Believing is Seeing

The causal role of interpretive bias in anxiety

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Believing is Seeing

The causal role of interpretive bias in anxiety

Eerst geloven, dan zien

De causale rol van vertekende interpretaties in angst

(met een samenvatting in het Nederlands)

Proefschrift

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Part I

General introduction

Introduction

People believe what they see, but do they realize that what they believe shapes what they see? Humans tend to give more weight to information that matches their beliefs or expectations. In other words, beliefs shape and select the information that is processed from the environment. If you believe that someone fancies you, an ambiguous smile from that person is suddenly clearly flirtatious. Unfortunately this tendency is often associated with certain disadvantages that range from mild to more serious and disrupting effects. A misinterpreted flirtatious smile might only lead to a moment of embarrassment. Believing that someone is guilty of a crime, on the other hand, results in selectively paying attention to information that proves guilt, while ignoring information that might contradict this belief. As a consequence someone might be convicted for a crime he/she did not commit.

The coloured processing of information is strongly present in emotions such as anxiety due to a close relationship between cognitions and emotions. In the face of threat, anxious individuals will detect a disproportionate amount of threat signs in the environment and any ambiguity will be resolved as threatening. It has been suggested that this biased information processing plays a pivotal role in the onset, maintenance, and exacerbation of psychopathological anxiety. The present thesis is devoted to the hypothesised causal role of interpretive bias in anxiety.

Cognitive theory

Beck (Beck, 1976; Beck, Emery, & Greenberg, 1985) offers a framework to elucidate the relationship between cognitive processes and emotion. His cognitive theory stipulates that people have long-term schematic memory structures encompassing representations of past experiences and emotions that are postulated to guide the intake and organisation of new information. These memory structures bias information processing to favour information that is congruent with the schematic structure. That is, they cause people to selectively filter stimulus input by attending to schema-congruent information (attentional bias), to interpret ambiguous information in a congruent way (interpretive bias), and to increase accessibility of memories congruent with their content (memory bias). Importantly, the cognitive model proposes that differences in the operation of these schemas underlie vulnerability to emotional disorders. Anxiety-prone individuals will have hyper-active danger related schemas. Their schemata will consist of a wider range of threat representations due to their genetic dispositions and specific learning experiences. Since the schema selectively encodes new information, a danger schema will result in a bias towards the processing of threatening information. For instance, an individual vulnerable to social anxiety will selectively direct his/her attention to angry faces, will interpret ambiguous facial expressions as signs of disapproval, and will remember a disproportionate amount of rejections. This biased information processing, in turn, is predicted to play a critical role in the aetiology and maintenance of pathologic anxiety.

Thus, according to Beck's cognitive theory, anxious individuals should be characterised by a bias affecting all information processes (attention, interpretation, and memory). The theory also suggests that these biases causally contribute to (pathological) anxiety and vice versa. These specific hypotheses can be put to test, and as a result his theory has been a source of inspiration for much research.

Processing bias and anxiety

Attentional bias

Considerable evidence has confirmed that anxiety is associated with selective attention for threatening information. Macleod, Mathews, and Tata (1986), for example, examined attentional bias with a dot probe task. In this paradigm, two words are simultaneously presented on a computer screen and occasionally a small dot appears in one of the two screen locations previously occupied by one of the words. Participants are required to detect the dot as quickly as possible. Attention to particular words results in quick detection of dots appearing in a same region of the computer screen and slow detection of dots appearing in a different region. Results showed that patients with a generalised anxiety disorder detect dots replacing negative words (for example MURDER) faster than neutral words. These patients selectively attend to threatening information.

The attentional bias finding with a dot probe task has been replicated in other clinical populations; selective attention for physical threat words in patients with panic disorder (Asmundson, Sandler, Wilson, & Walker, 1992), social threat words in social phobia (Asmundson et al.), contamination-related words in obsessive compulsive disorder (Tata, Leibowitz, Prunty, Cameron, & Pickering, 1996), and mildly threatening words in posttraumatic stress disorder (Bryant & Harvey, 1997). Selective attention has also been observed with other tasks such as a dichotic listening task (Foa & McNally, 1986), an Emotional Stroop task (van den Hout, Tenney, Huygens, & de Jong, 1997), a visual search task (Gilboa Schechtman, Foa, & Amir, 1999), and an emotional spatial cueing task (Fox, Russo, Bowles, & Dutton, 2001). For an extended overview of studies examining attentional bias in anxiety see the recent article by Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, and IJzendoorn (2007). In sum, an overwhelming body of evidence argues that anxiety is associated with selective attention for disorder specific information.

Interpretive bias

There is also a large body of evidence indicating that anxiety is associated with the tendency to interpret ambiguous information in a threatening way. Butler and Mathews (1983) were one of the first examining this. Patients with a generalised anxiety disorder received a questionnaire consisting of brief, ambiguous scenarios, for example: “You wake with a start in the middle of the night, thinking you heard a noise, but all is quiet”. Subsequently, participants received three interpretations of the scenario and were asked to rank-order the interpretations to the extent to which they would come to mind. Results showed that, compared to a non-anxious control group, patients more often chose the threatening interpretation (“It could be a burglar”). This scenario paradigm has also revealed a negative interpretive bias in patients with social phobia (Amir, Foa, & Coles, 1998). In this case, ambiguous social scenarios were presented, for example: “A group of friends are having lunch and they stop talking when you approach”. Again the group of patients chose the negative interpretation (“They are talking negatively about me”) more often than the positive (“They are about to ask me to join them”) or neutral (“The conversation had just reached its end”) one, when compared to the non-anxious control group.

Similar findings of an association between anxiety and negative interpretations emerged from studies using other tasks. Homophones (words with the same sound, but different meanings and spellings) have been used to examine interpretive bias. Patients with generalised anxiety auditorily received homophones with threatening and nonthreatening meanings (e.g. ‘dye’ and ‘die’). They were asked to write them down. A patients’ spelling revealed his/her threatening interpretation of the homophone (Mathews, Richards, & Eysenck, 1989). Interpretations have also been assessed with a lexical decision task using homographs (words with multiple meanings, e.g. ‘stroke’ meaning ‘fondle’ or ‘heart stroke’) that are followed by target words related to either the threatening or neutral meaning. The time taken to make a lexical decision (word or non-word) about the targets reveals the interpretation of the homograph. Richards and French (1992) showed that performance on targets related to the threatening meaning of a homograph was facilitated in high anxious individuals.

Not only the interpretation of experimentally presented stimuli is biased in anxious individuals, but also the interpretation of, for example, experienced physical sensations. Different pharmacological and physiological procedures have been used to induce bodily sensations, which resulted in anxiety and panic attacks in patients with a panic disorder but rarely did so in normal individuals (Pitts & McClure, 1967). Clark (1993) showed that these effects in patients are due to their misinterpretation of the sensations. In addition, even the interpretation of own behaviour is biased in anxious individuals. That is, patients with social phobia interpreted their social functioning when giving a speech as more negative than the observers (Derakshan & Eysenck, 1997). While this seems to directly indicate that there is a negative biased interpretation of own functioning in social situations, a recent study showed that this depends on the type of social interaction. Since patients have actual performance deficits in social conversations, their negative opinion about that performance is accurate rather than biased. Cognitive distortions do play a role in other social situations such as giving a speech (Voncken & Bögels, in press).

In sum, the presence of an interpretive bias in clinical and non-clinical anxious individuals has been shown using a wide range of different stimuli and tasks.

