Trained interpretive bias survives mood change

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Evidence is accumulating that interpretations can be trained using Cognitive Bias Modification procedures (CBM). The effects are replicable, stable over time and there is some evidence of generalizability. As a next step in determining the boundaries of the CBM model, the present experiment was designed to test whether modified interpretative style endures fluctuations in mood. Participants were trained to interpret ambiguous scenarios in either a positive \((n = 42)\) or negative \((n = 40)\) way. Then, participants were exposed to either a positive \((n = 41)\) or negative \((n = 41)\) mood induction procedure to change their current mood state. Results showed that the modified interpretive bias did not change in reaction to a mood change. That is, differences in interpretation of new ambiguous information were related to the interpretative bias modification procedure and not to the current mood state.

\begin{itemize}
\item 1. Introduction
\end{itemize}

A robust association has been revealed between anxiety and a negative interpretive bias when processing ambiguous information. The development of novel experimental techniques enabled the testing of the causal status of this interpretive bias by directly manipulating the bias and then assessing subsequent effects on anxiety (Mathews & MacLeod, 2002). Mathews and Mackintosh (2000) showed that negative interpretations have a causal influence on anxiety. Non-anxious individuals read ambiguous social scenarios that ended with a word fragment and solution of that fragment disambiguated the scenario in either a positive or negative direction. Results showed that the modification of interpretations was successful. Crucially, the modified interpretive bias affected anxiety; compared to the positively trained group, the negatively trained group became more anxious over the course of training.

Results from these computerized Cognitive Bias Modification (CBM) procedures that target the interpretation of ambiguous information (CBM-I) proved to be robust and replicable (Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Salemink, van den Hout, & Kindt, 2007; Yiend, Mackintosh, & Mathews, 2005). Effects have been extended to effects on emotional reactivity; the acquired more positive interpretive style protected against worsening of mood following a stress task (Wilson, MacLeod, Mathews, & Rutherford, 2006) or negative mood induction procedure (Holmes, Lang, & Shah, 2009). Furthermore, studies have shown that the CBM-I effects are not short-lived but endure at least for 24 h after a single training session (Mackintosh et al., 2006; Yiend et al., 2005) and at least a week after four sessions training (Mathews, Ridgeway, Cook, & Yiend, 2007). CBM-I effects survive changes in environmental context, including change in room, experimenter and setting (Mackintosh et al., 2006). It has been shown that CBM-I generalizes from a computer program to a paper and pencil task (Mathews & Mackintosh, 2000) and CBM-I directed at social functioning generalized to academic performance (Salemink, van den Hout, & Kindt, in press).

Results regarding cross-task transfer (generalization from a CBM-training task to another assessment task) are however mixed. Hertel, Mathews, Peterson, and Kintner (2003) showed that the modification of interpretive bias using a homograph-relatedness induction procedure affected later mental imagery. Participants had to judge the semantic relatedness of two words; a valenced word (positive or negative depending on the assigned modification condition) and a homograph. Homographs are words with multiple meanings and allow for the testing of interpretations. The effect of modification was evident on another task in which participants had to form a mental image of a given homograph.

In contrast, no effects of the scenario-based training were observed on an implicit measure of interpretive bias (Salemink et al., 2007). Following training, an Extrinsic Affective Simon Task (EAST) was presented that could indirectly assess interpretations by measuring the interference between valence and colour classifications. Participants learn to associate one response key (e.g., left) with positive words and another response key (e.g., right) with
negative words. Then they learn to associate a colour (e.g., green) with the left key and another colour (e.g., blue) with the right key. In the crucial trials, homographs are presented in colour. Results did not support the prediction that positively trained participants would be faster in responding to homographs in the green colour (positive key) than in the blue colour (negative key). Also, no effects of training were evident on an open-ended questionnaire (Salemink et al., 2007); participants did not differ in self-generated interpretations written down in response to ambiguous short descriptions. Nor were differences between training conditions observed in responses to ambiguous film fragments (Salemink et al., in press). Film fragments involved an actor or actress who approached the camera and commented on some aspects of the individual’s belongings in an ambiguous way. In general, the effects of CBM-I on interpretive bias, mood and emotional vulnerability seem reliable, they seem to survive the passage of time, whereas the evidence regarding transfer of bias to other tasks seems somewhat mixed.

