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Interpretation Training Influences Memory for Prior Interpretations

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Anxiety is associated with memory biases when the initial interpretation of the event is taken into account. This experiment examined whether modification of interpretive bias retroactively affects memory for prior events and their initial interpretation. Before training, participants imagined themselves in emotionally ambiguous scenarios to which they provided endings that often revealed their interpretations. Then they were trained to resolve the ambiguity in other situations in a consistently positive (n = 37) or negative way (n = 38) before they tried to recall the initial scenarios and endings. Results indicated that memory for the endings was imbued with the emotional tone of the training, whereas memory for the scenarios was unaffected.

Keywords: cognitive bias modification, interpretation bias, memory, anxiety

Although anxious individuals are disproportionately fast in detecting threatening stimuli and tend to interpret ambiguous events in a threatening manner (Mathews & MacLeod, 1994), evidence regarding anxiety-related memory biases is rare (MacLeod & Mathews, 2004). Recently, experiments by Hertel, Brozovich, Joormann, and Gotlib (2008) revealed memory biases in social anxiety by viewing them through the lens of interpretation biases. Individuals with generalized social phobia and controls first interpreted ambiguous yet potentially threatening social scenarios by formulating an ending to each one. Later they were asked to recall the scenarios and their endings. Compared to controls, socially anxious participants interpreted the scenarios more negatively, and their subsequent recall attempts reflected the meaning of those negative interpretations.

In a related, but initially separate development, the study of interpretation bias has taken a different direction as researchers have sought to establish causal connections between cognitive and emotional aspects of anxiety. By guiding the direction of resolving ambiguity, it is possible to modify bias and then examine the effects of this modification in subsequent tasks. These procedures are generally termed cognitive bias modification of interpretation (CBM-I), and they have successfully simulated findings of interpretation biases in anxious populations (Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Mathews & Mackintosh, 2000; Salemink, van den Hout, & Kindt, 2007; Yiend, Mackintosh, & Mathews, 2005). As might be expected, there have even been a few successful attempts to apply this CBM-I technique to the study of memory biases (Hertel, 2004; Tran, Hertel, & Joormann, 2010). These experiments trained participants to interpret ambiguity in a benign or negative way and examined transfer to memory processes. Results revealed that people can be trained, whether by idiosyncratic experience or experimentally, to remember subsequently encountered events in emotionally slanted ways. In this sense, both Hertel and Tran et al. trained proactive biases in memory.

In the present study, we examined whether trained interpretation bias also influences memory for ambiguous events in a retroactive fashion. When people become anxious, do they reflect back on preanxiety experiences and recall them in ways that are biased by their current state? Based on the method of revealing memory biases used by Hertel et al. (2008) the experiment consisted of three phases. In the first phase, participants listened to descriptions of 16 ambiguous social scenarios, each time providing their own endings. In the second phase, interpretative style was modified with Mathews and Mackintosh's (2000) interpretation bias training for 104 scenarios, irrelevant to those in Phase 1. The third phase consisted of the memory tests (as well as a subsequent check for interpretation bias). With this design we aimed to simulate real-world situations in which memory for prior events is changed as a consequence of developing an anxiety disorder. In a manner analogous to effects of misleading information on memory for previous reactions (Hertel, 1982), we predicted that participants who were trained to make negative interpretations would recall their previous interpretations as more negative than would participants trained to make more benign or positive interpretations. The prediction regarding memory for the scenarios themselves was less

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clear. Tran et al. (2010) found that CBM-I conducted prior to the to-be-remembered scenarios caused emotionally consistent intrusions in recall. Yet, the results of Experiment 2 by Hertel et al. (2008) suggested that such intrusions arose from imagery processes operating during initial interpretations (see Hirsch, Clark, & Mathews, 2006). From the latter perspective, our training procedures should not affect recall of scenarios encountered earlier.

Methods

Design

The experiment involved three main phases: encountering the to-be-remembered scenarios (TBRS), experiencing CBM-I, and responding to the memory and interpretation bias tests. Because CBM-I is associated with change in anxiety (Mathews & Mackintosh, 2000), a 3-min filler task was inserted between the training and subsequent testing to allow anxiety to return to baseline. State anxiety (STAI, Van der Ploeg, Defares, & Spielberger, 2000) was measured before CBM-I and after the filler task. Figure 1 illustrates the procedure.