Memory bias

Attempts to consistently find memory bias in anxiety have failed. While some studies have observed a memory bias (e.g. McNally, Foa, & Donnell, 1989; Nunn, Stevenson, & Whalan, 1984), the majority failed to observe such effects in anxiety (e.g. Mathews, Mogg, May, & Eysenck, 1989; Mogg, Mathews, & Weinman, 1987). These findings contradict Beck's cognitive model (1985), which predicts that processing biases should operate consistently across the whole spectrum of cognitive processes (attention, interpretation, and memory).

Williams, Watts, Macleod, and Mathews (1988; 1997) have put forward a revised cognitive formulation of psychopathology suggesting that different emotional disorders are associated with different patterns of cognitive bias. It is suggested that anxiety is characterised by a bias that favours threatening stimuli in an early, relatively automatic stage of information processing. Thus, anxiety should be characterised by biased automatic orienting of attention as well as biased disambiguating of ambiguous information. Furthermore, it is suggested that anxiety is also related to a bias in the more automatic component of memory (a solution that 'comes to mind'), whereas depression, for example, is thought to be associated with a bias in the more elaborative, strategic element of memory retrieval. Williams ascribed the abovementioned findings concerning memory bias to an absence in the distinction between implicit and explicit memory. When more direct and more indirect memory tests are contrasted, the majority of studies supports Williams et al.'s hypothesis (e.g. Amir, Foa, & Coles, 2000; Mathews, Mogg et al., 1989; Richards & French, 1991), though some fail to observe an implicit memory bias in anxiety (e.g. Mathews, Mogg, Kentish, & Eysenck, 1995; Nugent & Mineka, 1994; Richards, French, Adams, Eldridge, & Papadopolou, 1999). Thus, the role of a memory bias in anxiety remains equivocal.

Causal relationship

It is now well-established that individual differences in anxiety are related to differential processing of information. High anxious individuals, compared to low anxious individuals, have an increased likelihood to attend to threatening information and to interpret ambiguous information in a threatening manner. It is assumed that this biased information processing is not an incidental epiphenomenon of anxiety, but that it plays a crucial role in the maintenance or even the development of an anxiety disorder. Since the majority of the evidence comes from studies using a cross-sectional design, the issue of a *causal* relationship was left unaddressed. Firstly, the direction of the association remains unclear. Is biased information processing causing anxiety, or is anxiety the cause of those biases? Or do they operate together in some kind of interactive process? Secondly, it is possible that both the bias and anxiety are the products of a third variable. Results from cross-sectional studies provide the first piece of information: processing biases and anxiety are related. They do not, however, give insight into the causal direction or the issue of a possible third variable.

Causal pathways were already formulated in Beck's cognitive model of anxiety (1985); it stipulates that the affective state influences the processing of state congruent information and that biased processing is the cause of emotional disorders. Williams et al.'s model (1988; 1997) predicted that a predisposition for transient anxiety, as well as for a more trait like anxiety, affects cognitive processing, while the persisting tendency to selectively process emotionally threatening material is a vulnerability for the development of an anxiety disorder. Anxiety and biased processing could interact in such a way that a vicious circle is produced that results in the maintenance of anxiety. While correlational studies confirmed the relationship between processing bias and anxiety from 1985 onwards, remarkably, the causal basis of this association remained largely unexplored.

Examination of the causal nature is not only of theoretical importance, but also of clinical importance. Anxiety disorders are, together with depression, the most common psychiatric disorders (Poos, 2006). When considering the concept of Disability-Adjusted Life-Year (DALY), anxiety disorders result in the second greatest reduction in quality of life (immediately following coronary heart disease) (Hoeymans, Poos, & Gommer, 2006). It is thus important to better understand the precise development, maintenance, exacerbation, and relapse of anxiety disorders. Research on the causal relationship between biased information processing and anxiety disorders sheds light on these issues.

Prospective research

Indirect evidence for a causal role of processing biases in anxiety comes from studies with a prospective design. Such studies examine the direction of the association between a bias and anxiety by testing whether biased information processing predicts anxious reactions to later stressful life events. Attentional processing style was, for example, assessed in 31 women before undergoing a colposcopy diagnostic procedure (MacLeod & Hagan, 1992). Afterwards, fifteen women were diagnosed as positive for cervical pathology. Results revealed that the nature of their emotional reactions eight weeks later was predicted by the (automatic) tendency to attend to threatening words. In a similar vein, Pury (2002) showed that interpretive bias is also a predictor of emotional reactions to subsequent stress. Prior to an examination week, interpretive style was assessed in a group of students. During the exams, negative affect was measured and this appeared to be predicted by the previously measured tendency to interpret ambiguous items as threatening.

Although these findings are encouraging, and despite their prospective design, it cannot be ruled out that a third variable might have been involved. For instance, neuroticism might independently influence both processing biases and emotional reactions. This would be consistent with the observed association between processing biases and anxiety, while it does not necessarily represent a causal relationship. Studies with a pure experimental design are, therefore, indispensable in resolving the causality issue.

Experimental research

Experimental studies have been conducted to examine whether anxiety causally contributes to biased information processing and vice versa. The former is tested by modifying anxiety and examining effects on processing biases, while the latter is measured by manipulating a processing bias and examining the subsequent effects on anxiety.

Modifying anxiety. Modification of anxiety can consist of increasing anxiety in a non-anxious population and decreasing anxiety in an anxious population. Studies using the latter strategy generally take the form of outcome studies. Such outcome studies have demonstrated that reductions in anxiety following therapy are associated with reductions in interpretive bias. The negative interpretive bias that was evident in patients with a generalised anxiety disorder was no longer seen in recovered patients; the latter group was no longer different from non-clinical controls (Eysenck, Mogg, May, Richards, & Mathews, 1991). This finding of a reduced interpretive bias after therapy was replicated in a group of patients with social phobia (Franklin, Huppert, Langner, Leiberg, & Foa, 2005). In addition, psychological treatment is also capable of reducing attentional bias. Lavy, Van den Hout, and Arntz (1993) showed that a single-session treatment consisting of exposure tasks to reduce spider fear also resulted in reduced attentional bias to spider words. The attentional bias reduction has also been found after treating patients with generalised anxiety disorder (Mathews et al., 1995), obsessive compulsive disorder (Foa & McNally, 1986), and social phobia (Lundh & Ost, 2001). Given that the treatments were offered to reduce anxiety, this might suggest that anxiety contributes to processing biases. However, treatments may have served to reduce the bias directly and the reduction in bias may have contributed to a reduction in anxiety.

Other studies have examined whether the increase of anxiety is followed by effects on processing biases (van den Hout, Arntz, Janssen, de Jong, & Pool, 1998). To create such an increase in anxiety, participants who had never parachuted were invited to participate in an experiment and perform a parachute jump. It was examined whether an increase in anxiety was accompanied by selective attention to threat. Despite the fact that anticipation of the jump resulted in subjective anxiety, no difference in attentional bias was observed between the novice parachutists and a control group. Thus, it seemed that state anxiety per se is not sufficient for the materialisation of attentional bias. Macleod and Mathews (1988) examined the influence of trait anxiety next to increases in state anxiety. High and low trait anxious students were tested on attentional bias in two conditions: when state anxiety was low and when it was high (a week prior to their main annual examination). Results showed that only in high trait anxious students an increase in state anxiety was associated with an attentional bias towards threatening examination-related stimuli. Thus, state and trait anxiety alone are not sufficient, but the interaction between them seems to causally contribute to attentional bias.