Note that mood affects the interpretation of ambiguous affairs. Outcome studies for example demonstrated that reductions in anxiety following therapy are associated with reductions in negative interpretive bias. The negative interpretive bias that was evident in patients with a generalized anxiety disorder was no longer seen in recovered patients; the latter group was no longer different from the non-clinical controls (Eysenck, Mogg, May, Richards, & Mathews, 1991). Reduced threatening interpretive bias after therapy was replicated in a group of patients with social phobia (Franklin, Huppert, Langner, Leiberg, & Foa, 2005); However, as treatments have served to reduce the bias directly, a more controlled way to examine the influence of mood on information processing is manipulating mood state and examining the effects on interpretive bias. Richards, Reynolds, and French (1993) exposed high- and low trait anxious individuals to a mood manipulation procedure and found that anxious mood (independent of trait-anxiety) produced a bias toward disambiguating homophones in a threatening way (but see Blanchette and Richards (2003) for only an indirect effect of state anxiety on interpreting ambiguous information). The direct effect of mood state was replicated later; it was shown that a more general negative mood state, as opposed to the specific anxious mood state, can also influence the resolution of ambiguity in an affect-congruent way (Halberstadt, Niedenthal, & Kushner, 1995). Thus, current mood state is able to affect interpretations. The question that ensues from these findings is whether the changes in interpretive style induced by CBM-I would survive a change in mood state, then the pattern of interpretations would reflect differences between the CBM-I conditions. Alternatively, the mood induction procedure might wipe out CBM-I effects and might even overrule them. A third possibility is that mood state might interact with the acquired interpretive bias. That is, mood induction consistent with the valence of CBM-I could amplify the effects of training, while inconsistent mood induction could undermine the effects of training. Finally, we will explore whether CBM-I protects against a mood change in the opposite direction; whether a positive mood induction procedure is less effective in negatively trained participants than in positively trained participants, and vice versa.

2. Method

2.1. Participants

Participants were selected according to their trait-anxiety scores on the State-Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). To obtain a group with an average anxiety level, students with a score between the 25th and 75th percentile were invited to participate. A total of 82 students (75 female/7 male) took part in the present study for course credit or small remunerative reward. Their mean age was 21.1 years (SD = 2.5). Participants were randomly allocated to either the positive CBM-I/positive mood induction condition (n = 21, STAI trait M = 36.6, SD = 4.8), positive CBM-I/negative mood induction condition (n = 21, M = 36.8, SD = 4.8), negative CBM-I/negative mood induction condition (n = 20, M = 36.0, SD = 4.6), or negative CBM-I/positive mood induction condition (n = 20, M = 35.2, SD = 3.9). Participants did not differ significantly regarding trait-anxiety, Fs < 1.2.

2.2. Materials

2.2.1. CBM-I

The scenarios used in the experiment were Dutch translations of those used by Mathews and Mackintosh (2000). During CBM-I, eight blocks of 13 scenarios were presented on a personal computer, with an option for rest given after each block. Each block contained eight modification scenarios, three filler scenarios, and two probe scenarios. Participants were instructed to imagine themselves in the situations. The modification scenarios were created to train participants to make emotional interpretations of a particular valence. Each modification scenario consisted of three lines that were ambiguous in terms of valence. The final word of the scenario was presented as a word fragment and disambiguated the scenario, whose meaning had remained ambiguous until this point. Participants were instructed to press a spacebar when they felt they knew what the word was, and then to press the key corresponding to the first missing letter. This ensured that the time taken to respond to the word was not contaminated by variance in the time taken to locate the correct letter key. In the positive CBM-I condition the scenarios would have a positive outcome and in the negative condition a negative outcome. Following the solution of the word fragment, a comprehension question with relevant feedback appeared on the screen to reinforce the interpretation imposed by the word fragment. An example of a modification scenario, with the word fragment for each training condition in parentheses, is as follows:
You are at a course that your company have sent you on. Your tutor asks each member of the group to stand up and introduce themselves. After your brief presentation, you guess that the others thought you sounded shy (shy)/confident (confident).