Participants

Students (56 female and 19 male) participated for course credit or 10 Euros. They were randomly allocated to either positive CBM-I ($n = 37$) or negative CBM-I ($n = 38$). At the outset, the groups did not differ significantly in state anxiety, $p = .82$ ($M_{\text{pos}} = 35.8$, $M_{\text{neg}} = 36.1$).

Materials

Phase 1. The TBRS consisted of eight ambiguous social and eight nonsocial (filler) scenarios, translations of those used by Hertel et al. (2008, Experiment 2). An example follows:

> You are with a group of new friends at a local pub.
>
> You start to tell a joke you heard recently, and everyone looks at you.
>
> Their expressions change when you get to the punch line.

Phase 2. CBM-I scenarios were based on those used by Mathews and Mackintosh (2000) and revised to reflect student situations (Salemink et al., 2007; Salemink, van den Hout, & Kindt, 2009). Each of eight blocks contained eight initially ambiguous modification scenarios, three nonemotional and nonambiguous filler scenarios, one positive probe, and one negative probe. In each modification scenario, the final sentence contained a word fragment that disambiguated meaning in a consistently positive or negative direction according to condition. The two probes in each block were similar to the modification scenarios but ended in a fragmented word with fixed positive or negative valence, irrespective of CBM-I condition.

Phase 3. A booklet of 10 additional ambiguous scenarios—one per page—described student-related social situations. Again, the scenario endings contained word fragments, however this time the meaning remained ambiguous. In a second booklet, the title of each scenario was presented together with four versions of the original final sentence. The set included a possible positive interpretation, a possible negative interpretation, a positive foil sentence, and a negative foil sentence. The order within the set was randomized for each title and fixed across participants. (For examples see Mathews & Mackintosh, 2000).

Procedure

The session purportedly contained two separate experiments that focused on attention and concentration. To increase the distinction between phases, we presented each TBRS in Phase 1 aurally via headphones while showing the title against a blue background on the monitor. Participants were asked to imagine themselves as the central character and to generate at least one additional sentence. These endings were said aloud into a microphone and recorded. The experimenter remained in the room during three practice trials. Then the 16 TBRS were presented in a fixed random order.

Phase 2 was disguised as a separate experiment; participants filled out the STAI/state before three practice trials and eight blocks of CBM-I. All scenarios were presented visually in black font on a white background. Participants viewed each text, line by line, at a rate that was self-paced by spacebar press. In the final sentence a space for the missing word was filled by its fragment upon another press. Participants completed the fragment and consequently disambiguated the emotional meaning of the scenario. Then a comprehension question appeared; participants pressed Y for *yes* and N for *no*, and received feedback (*correct* vs. *wrong answer*). Following CBM-I, we administered exercises from the Wechsler Vocabulary subtests (Wechsler, 1981) for 3 min and a second STAI/state.

In Phase 3, participants were surprised by a request to remember the initial scenarios and the endings they invented. To cue recall, each title was again displayed against a blue background, with the first sentence simultaneously presented over headphones. Participants attempted to recall aloud the remaining two sentences. Then, after pressing the space bar, they were visually prompted to recall

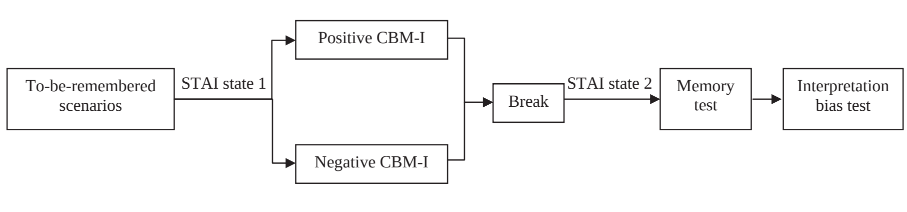

Figure 1. Overview of the experimental design and procedure.

their own ending. The memory test was followed by the interpretation test. In the first booklet participants completed the word fragment to end each scenario. In the second booklet they rated each sentence for its similarity in meaning to the original scenario by using a 4-point scale ranging from 1 (*very different in meaning*) to 4 (*very similar in meaning*).