Modifying processing bias. To examine whether a processing bias can exert a causal influence on anxiety, processing biases should be manipulated. In 2000, Mathews and Mackintosh reported such a study with a pure experimental design. Individuals with middle-range trait anxiety scores were invited to participate to ensure that pre-existing biases were unlikely to be marked. Participants were trained to either interpret information positively or negatively and the effects on anxiety were examined. Cognitive Bias Modification of Interpretations (CBM-I) was effectuated in the following way. Participants read 104 short scenarios that were ambiguous in nature and could equally likely have a positive or a negative ending. Every story ended with a word fragment (a word with several missing letters) requiring a solution. Fragment completion resolved the ambiguity resulting in either a positive (positive CBM-I) or negative (negative CBM-I) meaning of the preceding story. It was hypothesised that repeatedly interpreting ambiguous information in a certain direction would result in altered interpretations. To determine whether the procedure was indeed successful at modifying interpretations, two tasks were used as manipulation checks. The first task was a reaction time task; the time taken to solve a positive and negative word fragment. The second task was a recognition task; after the modification phase participants read a new set of ambiguous stories. They were subsequently asked to indicate the level of similarity between experimenter-provided interpretations and the original ambiguous story. Results from both manipulation checks confirmed the effectiveness of CBM-I. Positively trained participants were faster in solving positive word fragments and endorsed positive interpretations more often than the negatively trained group. More importantly, the modified interpretive bias resulted in a concomitant change of anxiety. That is, participants in the negative condition became more anxious while anxiety dropped in the positive condition. This pattern of findings provided support for the hypothesis stating that biased interpretation of ambiguous information causally contributes to anxiety.

A similar line of research was started in Australia examining the causal relationship between attentional bias and anxiety. Macleod, Rutherford, Campbell, Ebsworthy, and Holker (2002) trained participants to selectively direct their attention to either neutral or negative information. In a modified dot probe task, the dot appeared consistently at the location of the neutral word (attend neutral condition) or threatening word (attend threat condition). Results showed that they were successful in modifying the allocation of attention.

As a next step, they examined whether participants reacted differently to a stressor due the differential processing of this emotionally significant event. It appeared that participants trained to attend to threatening stimuli reacted more strongly to a post-training stress task than participants trained to attend to neutral stimuli. The results provided strong evidence for a causal contribution of biased attentional responses to emotional vulnerability. Note, however, that due to the absence of a control group the natural course of emotional responses to the stress task remained unknown. As a result, it is impossible to ascertain whether the results demonstrate that paying attention to threatening stimuli leads to an increased reactivity or whether they show that there is a protective influence of attending to neutral information. The results could even be indicative of other patterns contradicting the theoretical predictions.

CBM-I and anxiety: Remaining issues

The present thesis addresses the hypothesis that interpretive bias can make a causal contribution to anxiety. Of course, causal effects could also operate in the reverse direction with anxiety causally contributing to interpretive bias. This could reflect a positive feedback loop, in which misinterpretations increase anxiety, which in turn, strengthens the cognitive distortion, culminating in an anxiety disorder. This thesis concentrates on potential causes of anxiety, such as biased interpretations, but leaves open the possibility of a reversed causal relationship. In addition to increasing the theoretical understanding of anxiety disorders, our research could contribute to the refinement of cognitive treatments and prevention of pathological anxiety.

Mathews and Mackintosh's (2000) seminal work examining causal effects of interpretive bias on anxiety raised many new questions. The aim of this research project was to examine several of the most significant questions to gain further insight into the causal relationship. Our research questions concerned the following four issues: replication; generalisability; underlying mechanisms; and clinical application.

Replication

Mathews and Mackintosh's (2000) study was the only one examining the causal nature of the relationship between interpretive bias and anxiety. While their article consisted of several experiments, the field was in need of replications from other research groups. The first aim of the thesis was to examine the robustness of their findings by conducting a replication study.

Generalisability

Modification of interpretive bias was realised by presenting participants with ambiguous social stories that had to be disambiguated in either positive or negative direction by solving the pertaining word fragment (Mathews & Mackintosh, 2000). The active solution in a consistent direction was predicted to result in changed interpretive bias. This was examined with a reaction time measure and a recognition task. Since both the CBM-I procedure (independent measure) and the manipulation checks (dependent measures) consist of social stories presented lexically, they resemble each other in content and format. As the manipulation checks were all based on those two tasks, it was questioned whether the modified bias generalises beyond the tasks in which it was initially practiced. Not only is generalisability across assessment modalities predicted on theoretical ground, but also empirically. Correlational data has revealed robust interpretive bias effects in a range of different tasks. However, generalisation of the modified interpretive bias to other modes of measurement has never been tested. Generalisability across tasks was, therefore, the second aim of the research project.

Concerning generalisation across domains, it is not clear what one could predict on theoretical grounds. Beck's cognitive theory (1976) specifically states that a processing bias is congruent with the memory structure or specific mood state. As a matter of fact, several studies have shown that different anxiety disorders are associated with domain specific interpretive biases (Mathews & MacLeod, 1994; Vancleef & Peters, 2008). Patients with social phobia specifically interpret ambiguous *social* events in a negative fashion (Stopa & Clark, 2000), while patients with a panic disorder interpret ambiguous *physical sensations* in a negative fashion (Clark, 1993; Clark et al., 1997). Based on Beck's theory and the abovementioned empirical data, domain generalisability would not be expected following social interpretive bias modification.

Yet, other studies failed to observe domain specificity. Eysenck et al. (1991) showed that in a sample of patients with generalised anxiety their domain of interpretive bias (physical or social) was not related to their specific domain of concern (worry about physical or social topics). Furthermore, interpretive bias is the tendency to see the world in a negative way, which is highly similar to neuroticism. Interpretive bias might be considered the reflection of a trait related cognitive style that operates across disorders. As expected, other disorders such as depression (e.g. Butler & Mathews, 1983), eating disorders (Altabe, Wood, Herbozo, & Thompson, 2004), chronic pain (Pincus, Pearce, McClelland, Farley, & Vogel, 1994), and complicated grief (Boelen & van den Hout, 2008) are also associated with interpretive bias. To grasp the interplay between different constructs and emotions, Lilienfeld (1996) formulated a hierarchical model. The model is built up in several levels with higher levels representing more global and stable personality traits and lower levels representing specific constructs that are closely related to specific manifestations of psychopathology. Social evaluation sensitivity and physical sensations sensitivity are, for example, considered specific lower order constructs that are nested hierarchically within trait anxiety, a higher-order trait, which is nested within negative emotionality. If interpretive bias is a higher order processing style, encompassing different specific emotional disorders, we might expect modified interpretive bias to affect different domains of concern and different emotions. Following this line of argumentation, generalisation to other domains of anxiety would be predicted following social CBM-I. This contrasts Beck's theory, which suggests that interpretive bias would not generalise across domains due to its content specificity. The second aim of the thesis encompassed this issue of domain generalisability.