Then the comprehension fragment followed:

Did you feel dissatisfied with your speech?

The filler scenarios had no emotional content, nor did they contain any ambiguity. They were inserted to make the CBM-I procedure less obvious.

2.2.2. Test of interpretive bias (a): reaction times

During the training procedure, change in interpretation style was being measured with probes. Probe scenarios consisted of one negative and one positive probe per block, resulting in a total of eight negative and eight positive probes. The speed of resolving those probe word fragments was the dependent measure.

2.2.3. Test of interpretive bias (b): recognition test

After the mood induction procedure, interpretation style was assessed with a recognition task. Ten ambiguous recognition test items were presented in the same way as the training items, except that each scenario had a title and was presented in a uniquely identifiable context, following Mathews and Mackintosh (2000). To maximize the resemblance of these items to those presented in the training phase, participants once again were required to solve a word fragment and to answer a comprehension question. However, the valence of the scenario now remained ambiguous.

In the second part of the recognition test, participants saw the title of the ambiguous scenario, this time together with four interpretations of the scenario. These interpretations represented a possible positive interpretation, a possible negative interpretation, a positive foil sentence, and a negative foil sentence. Participants rated each sentence independently for its similarity in meaning to the original scenario. A 4-point scale was used, ranging from 1 (very different in meaning) to 4 (very similar in meaning).

2.2.4. Filler task

As CBM-I is associated with change in anxiety, a 3 min break was inserted between CBM-I and the mood induction procedure to reduce possible changes in anxiety. In the break, participants completed a filler task consisting of exercises from the Wechsler Vocabulary subtests (Wechsler, 1981) until they heard a short beep after 3 min, which signalled the end of the filler task and resumption of the computer experiment.

2.2.5. Mood induction procedure

To induce mood changes, participants were asked to listen to music, presented through head phones, for 7 min and to try to focus on a time or event in their lives when they felt sad or happy (depending on the positive or negative mood induction condition). This procedure of focusing on past events while listening to music has proven its superior effectiveness in affecting mood (Van der Does, 2002). Participants in the negative mood induction condition received ‘Lux aeterna’ by Yong Lygeti and ‘La primavera’ by Antonio Vivaldi was presented in the positive mood induction condition. Furthermore, participants were told that they could probably easily prevent or counter any effects of the music, but they were asked to allow the effects to happen and to enter the mood state.

2.2.6. Mood assessment

Directly before and after the mood induction procedure, participants gave three ratings of their current positive mood (happy, cheerful, and general positive mood state) and of current negative mood (sad, tense, and general negative mood state). Computerized visual analogue mood scales (VAS) were used with the following anchor points: not at all (0) and extremely (100). The scale consisted of a 15-cm horizontal line and participants could indicate their mood with a mouse click on the line.

2.3. Procedure

Upon entrance of the lab, participants were informed about the procedure and written informed consent was obtained. Participants were placed behind a computer in a separate cubicle and specific instructions were provided on the screen.

The computer program presented the STAI trait questionnaire first. Then participants were randomly assigned to either the positive CBM-I condition or the negative condition. The main task was preceded by five practice scenarios with a neutral content. After a break of 3 min in which the filler task was performed, participants indicated their present mood state on six computerized visual analogue scales, which was followed by the mood induction procedure. Participants listened for 7 min to a music fragment and focused either on a happy or on a sad memory. This was followed by the second assessment of present mood state with the analogue scales. Finally, the recognition task was presented. At the end of testing, participants were debriefed. The whole session took approximately 70 min.

