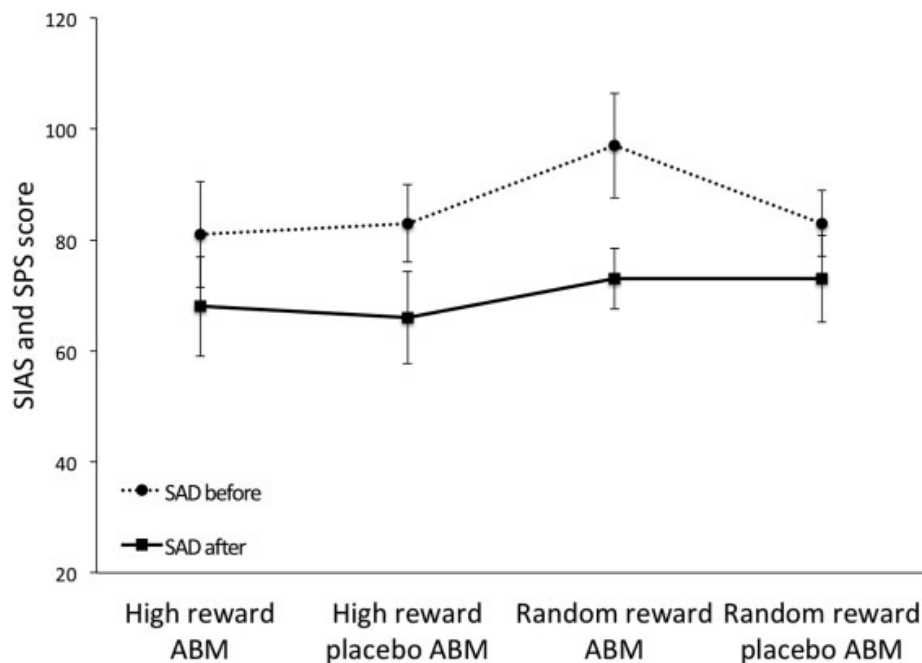


Figure 4. Combined SIAS and SPS score before and after the six-week training period in the four experimental groups.

TABLE 4
Results from a mixed model analysis of covariance comparing the effects of ABM and reward on social anxiety symptoms over time

<i>Source of variance</i>	<i>Sum of square</i>	<i>Mean square</i>	F	df	p	η_p^2
Time	3479.62	3479.62	28.213	1	0.000	0.562
Time × Time since GCBT	459.15	459.15	3.72	1	0.067	0.145
Time × ABM	21.84	21.84	0.177	1	0.678	0.008
Time × Reward	118.58	118.58	0.961	1	0.337	0.042
Time × ABM × Reward	4.47	4.47	0.036	1	0.851	0.002
Error	2713.35	123.33		22		

DISCUSSION

The results from this first study on using reward to modify dysfunctional attention in outpatients with social anxiety disorder are encouraging. Rewarding attention shifts to neutral stimuli significantly influenced attention biases towards threat. Participants receiving training with high reward changed from having a severe threat focus to a mild avoidance focus. This effect of reward over and above the modification effect of GCBT is notable because research has shown that attention biases in social anxiety patients can be greatly reduced by CBT (Lundh & Öst, 2001; Mattia, Heimberg, & Hope, 1993). These results also accord well with recent studies showing how efficiently reward modifies attention. Rewarding attention shifts with modest monetary reward can enhance attentional selection of neutral stimuli (see Chelazzi et al., 2013, for review). This enhancement transfers over time and to different stimuli and tasks. Our results suggest that computerized attention training using reward has the potential to alter psychopathological processes in anxiety to a greater degree than current treatment methods have been able to.