Macleod et al. (2002) examined the effects of attentional bias on emotional reactions to a stressor. It is assumed that effects on mood are caused by modified processing of situations or events. Macleod et al. subjected participants to a stress task that contained difficult anagrams. Participants could focus on the items that were successfully solved, or those that were not. In contrast, effects of biased interpretations were examined on direct mood states (Mathews & Mackintosh, 2000). This distinction is comprehensible, when considering the fact that interpretive bias is defined as the tendency to disambiguate *ambiguous* information positively or negatively. Thus, events containing ambiguity are needed for interpretive bias to be deployed. During CBM-I and the recognition task, participants are already processing the required ambiguous information. Thus, interpretive bias can exert its influence on mood without the requirement of a stress task. Note that the active deployment of interpretive bias is crucial. Mathews and Mackintosh also developed a passive CBM-I procedure (participants *received* the disambiguation rather than having to *actively generate* it) that did not affect anxiety. Thus, modification of interpretive bias does not result in changed anxiety *per se*, but only when interpretations of encountered ambiguous information are generated actively. However, it is also possible that the observed mood change reflects the direct impact of the procedure on mood state due to, for example, completing valenced words or mere exposure to either positive or negative information. An ambiguous stress task requiring interpretation is then needed to determine whether mood changes are caused by modified information processing. Therefore, this thesis also examined CBM-I effects on emotional responding to an ambiguous stress task.

Generalisability of the modified interpretive bias is relevant for understanding the boundaries of the CBM-I model and for potential clinical application that requires generalisation of the altered interpretive bias to daily life. Therefore, the second aim of the present thesis was to examine generalisability to other interpretive bias tasks, domains of fear, and emotional responses to ambiguous stress situations.

Underlying mechanisms

Mathews and Mackintosh's (2000) findings indicate that CBM-I is successful in affecting interpretive bias. This raises the question of how such effects are obtained and what exactly is learned during CBM-I. In other words, what is the underlying mechanism of changed interpretations? Besides priming effects, Mathews and Mackintosh also suggested that participants implicitly acquire an emotional interpretation rule and without explicit awareness or intent apply that rule to new ambiguous situations. As these are post-hoc explanations that have not been subjected to specific tests, we conducted an experiment to test the alleged implicitness of such a rule.

The conclusions that have been drawn in Mathews and Mackintosh's (2000) work about causality are based on the crucial assumption that the CBM-I procedure affects interpretive bias, and that the altered interpretive bias *then* affects anxiety. However, this cascade represents only one of several possible interpretations of the observed data. For instance, the modification procedure could have a *direct* effect on anxiety by changing mood through abundant exposure to either positive or negative information, while interpretations need not necessarily be altered. As this critical assumption of an *indirect* relationship between the CBM-I procedure and anxiety, mediated by an altered interpretive bias, has not been tested, we aimed to examine the process of change.

In sum, both the implicit interpretation rule, as well as, the indirect relationship between CBM-I and anxiety was examined as part of testing the underlying mechanism in CBM-I. This was the third aim of the thesis.

Clinical application

The observation that modification of interpretive bias is followed by a change in anxiety (Mathews & Mackintosh, 2000) has clinical implications. Take the observation that interpretive bias affects anxiety in a sample of mid-range anxious individuals. Inducing a positive interpretive bias in patients with an anxiety disorder could, therefore, have beneficial effects on their anxiety level.

As the modification procedure covers only one hour, while someone's interpretive style is an enduring habit that is utilised for years, the CBM-I effects could be rather transient with quick return to the original interpretive tendency and associated mood state. Conversely, it could be argued that CBM-I might lead to a short-lived change in interpretive style that would be accompanied by a (short-lived) change in actual behaviour. Suppose that, as a result of the new behaviour, other people respond more positively and that the new behaviour gets rewarded and reinforced. Then the effects of CBM-I might be longer lasting, resulting in enduring new behaviour, and have potential clinical application. The fourth aim was to examine the effects of positive CBM-I in anxious individuals.

What could we expect from positive CBM-I in high anxious individuals? Since anxious individuals are more anxious before undergoing CBM-I than mid-range anxious individuals, there is more room for improvement on anxiety. Stronger anxiolytic effects of positive CBM-I could be expected in the anxious sample. On the other hand, maintaining mechanisms may be present in patients and highly anxious individuals that are absent in mid-range anxious individuals, therefore one might anticipate that the treatment is less effective or not effective at all in this anxious sample. The potential clinical possibilities of CBM-I were examined in a sample of high anxious students and in a clinical sample of patients with an anxiety disorder.

Focus and outline of the present thesis

The primary objective of this thesis was to further elucidate the causal relationship between interpretive bias and anxiety. The following four themes, as explained in detail above, were examined in different empirical studies that are described in six chapters: replication (Chapter 1 and 2), generalisability (Chapter 1, 2, 3, 5, and 6), underlying mechanisms (Chapter 1 and 4), and clinical application (Chapter 5 and 6).

Chapter 1 describes a replication study. Students were trained to interpret ambiguous information either in a benign way or in a threatening way and effects on anxiety were inspected. To examine the effects of CBM-I on emotional responding to an ambiguous real life situation, participants performed an ambiguous stress task after CBM-I. Furthermore, we examined whether participants were aware of the fact that their interpretive style was modified and whether this awareness was related to change in interpretive bias.

Chapter 2 reports a CBM-I experiment that was conducted to examine the robustness of the effects of modified interpretive bias on anxiety. In addition, including an implicit interpretive bias measure, as well as, an open-ended interpretive bias questionnaire allowed us to test generalisation of the modified interpretive bias to other interpretive bias measures.

Chapter 3 is completely devoted to generalisability of the modified interpretive bias. Generalisability to other interpretive bias tasks was addressed by including video clips and a vignette task following CBM-I. Also generalisability to another domain of interpretations (performance at school) was addressed.

In *Chapter 4*, the assumption that there is an *indirect* relationship between the CBM-I procedure and anxiety, mediated by an altered interpretive bias, was tested. In the first part of Chapter 4 structural equation modelling was used to determine the pathway leading to anxiety change in a CBM-I experiment. The second part focused on exposure, an element of the CBM-I procedure that could be responsible for the observed direct effects of CBM-I on state anxiety.

Chapter 5 reports the results of a CBM-I experiment designed to explore the clinical potential of this training program in an analogue sample. High trait anxious students (N = 34) were randomly assigned to one of two conditions: a positive CBM-I or a control condition. The CBM-I program was extended from one session to eight sessions and offered online. Interpretive bias effects were measured with the standard manipulation checks and generalisability to other interpretive bias tasks (a questionnaire) was also measured.

Besides examining effects on state and trait anxiety, generalisability to social anxiety and general complaints was assessed. Finally, we examined whether interpretive bias exerted a causal influence on anxiety vulnerability.

The study in the last chapter (*Chapter 6*) was designed to further examine whether the CBM-I method can be used as a tool in treating patients with an anxiety disorder. A positive and control (50% positive interpretations and 50% negative interpretations) CBM-I was performed in a sample of patients with anxiety disorders (*N* = 36). We examined whether elevated levels of anxiety could be attenuated by reducing the associated tendency to impose negative interpretations on ambiguity. Therefore, effects on state and trait anxiety were gathered, up to three months follow-up. Also generalisability to other mood states was investigated by including various clinical outcome measures (depressive mood, general complaints, and general positive and negative affect).

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Part II

Empirical studies

1

Trained interpretive bias and anxiety

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Abstract

The relationship between anxiety and interpretive bias has been studied extensively, but the causal direction of this relationship remains largely unexplored. Do negative interpretations cause anxiety or is anxiety the cause of negative interpretations? Or are the two mutually reinforcing? The present study addressed this issue by experimentally inducing either a negative or a positive interpretive bias using Mathews and Mackintosh' cognitive bias modification paradigm (J Abnorm Psychol, 2000, Vol. 109, 602-615) and then examining its impact on state anxiety and anxiety vulnerability. In addition, it was investigated as to whether the interpretive bias was trained implicitly. Results indicated that style of interpreting could be modified. That is, when confronted with ambiguous information after training, participants (*N* = 118) interpreted this information congruent with their (positive or negative) training condition. Data on the issue of implicitness showed that participants tended to be explicitly aware of the valence of their training stimuli. Effects of trained interpretive bias on anxiety were only marginal and absent on anxiety vulnerability. It appears that interpretive bias can be trained reliably, but its effects on mood and vulnerability require further explanation.