3. Results

3.1. Test of interpretive bias (a): reaction times

Regarding accuracy, participants in the positive and negative CBM-I group did not differ significantly in the percentage of incorrect responses to probe word fragments, $t(80) = 1.13$, ns ($M_{pos} = 4$, $SD = 1.6$ vs. $M_{neg} = 9$, $SD = 2.3$) nor to comprehension questions in the probe trials, $t(80) = 1.32$, ns ($M_{pos} = 6.0$, $SD = 5.8$ vs. $M_{neg} = 4.4$, $SD = 4.9$). Reaction time data were set aside if the response to the probe word fragment or the corresponding comprehension question was incorrect, or if the latency was less than 200 ms (.08%) or greater than three SDs above the overall mean of all participants (cut-off = 3529 ms; 2.4%). To test whether the CBM-I procedure was effective in influencing interpretations, a $2 \times 2$ mixed model ANOVA was performed on the reaction time data with group (positive vs. negative CBM-I) as the between-subjects factor and probes (positive vs. negative) as the within-subject factor. Results revealed the predicted Group × Valence interaction effect, $F(1, 80) = 9.2, p < .01$, $\eta_2^2 = .10$. This interaction was decomposed by separate paired sample t-tests comparing positive and negative interpretations within each CBM-I condition. This indicated that participants trained to interpret information positively were significantly faster to complete positive ($M = 1303$ ms, $SD = 281$) than negative probe fragments ($M = 1398$ ms, $SD = 290$), $t(41) = -2.6, p < .05, d = .33$, and showed a trend for negatively trained participants to complete negative fragments ($M = 1380$ ms, $SD = 316$) faster than positive probe fragments ($M = 1453$ ms, $SD = 349$), $t(41) = 1.8, p = .09, d = .22$. Thus the CBM-I procedure was effective in modifying interpretations.

3.2. Mood induction

To obtain a score for positive and negative affect, the three positive subscales were averaged and the same was done with the three negative subscales. To examine the effectiveness of the mood induction procedure in affecting mood, a $2 \times 2$ (Mood induction) × 2 (Time: before vs. after the mood induction procedure) mixed model ANOVA was carried out for both positive and negative emotions separately (see Fig. 1).
For positive emotions, this analysis revealed a main effect of mood induction group, \( F(1, 78) = 30.5, p < .001, \eta^2_p = .28 \), indicating a more positive mood state in the positive mood induction group compared to the negative mood induction group. Furthermore, a Mood induction \( \times \) Time interaction effect was observed, \( F(1, 78) = 168.5, p < .001, \eta^2_p = .68 \). This effect was followed up by pairwise comparisons within each mood induction group. Results indicated that participants in the positive mood induction group became significantly more positive (\( M_{pre} = 56.8, SD = 16.3; M_{post} = 72.7, SD = 15.8 \), \( t(40) = -8.1, p < .001, d = .99 \), and the negative mood induction group became significantly less positive (\( M_{pre} = 57.0, SD = 14.3; M_{post} = 38.0, SD = 14.6 \), \( t(40) = 10.3, p < .001, d = 1.31 \). The effectiveness of the mood induction procedure did not interact with CBM-I training condition, \( F(1, 78) = .08, p = .78, \eta^2_p = .001 \).

The \( 2 \times 2 \times 2 \) mixed model ANOVA was also performed for negative emotions and revealed a main effect of mood induction group, \( F(1, 78) = 30.5, p < .001, \eta^2_p = .28 \), indicating that participants in the negative mood induction group felt more negative than participants in the positive mood induction group. The main effect was qualified by a significant Mood induction \( \times \) Time interaction effect, \( F(1, 78) = 97.7, p < .001, \eta^2_p = .56 \). Post-hoc analyses indicated that participants in the negative mood induction condition became significantly more negative (\( M_{pre} = 29.7, SD = 14.0; M_{post} = 45.4, SD = 14.0 \), \( t(40) = -7.2, p < .001, d = 1.12 \), while participants in the positive mood induction condition became significantly less negative (\( M_{pre} = 32.3, SD = 16.3; M_{post} = 18.6, SD = 14.9 \), \( t(40) = 6.9, p < .001, d = .95 \). Again the three-way interaction effect \( CBM-I \times \) Mood induction \( \times \) Time was not significant, \( F(1, 78) = .01, p = .95, \eta^2_p = .001 \).