Coding and scoring procedures. Two raters, blind to CBM-I allocation, coded the audio recordings from the first and third phase. Endings from Phases 1 and 3 were coded as negative (−1), neutral (0), or positive (1); κ averaged across scenarios was .83 in Phase 1 and .79 in Phase 3. We also scored the number of social TBRS that contained intrusions (0–8) and the valence of those intrusions (averaged across the eight social scenarios). A recalled scenario was scored as containing an intrusion if there were any terms that had not been presented originally (average $\kappa = .70$). Raters coded intrusion valence as belonging to one of the three categories (average $\kappa = .81$). Averaged valence scores ranged from −1 to + 1.

Results

The emotional valence of initial and remembered endings, together with the nature of intrusions in scenario recall, constitute the main categories of dependent measures. These outcomes are described first and followed by reports of evidence for training effects. For all analyses, the significance level was set at .05.

Memory for Initial Interpretations

We evaluated the effects of CBM-I on memory for the emotional quality of the participant-supplied endings in Phase 1 by using a Group-by-Phase mixed-design ANOVA.[1]

There was a significant main effect of group, $F(1, 67) = 7.58$, $p < .01$, $\eta^2_p = .10$, indicating that overall positively trained participants produced more positive interpretations than negatively trained participants. However, this effect was qualified by a significant Group × Phase interaction $F(1, 67) = 7.89$, $p < .01$, $\eta^2_p = .11$. The finding that the change in valence across phases depended upon training is shown in Figure 2. Although the groups' valence scores did not differ before training, $t(67) = 1.4$, $p = .17$ ($M_{pos} = 0.15$, $SD = 0.21$; $M_{neg} = 0.07$, $SD = 0.24$), they differed significantly afterward, $t(67) = 3.33$, $p < .001$. Positively trained participants remembered their endings as having been more positive ($M = 0.25$, $SD = 0.29$), compared to those in the negative group ($M = 0.02$, $SD = 0.28$). Thus, interpretation training influenced memory for prior interpretations of ambiguous scenarios.

Intrusions in Scenario Recall

An independent samples *t* test revealed that the groups did not differ significantly in the overall number of intrusions in scenario recall, $t(71) = 0.67$ ($M_{pos} = 3.3$, $SD = 1.6$; $M_{neg} = 3.0$, $SD = 1.3$).[2] Moreover, CBM-I failed to affect the valence of the intrusions, $t(69) = 0.7$ ($M_{pos} = 0.06$, $SD = 0.26$; $M_{neg} = 0.01$, $SD = 0.36$). Memory for the emotional qualities of the initial scenarios therefore was unaffected by training.

Modification of Interpretation Bias

Probe latencies. Data were set aside if the response to the fragment or the corresponding comprehension question was incorrect (4.0%), or if the latency was less than 200 ms (0.3%) or greater than three SDs above the overall mean (2.4%). A mixed-design ANOVA included group as the between-subjects factor and probe valence (positive vs. negative) as the within-subject factor. There was a significant main effect of probe type, $F(1, 73) = 4.63$, $p < .05$, $\eta^2_p = .06$ with faster responses to positive than to negative probes. In addition, the predicted Group × Valence interaction was confirmed, $F(1, 73) = 11.73$, $p < .001$, $\eta^2_p = .14$. Although negative training did not differentiate latencies according to valence, $t(37) = 0.84$ ($M_{pos} = 1270$ ms, $SD = 452$ vs. $M_{neg} = 1236$ ms, $SD = 403$), positive training did, $t(36) = -4.29$, $p < .001$ ($M_{pos} = 1368$ ms, $SD = 376$; $M_{neg} = 1516$ ms, $SD = 422$). Independent *t* tests revealed a significant group difference in responding to negative probes only, $t(73) = -2.93$, $p < .01$. Positive training slowed responses to negative word fragments.

Similarity rating test. As a second manipulation check, a mixed-design ANOVA was performed on the similarity ratings in Booklet 2, with group as the between-subjects factor and valence and target (possible interpretation vs. foil sentence) as within-subject factors. Analysis revealed significant main effects of valence, $F(1, 71) = 8.22$, $p < .01$, $\eta^2_p = .10$, and target, $F(1, 71) = 614.72$, $p < .001$, $\eta^2_p = .90$, reflecting respectively greater endorsement of positive and possible interpretations. The significant Group × Valence interaction, $F(1, 71) = 64.44$, $p < .001$, $\eta^2_p = .48$, was qualified by the 3-way interaction, $F(1, 71) = 28.72$, $p < .001$, $\eta^2_p = .29$ (see Figure 3).[3] The simple interaction of Group × Valence was more extreme for possible interpretations, $F(1, 71) = 54.53$, $p < .001$, $\eta^2_p = .43$, than for foils, $F(1, 71) = 35.91$, $p < .001$, $\eta^2_p = .34$. Regarding possible interpretations, positively trained participants interpreted new ambiguous information in a more positive than negative way, $t(36) = 9.05$, $p < .001$, while negatively trained participants interpreted the information to be more negative than positive, $t(35) = -2.94$, $p < .01$. In short, participants interpreted new ambiguous information in a manner consistent with their training, confirming the effectiveness of the CBM-I.