Introduction

Research on selective information processing has revealed a robust association between anxiety and negative interpretive bias. A wealth of evidence comes from studies using a cross-sectional design (Amir, Foa, & Coles, 1998; Eysenck, Mogg, May, Richards, & Mathews, 1991; MacLeod & Cohen, 1993). Such studies have left the causality issue unaddressed: Is biased information processing causing anxiety and anxiety vulnerability, or is the former just a cognitive correlate of anxiety? To the best of our knowledge, there is only one prospective study (Pury, 2002) which examined whether interpretive bias is a predictor of emotional reactions to stress in students. Prior to an examination week, interpretive style was assessed with a homophone spelling task. During the exams, negative affect was measured. The results indicated that interpretive bias predicted later negative affect. Although these findings are encouraging, and despite the prospective design, it cannot be ruled out that a third variable was involved. Experimental research would seem to be indispensable in resolving the causality issue, and such research was recently undertaken. Specifically, interpretive biases have been successfully modified in non-anxious individuals (Mathews & Mackintosh, 2000; Yiend, Mackintosh, & Mathews, 2005) and the effects of such Cognitive Bias Modification of Interpretations (CBM-I) on anxiety have been examined.

In their study, Mathews and Mackintosh (2000) encouraged participants to interpret ambiguous information differently by having them read ambiguous social stories, for which half of the participants were required to generate emotionally negative outcomes, and the remaining half positive outcomes. The stories were three lines in length and remained ambiguous in terms of their emotional meaning until the final word. This last word was a word fragment, the completion of which produced either a positive or negative disambiguation of the story. Because there was only one possible meaningful solution for each fragment, participants were forced to disambiguate the fragment in either a threatening or a benign way. The time taken to solve a word fragment was used as an outcome measure. It was found that participants in the positive CBM-I group responded faster to positive fragments and participants in the negative CBM-I group responded faster to negative fragments. To investigate whether interpretation style was indeed altered, disambiguation of new ambiguous stories was tested with a subsequent recognition test. Participants received another set of social stories that were left ambiguous in outcome. Then four interpretations of each story were presented and each interpretation was rated by the participants for its similarity in meaning to the original. The results revealed that participants in the positive CBM-I condition endorsed the positive interpretations more than the negative ones. The reverse was found in the negative CBM-I group. More importantly, evidence was found in support of the hypothesis that trained interpretive bias causally affects self-reported anxiety. The first aim of the present study was to replicate these findings, by examining the effect of a trained interpretive bias on self-reported anxiety.

Interpretive bias may also contribute to the maintenance of anxiety disorders by affecting anxiety vulnerability. It has been hypothesised that attentional and interpretive bias affect anxiety vulnerability by negatively distorting the processing of emotionally significant events (Mathews & MacLeod, 2002). Support for this hypothesis was observed following the training of an attentional bias with a modified attentional dot probe task (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). Although no effect of a trained attentional bias on state anxiety was observed, participants trained to attend to threat stimuli reacted more strongly to a post-training stress task than participants trained to attend to neutral stimuli. A further aim of the present experiment was to test whether trained interpretive bias enhances emotional reactions to stress, apart from possible effects on state anxiety.

In addition to examining the main hypothesis that interpretive bias is causally related to anxiety, we also aimed to explore in more detail what is learned during CBM-I. Mathews and Mackintosh (2000) suggest that the modified interpretive bias is implicit in the sense that participants are unaware that the bias was being trained. This suggestion was based on the finding that 'participants denied having any ideas about the purposes of the study' and 'none reported suspecting that the first part of the study was intended to influence their interpretations' (Mathews & Mackintosh, p. 606). It was concluded that 'it thus seems possible that without explicit awareness or intent, participants were trained to apply a biased interpretation rule to the situations described…' (Mathews & Mackintosh, p. 614). While participants may not have guessed what the specific intentions of the experimenters were and while they may have been unaware of the relationship between the training phase and the test phase, it remains possible that they were aware that they were exposed to a range of scenarios, the outcomes of which tended to be negative or positive. Participants may learn that in this specific situation (participating in this experiment), in this specific room (lab setting) and with those specific stimuli (social situations), stories end negatively (or positively). Unaware of the relationship between the training and test phase, they might still apply the rule about negative or positive stories throughout the entire experiment. To test this alternative hypothesis, participants were explicitly asked whether they were aware of the emotional valence of the stories.

In sum, the first aim of the present study was to replicate Mathews and Mackintosh's (2000) finding that through specific training, participants can be made to disambiguate ambiguous information either positively or negatively. The second and third aims were to determine whether or not this training can causally influence anxiety, and anxiety vulnerability, respectively. The fourth aim was to examine the alleged implicitness of the CBM-I procedure. With regard to the aim of replicating the successful training of an interpretive bias, it was expected that CBM-I should be effective in creating two groups, differing in terms of their responses on each measure of interpretive bias delivered during training or the subsequent test trials. It was hypothesised that if the modification was successful, then across CBM-I trials, participants in the positive condition would come to show faster responses to positive word fragments and participants in the negative condition would come to show faster responses to negative words. Furthermore, congruency effects should be revealed between the valence of the original CBM-I stories and the interpretation of subsequently presented ambiguous stories. Assuming the modification to be effective, it was hypothesised that participants would be more anxious after negative CBM-I than after positive CBM-I. It was also hypothesised that participants who were exposed to negative interpretations would display a more intense negative emotional reaction to the stress task, compared to participants who were exposed to positive interpretations. The final hypothesis was that successful training of interpretive bias would be accompanied by the conscious comprehension of the emotional valence of the training stimuli. The degree to which such comprehension is necessary for the successful training of interpretive bias could then be examined by assessing the magnitude of impact of (positive or negative) training upon interpretive bias when individual differences in the degree of explicit insight are controlled for.

Method

Design

The experiment involved four phases: (i) a training phase, (ii) a rest phase, (iii) a recognition test phase, and (iv) a stress phase (see Figure 1).