In sum, results showed that the mood induction procedure was successful in modifying mood; congruent change in mood was observed. No differences in mood change were found between the positive and negative CBM-I group, suggesting that the mood induction was equally effective in both groups.

### 3.3. Test of interpretive bias (b): recognition task

To examine interpretations following the mood induction procedure, a \( 2 \times 2 \times 2 \times 2 \) mixed model ANOVA was conducted on the recognition test data with CBM-I and mood induction as between-subjects variables and valence (positive vs. negative sentences) and target (possible vs. foil sentences) as the within-subject variables. This analysis revealed a main effect of valence, \( F(1, 78) = 9.2, p < .01, \eta^2_p = .11 \), and target, \( F(1, 78) = 816.3, p < .001, \eta^2_p = .91 \), reflecting, respectively, greater endorsement of positive and possible interpretations. Furthermore, the CBM-I \( \times \) Valence interaction effect was significant, \( F(1, 78) = 38.9, p < .001, \eta^2_p = .33 \). These effects were qualified by a significant CBM-I \( \times \) Valence \( \times \) Target interaction effect, \( F(1, 78) = 6.6, p = .01, \eta^2_p = .08 \) (see Fig. 2). This interaction was decomposed by separate paired sample t-tests comparing positive and negative responses within the two CBM-I groups for possible interpretations. For positively trained participants, this analysis indicated that they interpreted information as significantly more positive (\( M = 3.05, SD = .40 \)) than negative (\( M = 2.35, SD = .53 \), \( t(41) = 6.0, p < .001, d = 1.49 \). In addition, negatively trained participants interpreted information as significantly more negative (\( M = 2.89, SD = .50 \)) than positive (\( M = 2.64, SD = .43 \), \( t(39) = 2.1, p < .05, d = .54 \)). Effects involving the factor mood induction were not significant, \( (Mood \ induction \ \times \ Valence, F(1, 78) = .68, p = .41, \eta^2_p = .009 \). and Mood induction \( \times \) CBM-I \( \times \) Valence, \( F(1, 78) = 1.12, p = .27, \eta^2_p = .015 \), indicating that temporary mood states were not related to interpretations.

### 4. Discussion

As expected, CBM-I was successful in modifying interpretive bias. The positive CBM-I group solved positive word fragments faster than the negative fragments, and the negative CBM-I group tended to show the reverse pattern of faster responses to negative fragments compared to positive fragments. These findings converge with earlier studies that showed the effectiveness of CBM-I in affecting interpretations (e.g., Yiend et al., 2005).

The central aim of the study was to examine whether changes in mood affect the new interpretive style. It did not. Following the mood induction procedure, participants who had received the positive interpretive bias training still interpreted new ambiguous information more positively than negative, whereas participants who had received the negative interpretive bias training still interpreted ambiguous information more negative than positive. While earlier studies showed effects of mood on the interpretation of ambiguous information (Halberstadt et al., 1995; Richards et al., 1993), in the present study CBM-I might have overruled the effects of the mood induction procedure on interpretations.

Regarding the effectiveness of the mood induction procedure, no differences were observed between the positive and negative CBM-I conditions in mood change. That is, the mood induction
procedure was equally effective in the positive and negative CBM-I condition and CBM-I did not protect against a mood change in the opposite direction. This seems to contrast with earlier findings where positive CBM-I protected against a negative mood induction (Holmes et al. 2009). All their participants were trained to interpret ambiguous scenarios in a positive way. To induce a negative mood following training, participants read negative self-statements and listened to depressing music. It was shown that following imagery training (imagine the scenario resolutions) sad mood increased less than following verbal training (think about the verbal meaning).