State Anxiety

To inspect whether the groups were comparable regarding state anxiety, a 2 × 2 mixed-design ANOVA was performed on the state anxiety data with group (positive vs. negative CBM-I) as the between-subjects factor and time (pre-CBM-I vs. post-CBM-I following the filler task). No significant effects were found (smallest $p = .18$), including the Group × Time interaction effect, $F(1, 73) = 1.18$, $p = .28$, $\eta^2_p = .02$. The overall average was 35.4 ($SD = 6.1$).

[1] We lost data from one participant due to a faulty recording; five participants forgot five or six of their own endings, and their data were omitted from the analysis.

[2] One participant failed to remember six of the eight scenarios, so these data were excluded. Because two participants made no intrusions at all, their data did not contribute to the analysis regarding the valence of intrusions, presented next.

[3] The data from two participants were omitted, because they did not understand the task.

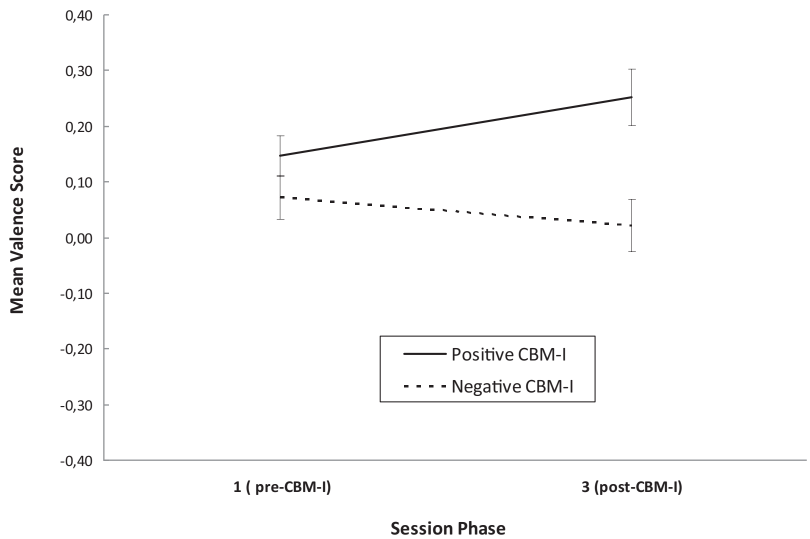

Figure 2. Mean valence rating of interpretations in Phase 1 and remembered interpretations in Phase 3, depicted for both the positive and negative CBM-I groups. Error bars denote 1 *SE*.

Discussion

Our aim was to examine whether interpretation bias retroactively interferes with memory for the emotional quality of earlier reactions to social situations and with memory for the actual details. The modification of interpretations successfully replicated earlier CBM-I findings. Positively trained students interpreted new ambiguous scenarios (in Phase 3) as more positive than negative and the reverse characterized negative training. It is important that the positively trained students remembered their previous reactions as having been more positive. It is unlikely that this difference is due to mood effects, because the groups were comparable in state anxiety. However, influences from undetected differences in negative mood cannot be ruled out. Finally, as anticipated on the basis of prior evidence concerning the basis of memory errors in social anxiety (Hertel et al., 2008), interpretation training did not affect the nature of intrusions in recall of scenario details.