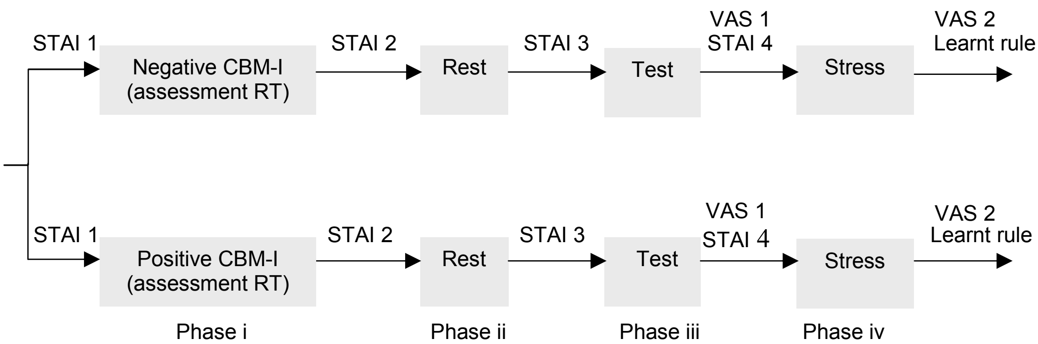

Figure 1.
Overview of the experimental design

In the training phase, interpretive bias was modified by having participants read social stories whose emotionally valenced meaning remained ambiguous until the final sentence, which disambiguated the story either negatively or positively. The dependent variable was the time taken to solve word fragments in probe stories (see *Experimental stimuli*). The training phase was followed by a rest phase in which the participants performed an unrelated filler task. Next, in the recognition test phase, participants read ambiguous stories and received four interpretations of each story. For each interpretation, the dependent variable was the level of similarity in meaning to the original ambiguous story. In the stress phase, participants were administered a stress task with a pre- and post assessment of mood (VAS) (see *Stress task*). To test whether the two CBM-I groups were comparable in anxiety, participants completed the State and Trait versions of the State and Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) before the start of the experiment. To examine the effect of CBM-I on state anxiety, the State version was administered another three times during the session: immediately after CBM-I; immediately after the filler task; and after the recognition test. The session ended with two questions to test whether an explicit rule was learnt (see *Assessment of learning a rule*).

Participants

A total of 128 students of Amsterdam University participated in the experiment for course credit. Ten students dropped out of the study. Five participants were unable to complete the tasks due to difficulties with the Dutch language, two due to extreme slowness, and three due to computer problems. In the final sample, there were 58 participants in the negative CBM-I group and 60 in the positive CBM-I group. The age of this remaining group (90 females and 28 males) ranged from 17 to 50 (*M* = 20.8 years).

Materials and apparatus

Experimental stimuli. The stories used in the experiment were translations of those used by Mathews and Mackintosh (2000). During the training (phase i), 10 blocks of 13 stories were presented on a personal computer, with an option for rest given after each block. Each block contained eight modification stories, three filler stories, and two probes. The modification stories were created to train participants to make emotional interpretations of a particular valence. Each modification story consisted of three lines that were ambiguous in valence. The final word of the story was presented as a word fragment and disambiguated the story, whose meaning had remained ambiguous until this point. In the positive CBM-I group, solution of the word fragment resolved the ambiguity in a positive way and in the negative group in a negative way. Participants were asked to complete the fragments as quickly as possible, after which a comprehension question with relevant feedback appeared on the screen to reinforce the interpretation imposed by the word fragment. An example of a modification story, with the word fragment for each CBM-I 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 …*
> *sh- (shy)/con--d--t (confident).*

Then the comprehension question followed:

> *Did you feel dissatisfied with your speech?*

The filler stories had no emotional content, nor did they contain any ambiguity. They were inserted to make the CBM-I procedure less obvious. The probes were similar to the modification stories, but they had a fixed positive and negative valence, irrespective of CBM-I condition. Thus both groups received the same word fragments as probes. These probes were inserted to examine differences in speed of resolving word fragments of different valence across the training phase.

After CBM-I, interpretation style was assessed (phase iii). Ten ambiguous recognition test items were presented in the same way as the training items, except that each story had a title and was presented in a uniquely identifiable context, replicated from Mathews and Mackintosh (2000). To maximise the resemblance of these items to those presented in the training phase, participants once again were required to resolve a word fragment and to answer a comprehension question in each test item. However, the valence of the story now remained ambiguous. For example, an ambiguous test item is as follows (with the completed word fragment in parentheses):

> *The house-warming party*
> *Your neighbour has a house warming party and you are invited. You arrive to find many other guests whom you do not know. You try talking to some of them, and can see how much they are interested in your …*
> *c--ver--ti-n (conversation).*

Then the comprehension question followed:

> *Was the party thrown by a relative of yours?*

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

(a) You talk to some guests and can tell that they find you interesting.
(b) You talk to some guests but they think what you say is boring.
(c) You meet some guests whom you know and enjoy talking to them.
(d) You don't know any one there and everyone ignores you completely.

Emotional assessment instruments. Level of anxiety was measured with the State/Trait Anxiety Inventory (Spielberger et al., 1983). Stress vulnerability was measured with two computerized visual analogue mood scales (VAS) before and after the stress task (phase iv). One scale assessed anxiety and was labelled at opposite ends with the words *'relaxed'* and *'anxious'*, respectively. The other scale assessed depression and was labelled at opposite ends with *'happy'* and *'depressed'*. Both scales consisted of a 15-cm horizontal line and participants could indicate their mood with a mouse click on the line. Each scale completion yielded a score ranging from 0 to 100, with a higher score indicating a higher level of the relevant negative mood state.

Assessment of learning a rule. Whether participants had explicitly learnt a rule about the emotional valence of the training stimuli was assessed in two ways at the end of the experiment. Firstly, the participants scored the statement *'The stories in the present study often ended ---'* by indicating their answer on a computerized VAS, with the left extreme being *'very badly'* and the right extreme being *'very well'*. Secondly, it was asked *'If you had to characterise the typical ending of the stories you have read in this study, then you would say that the ending was often 1. negative, 2. positive, or 3. neutral.'* The answer was given by pressing a number on the keyboard.

Filler task. In phase ii (rest phase) a paper and pencil filler task was used to reduce possible increases in anxiety due to the training procedure itself. Participants completed exercises from the Wechsler Vocabulary subtests (Wechsler, 1981) until they heard a short beep after ten minutes, which signalled the end of the filler task and resumption of the computer experiment.

Stress task. An anagram stress task was given to elicit hypothesised variations in stress vulnerability affected by CBM-I (phase iv). The task was adapted from the anagram stress task used by Macleod et al. (2002), which has demonstrated its stress inducing qualities. Participants were told that the task would be difficult, but that highly intelligent participants like students usually perform well. It was also explained that a meeting with other students (see *Procedure*) would take place afterwards, to discuss each individual's performance. Participants were shown 15 anagrams on a computer screen, one at a time. The objective was to solve as many anagrams as possible, by writing down the correct words on a response sheet and pressing the space bar to receive the next one. When no response was detected in 20 s, the computer signalled that they had to be faster. Half of the anagrams were extremely difficult and consisted of 13 or more letters. The other half ranged from simple to quite difficult (4 to 9 letters). Participants were informed about the extreme difficulty of the anagram task at the end of the experiment.

Experimental software. The experiment was carried out on a PC compatible computer and programmed using E-prime version 1.1 (Schneider, Eschman, & Zuccolotto, 2002).

Procedure

Participants were tested in groups of 4 to 7 persons. The computers in the room were separated with a partition to prevent participants from seeing each other during testing. After the experimenter explained the procedure in sufficient detail, participants gave written informed consent. Each participant was allocated at random to the positive or negative CBM-I condition. The computer-program was initiated by pressing the spacebar and began by presenting the state and trait versions of the STAI (Spielberger et al., 1983). Then participants carried out the CBM-I procedure for approximately one hour, which was followed by the STAI-state questionnaire. After a break of ten minutes in which the filler task was performed, participants completed the STAI state questionnaire for the third time. Participants then carried out the recognition test and thereafter completed the STAI questionnaire for the fourth and final time. The session ended with the stress task and the assessment of explicit knowledge of the training valence. The whole session took approximately two hours. At the end of the testing session, participants were debriefed and the non-existence of a meeting about their performances on the stress task was revealed.