Reward did, however, not reduce social anxiety symptoms further than GCBT in outpatients with SAD. This is partly surprising in light of cognitive models of social anxiety that predict a relationship between attention bias and anxiety. However, the exact nature of the relationship between changes in attention bias and effects on social anxiety symptoms is still unclear. In our results there was no correlation between attention bias and SIAS and SPS score. This result, in the context of mixed results in ABM studies, may suggest two general points. Firstly the need for better measurement of attention bias and secondly a revision of the theoretical premises of ABM studies. In the literature on attention bias two types of attentional biases toward threat are usually assumed. The normal tendency people have to attend faster to negative facial expressions than other stimuli (Eastwood, Smilek, & Merikle, 2001; Fox, Lester, Russo, Bowles, & Dutton, 2000; Hodsoll, Viding, & Lavie, 2011) and a dysfunctional attention bias to threat proposed in cognitive theories of social anxiety (Clark & Wells, 1995;

Heimberg et al., 2010) that results in difficulties disengaging from threat (see Amir, Elias, Klumpp, & Przeworski, 2003). A socially anxious individual attends (just like anyone else) to potentially threatening stimuli, such as a grumpy looking clerk in the supermarket. Then depending on his interpretation of that stimuli (“He will say something rude and I will look stupid” vs. “He must be having a bad day”) dysfunctional attention bias is either activated or not. If the situation is interpreted as an imminent threat (“I will look stupid”) attention is shifted toward internal and external stimuli relating to the threat, increasing anxiety and inhibiting re-evaluation of the situation. According to this, the interpretation of imminent threat is necessary for the activation of dysfunctional attention biases. This raises the question of whether current ABM methods tap into the dysfunctional attention bias of socially anxious individuals. If the dysfunctional bias is not consistently activated by these methods, the results will likely vary. The fact that studies using ABM over the internet have all failed to show benefits for attention bias and social anxiety (Carlbring et al., 2012; Neubauer et al., 2013; Rapee et al., 2013) may reflect that attention biases are not activated since all the studies that have shown benefits have been conducted in the laboratory (Amir et al., 2009; Heeren et al., 2012; Schmidt et al., 2009). In future studies of attentional bias it is important to make certain that the methods used measure and modify dysfunctional attentional biases to threat.

ABM training with the probe paradigm did not affect participants’ attention bias or SAD symptoms beyond the effects of GCBT. There was no interaction between the probe attention training and reward indicating that reward did not enhance the effects of the probe attention-training task. We conclude that the modifying effect of reward is likely to be independent of the effects of the probe task manipulations. Since this study is the first to test ABM as an addition to CBT for adult anxiety patients in clinical settings, these findings may provide insights into the clinical relevance of current ABM methods. Our results add to the growing evidence that benefits of ABM through dot-probe training are unreliable (Bunnell et al., 2013). The results suggest that reward may be more powerful in ameliorating attention biases.

A limitation to this study is that initial attention bias was not completely matched between groups. It is possible that variations in pre-treatment bias affected the results since recent studies have shown that attentional bias is a moderating variable for changes in social anxiety scores (Amir, Taylor, & Donohue, 2011; Kuckertz et al., 2014). The omission of attention bias towards threat in inclusion criteria and sometimes no measurement of changes in attention bias (Bunnell et al., 2013) in studies aiming to investigate amelioration of biases may partly explain the lack of ABM benefits in many studies. Furthermore, participants entered the study at different time points, which may have affected the findings. Undergoing attentional training may be more beneficial at the beginning of therapy than after it, since reducing the attention bias might help patients make better use of the GCBT. However, since we

controlled for time since the GCBT ended in all analyses, this is unlikely to account for our results. We finally note that we had limited statistical power for between-groups analyses. Nonetheless, reward was found to modulate attentional biases. We note importantly that the current results need to be independently replicated in future studies.

CONCLUSIONS

While there are certainly limitations to this initial study, our results suggest that financial reward during attention shifts can be used to modulate attention biases and that such effects may dwarf any effects of traditional dot-probe ABM. This may have strong implications for the future treatment of anxiety symptoms, and further underscores the strong effects rewards have on attention.

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