The absence of CBM-I effects on the mood induction procedure in the present study might be due to less use of imagery. In the present study, although participants received instructions to imagine themselves in the described situations, imagery was not practiced beforehand, nor assessed (and thus not reminded) after every trial, as was done in the Holmes et al. study. It seems that creating a central role for imagery would be relevant to obtain protection from later mood deterioration.

However, other explanations might be possible as well and these will be discussed for both the lack of CBM-I effects on mood induction and the lack of mood effects on the processing of ambiguous information. First, absence of effects might be due to (a lack of) transfer-appropriate processing (Hertel, 2002). In the current study, there is no match between task formats; CBM-I training consists of attending to the positive (or negative) meaning of ambiguity, while the mood induction procedure consisted of listening to music and recalling a specific happy or sad experience. This latter task does not contain much ambiguity. As a result, there might have been not enough room for the trained interpretive bias to exert its influence. In addition, the mood induction procedure and the interpretive bias test task (disambiguating social scenarios) do not match either. This might have hampered transfer-appropriate processing and reduced the potential impact of mood on interpretations. Furthermore, previous research has revealed domain-specificity in processing biases (Bar-Haim, Lamy, Bergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007).

The lack of CBM-I effects on mood induction and the absence of mood effects on interpretations might be due to a potential mismatch between depression-related mood induction and anxiety-related interpretive bias tasks. Future research is necessary to critically test the role of different factors that seem to be related to effects of CBM-I on mood and information processing (see also Hopitt, Mathews, Veldman, & Mackintosh, 2009).

Another possibility is that the changes in affective state might have been too mild. When compared to two other relevant mood induction studies, the percentage change in negative mood measured with a VAS scale following a negative mood induction procedure was similar (Holmes et al., 2009: 15.6%, Van der Does, 2002: 15.3 %, the present authors: 15.8%). This indicates that the studies were comparable and that the lack of mood effects on interpretive bias is unlikely due to an ineffective mood induction procedure.

Finally, lack of mood effects on interpretations could potentially be due to problems with the power. Examination of the size of the mood effects on interpretation within each CBM-I condition (Cohen, 1998) revealed a moderate effect size in the negative CBM-I group (d = .54), however a small effect in the counterintuitive direction was found in the positive CBM-I group (d = .11), indicating that within this latter group participants with a more negative mood state interpreted ambiguity slightly more positive than participants with a more positive mood state. Thus, no clear-cut effects of mood on interpretations were found following training within each CBM-I group. Examination of the direct effect of mood on interpretations (regardless of CBM-I condition), revealed a small difference between the mood induction groups in endorsing positive interpretations (d = .14) and in endorsing negative interpretations (d = .21). Given a conventional alpha level of .05 and statistical power of .80, then 393 participants are necessary to detect this small difference in interpretation between the mood induction groups. It seems that the effects of mood on interpretations following CBM-I are mixed and small in size.

The current study demonstrated that modified interpretive bias persists after a change in mood. Future research examining these processes in high trait anxious individuals or patients with an anxiety disorder is needed for theoretical and clinical reasons. It will be important theoretically to examine whether the same effects can be observed in a sample with elevated levels of emotional vulnerability as the interaction between trait and state aspects plays an important role in cognitive models of emotion (Williams, Watts, Macleod, & Mathews, 1997). A negative mood state elicits a vigilant processing mode in vulnerable individuals (in which threatening information is selectively processed), while such a negative mood state results in the maintenance of the avoidant processing mode in less vulnerable individuals. As mid range anxious individuals participated in the present study, it would be informative to examine the influence of mood state on the modified interpretive bias in high anxious individuals. Should CBM-I be used clinically, then it will be important to determine whether the acquired more positive interpretive bias style in anxious patients survives such a negative mood state.

There is encouraging evidence that interpretations can be trained using computerized bias modification procedures. Anxious individuals could follow such a procedure to learn to interpret information in a more positive way. For long-term clinical effects, the acquired more benign interpretive bias must be able to survive temporary decreases in mood that are present in the real world. The present study shows that, when a negative mood state occurs the modified interpretive bias persists.

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References


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