Results

Reaction times to probes

A 2 x 2 x 2 mixed model ANOVA was performed with group (positive vs. negative CBM-I) as the between-subjects factor and probes (positive vs. negative) and time (first vs. second half) as the within-subject factors. A large main effect of time was found, $F(1, 116) = 169.2$, $p < .001$, indicating faster responses in the second half of CBM-I . However, this effect was qualified by a significant Probe x Time interaction effect, $F(1, 116) = 38.7$, $p < .001$ and a Group x Time interaction effect, $F(1, 116) = 4.3$, $p < .05$. The predicted Group x Probe interaction effect was significant, $F(1, 116) = 25.0$, $p < .001$. Participants in the negative

CBM-I group reacted significantly faster to negative than to positive probes (negative probes *M* = 1403.3 ms, *SD* = 476.5 vs. positive probes *M* = 1536.1 ms, *SD* = 513.2), and participants in the positive CBM-I group reacted faster to positive than to negative probes (positive probes *M* = 1350.5 ms, *SD* = 359.7 vs. negative probes *M* = 1568.7 ms, *SD* = 479.9) (see Figure 2). Thus, as indicated by the reaction time to solve word fragments congruent with CBM-I condition, the procedure was highly effective in modifying interpretive bias.

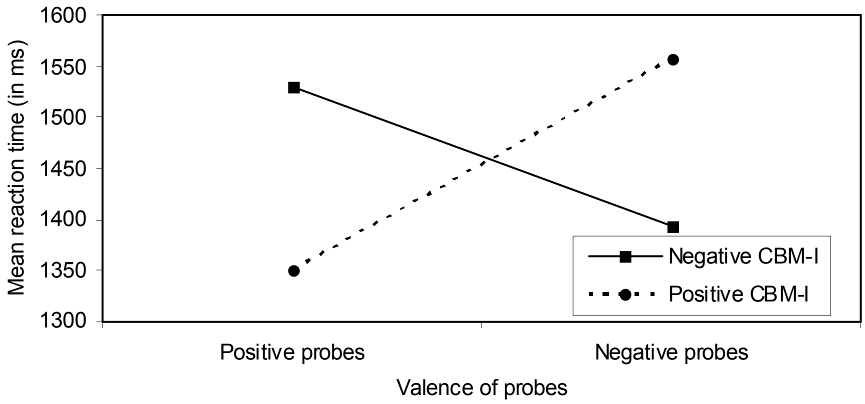

Figure 2.
Mean reaction times (in ms) to solve positive and negative probes during CBM-I

Recognition ratings

Mean recognition ratings were individually calculated and entered into a 2 x 2 x 2 mixed model ANOVA with group as the between-subjects factor and valence (positive vs. negative) and target (possible vs. foil interpretation) as the within-subject factors. This analysis revealed a large main effect of valence, $F(1, 116) = 40.4$, $p < .001$ and target, $F(1, 116) = 698.3$, $p < .001$, reflecting respectively greater endorsement of positive and possible interpretations. However, these effects were qualified by a significant Group x Target interaction effect, $F(1, 116) = 6.9$, $p < .01$ and a Group x Valence interaction effect, $F(1, 116) = 93.4$, $p < .001$. More interestingly, the analysis revealed the predicted three-way interaction effect of Group x Valence x Target, $F(1, 116) = 26.6$, $p < .001$. To decompose this interaction effect, we carried out separate analyses for possible and foil interpretations. Both analyses revealed a Group x Valence interaction effect: for possible interpretations, $F(1, 116) = 95.0$, $p < .001$ and for foil interpretations, $F(1, 116) = 45.1$, $p < .001$. This reflected the fact that positively trained participants were more likely to rate the positive interpretations as being similar to the original stories than were negatively trained participants (for possible interpretations: positive group *M* = 3.06, *SD* = 0.43 vs. negative group $M = 2.64$, $SD = 0.40$, $d = 1.52$). Conversely, negatively trained participants were more likely to rate the negative interpretations as being similar to the meanings of originally presented stories than were the positively trained participants (for possible interpretations: negative group $M = 2.92$, $SD = 0.44$ vs. positive group $M = 2.25$, $SD = 0.44$, $d = 1.01$) (see Figure 3). Thus participants interpreted ambiguous information in a fashion that was congruent with their CBM-I condition.

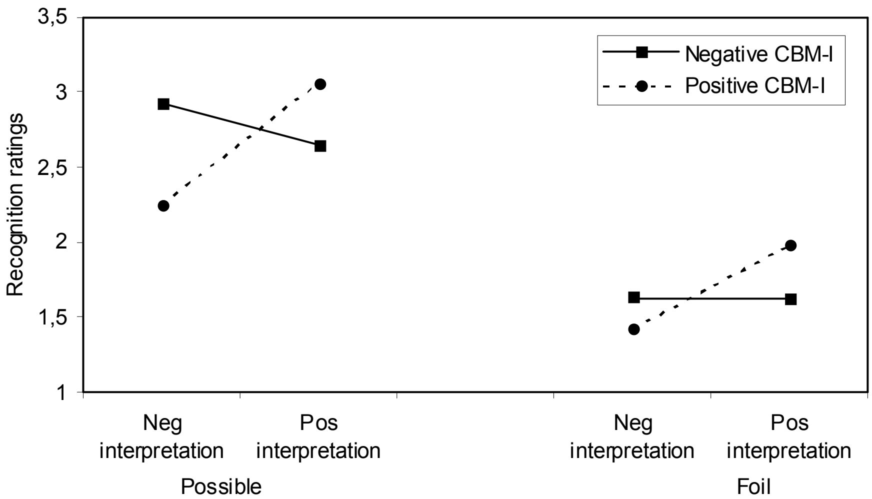

Figure 3.
Recognition ratings for possible and foil interpretations with negative and positive valence depicted for each CBM-I group
Note. Recognition ratings ranged from 1 (*very different*) to 4 (*very similar*). Neg interpretation = negative interpretation and pos interpretation = positive interpretation.

The recognition data were also analysed using the signal detection method (McNicol, 1972). Some empty cells necessitated collapsing values on the 4-point scale into a 2-point scale by counting responses of 1 or 2 (very different or fairly different) as a difference response and 3 or 4 (fairly similar or very similar) as a similar response. Two measures were calculated: sensitivity (the ability to discriminate between possible and foil interpretations) and response bias (the tendency to prefer *different* or *similar* as a response). A 2 x 2 ANOVA with group as the between-subjects factor and valence as the within-subject factor was performed with a nonparametric measure of sensitivity, the arcsin transformation of P(A), as the dependent variable. There was a significant main effect of group, $F(1, 116) = 7.7$, $p < .01$ due to the fact that, in general, negatively trained participants were more sensitive. However, this effect was qualified by a significant Group x Valence effect, F(1,

116) = 11.2, p = .001. For participants exposed to the negative interpretations, mean sensitivity was greater for negative than for positive items (0.75 vs. 0.71 respectively) and the reverse was found for participants exposed to the positive interpretations (0.71 for positive items vs. 0.66 for negative items) (non transformed means were given). The analysis of response bias (beta) scores produced a significant main effect of valence, $F(1, 116) = 13.9$, $p < .001$ and of group, $F(1, 116) = 5.8$, $p < .05$. In general, participants responded with more *similar* answers to positive items compared to negative items and positively trained participants made more *similar* responses. More importantly, the predicted Group x Valence interaction effect was significant, $F(1, 116) = 17.7$, $p < .001$. Participants trained in positive interpretations responded with more *similar* responses to positive items compared to the negatively trained group (2.3 vs. 0.6) and the latter group endorsed the negative items more often compared to the positively trained group (0.7 vs. 0.2). Thus, these results from the signal detection analysis again confirm the effectiveness of CBM-I in changing interpretations.