The idea that memory for prior reactions might be influenced by subsequently established interpretative bias is somewhat analogous to the effects of misleading information (Hertel, 1982). Johnson and Raye's (1981) reality monitoring framework provides one way to understand these errors. As participants recalled the ambiguous scenarios in the first part of each memory trial, they likely generated an interpretation that was informed by training and available during the second part of the trial to compete with any memory of their initial interpretation. The reality-monitoring perspective holds that confusions are likely when the sources of generation are similar. In this case, both the to-be-remembered ending and the proposed new interpretation would both be internally generated, and the more recent interpretation might often win the race. A slightly different possibility is that a frame of mind resulting from training might make it difficult to retrieve inconsistent continuations and therefore the "remembered" ending would be constructed anew. In this case, the mechanism would be replacement and not competition. Choice among these possibilities awaits further research. At this point, however, it is interesting to note that similar issues apply to other types of CBM-I effects. For

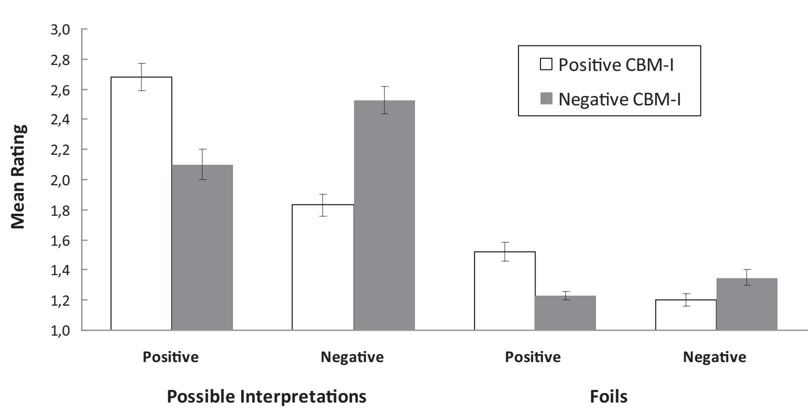

Figure 3. Mean similarity ratings for possible and foil interpretations, according to statement valence and CBM-I group. Similarity ratings ranged from 1 (very different) to 4 (very similar). Error bars denote 1 *SE*.

example, Hoppitt, Mathews, Yiend, and Mackintosh (2010) provided evidence that interpretation training can sometimes "prime" semantic categories, instead of changing specific interpretations.

Our lack of evidence for training effects on memory for the scenarios is consistent with evidence that memory intrusions arise from interpretive processes operating during initial exposure (Hertel et al., 2008; Hirsch et al., 2006). Similarly, Kindt, Soeter, and Vervliet (2009) found that propranolol delivery before the reactivation of a fear memory did not affect the declarative memory for the acquired contingency between a conditioned and unconditioned stimulus, however it did result in changes in the emotional response. This correspondence across different paradigms suggests that emotional responses to recently formed memories can be modified, while leaving other aspects of the experience intact. In real-world situations, however, perceptions and interpretations might not be so easily differentiated. Moreover, our coding scheme might have been insufficiently sensitive to detect more subtle interpretation-based intrusions. In short, a firm conclusion about retrospective influences of CBM-I on memory for scenarios awaits results of future research.

A possible limitation in our procedure concerns the large number of intervening scenarios (in CBM-I) between initial exposure and the memory test, which might make it difficult to remember the initial scenarios. However, we set the TBRS apart from the training scenarios by presenting them in a different modality (auditory vs. visual), context (main experiment vs. filler experiment from colleague), and with different themes (generally social vs. specific student related situations), and background (blue vs. white). Ultimately, the percentage of recall attempts that contained intrusions was quite similar to the percentage found by Hertel et al. (2008), who of course did not employ training scenarios (M = 40% vs. 45%, respectively). A second possible limitation was the short delay between initial exposure and test. In this respect, the training scenarios seem to simulate social experiences stretched out over time. However, future studies should delay the test in the interest of extending the results to the modification of maladaptive memories.

In sum, we demonstrated that modifying interpretations following exposure to ambiguous information affects the later recall of initial interpretations. These results illustrate the relationship among different biases in information processing and the fact that cognitive biases influence each other (see also Hirsch et al., 2006). Furthermore, the change in memory for ones initial interpretation is related to elements from cognitive restructuring interventions in cognitive behavior therapy. To modify anxiety and behavior, socially anxious patients are encouraged to critically question the accuracy of their negative thoughts (i.e., negative interpretations) about past events and to change those interpretations into a more realistic and less negative direction (Beck, Emery, & Greenberg, 1985). A clinical application of CBM-I, besides having beneficial effects on patients' current interpretations, potentially would be capable of affecting memory for past dysfunctional interpretations or dysfunctional memory of past interpretations.

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