Anxiety scores

There were no differences between the groups on the STAI-state and trait scales prior to CBM-I. With regard to state anxiety, measured at four points across the session, overall, no significant effects emerged (Figure 4).

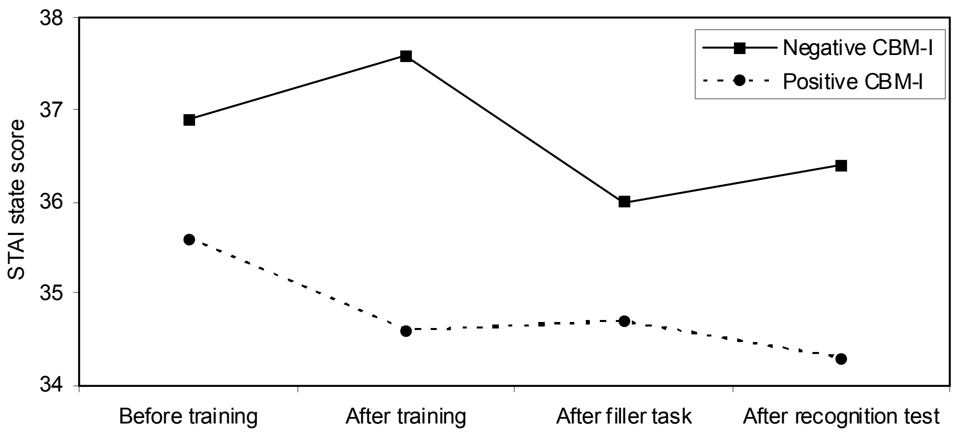

Figure 4.
Mean state anxiety scores at four points for each CBM-I group

To specifically determine the impact of CBM-I on state anxiety, a 2 x 2 ANOVA was carried out with group as the between-subjects factor and time (before and after CBM-I) as the within-subject factor. A trend for a Group x Time interaction effect was revealed, $F(1, 116) = 2.12$, $p = .07$ (one-tailed), $d = .27$. The nature of this interaction effect was consistent with the prediction that after CBM-I, negatively trained participants would be more anxious than positively trained participants (*M* = 37.6, *SD* = 8.9 vs. *M* = 34.6, *SD* = 8.1). To test whether these anxiety scores returned to baseline following the rest phase, another 2 x 2 ANOVA was carried out with time (before and after the filler task) as the within-subject factor. This analysis revealed a significant Group x Time interaction effect, $F(1, 116) = 3.3$, $p < .05$ (one-tailed), reflecting the fact that the heightened scores in the negatively trained group decreased compared to the scores in the positively trained group. It seems that CBM-I had some influence on anxiety level, which disappeared after the rest phase.

Emotional reactions to the stress task

To assess changes in anxiety and depression elicited by the stress task, the scores obtained on the analogue mood scales were subjected to a 2 x 2 ANOVA with CBM-I group as the between-subjects factor and time (before vs. after the stress task) as the within-subject factor. While the main effect of group was not significant in the analysis of either mood scale (anxiety: $F(1, 116) = 0.45$, *ns*, depression $F(1, 116) = 0.16$, *ns*), a significant main effect of time was found for both anxiety and depression scale scores; anxiety: $F(1, 116) = 56.7$, $p < .001$, depression: $F(1, 116) = 9.3$, $p < .01$. This indicated an increase in anxiety and depression after the stress induction procedure (anxiety: before 16.5 vs. after 29.8, depression: before 34.4 vs. after 38.2). However, the crucial Group x Time interaction effect was not significant (anxiety: $F(1, 116) = 0.54$, *ns*, depression: $F(1, 116) = 0.05$, *ns*). Hence, although the stress task was capable of elevating negative mood, the degree of elevation did not differ across CBM-I conditions. Thus, the hypothesis that participants trained in negative interpretations would react with more stress to the task was not confirmed.

Learning a rule

In the group exposed to positive CBM-I, 93% of the participants indicated that the stories ended positively. Conversely, 88% of the negatively trained participants indicated that the stories ended negatively. This indicates that both groups were, by and large, aware of the emotional nature of the stimuli presented. Analysis of the VAS-scale ratings concerned with explicit knowledge of the stories revealed a highly significant group effect, $t(116) = 19.5$, $p < .001$. This confirms that the stories were considered negative after negative CBM-I (*M* = 25.3) and positive after positive CBM-I (*M* = 82.1).

Secondly, to appraise the influence of this explicit knowledge on the actual interpretive bias shown following CBM-I, the analyses of the recognition ratings were repeated with level of knowledge concerning the valence of the stories added as a covariate. With regard to VAS scale scores obtained for foil sentences, the previously demonstrated Group x Valence effect failed to reach significance when degree of explicit knowledge was added as a covariate. For the scores obtained for possible interpretations, the effect remained significant, although the F-value dropped substantially from $F = 95.0$ to $F = 9.9$. Given these findings, it seemed plausible that knowledge about the valence of the stories might mediate the differential recognition performance of the CBM-I groups. To determine whether there was a mediational pathway, two separate four step mediational pathway analyses were performed for foil and possible interpretations respectively (Baron & Kenny, 1986; Holmbeck, 2002). For foil sentences, it was shown that group was a significant predictor of recognition, $r = .50$, $p < .001$. Secondly, it was shown that group is a significant predictor of the possible mediator knowledge, $r = .88$, $p < .001$. The third step was to show that knowledge is a significant predictor of recognition, when controlling for CBM-I group. This was the case, ß = -.38, $p < .05$. Finally, it was tested whether group was a significant predictor of recognition, when controlling for knowledge. This analysis revealed that the effect of group on recognition ratings was no longer significant, ß = .16, *ns*. To determine whether the total effect of group on recognition ratings was reduced significantly upon introduction of the mediator, we used Sobel's (1988) significance test. It was shown that the mediation was significant, $z = 1.99$, $p < .05$ and that knowledge accounted for 69% of the total effect of CBM-I group on the foil recognition ratings. The same analyses were performed for possible interpretations and revealed that knowledge again partially mediated the relationship between CBM-I group and recognition ratings. The first step showed that group significantly predicted recognition, $r = .63$, $p < .001$. Secondly, as was already shown, group predicted knowledge significantly, $r = .88$, $p < .001$. Thirdly, knowledge was a significant predictor of recognition, when controlling for group, ß = -.30, $p < .05$. And during the final step, when controlling for knowledge, the effect of group on recognition was reduced, but not eliminated, ß = .37, $p < .05$. Sobel's significance test showed that the mediation was significant, $z = 2.96$, $p < .05$ and that 45% of the effect of CBM-I group on possible interpretations was mediated by explicit knowledge regarding the valence of the stories. Thus, both for possible and foil sentences, CBM-I seemed to directly influence recognition, but also seemed to exert some of its influence via explicit knowledge about the stories.

Discussion

The results of the present study show that biased processing of ambiguous information can be modified by training. Positively trained participants solved the positive word fragments faster than the negative ones and the reverse was found to be the case for the negatively trained participants. More importantly, when confronted with new ambiguous information, participants interpreted this information congruent with their positive or negative CBM-I condition. However, neither the effects on state anxiety, nor on stress vulnerability, were significant. Participants who were exposed to positive and negative interpretations did not differ on measures of anxiety or anxiety vulnerability. Regarding awareness of the training procedure, results indicated that the vast majority of the participants were explicitly aware of the emotional outcomes of the disambiguations of the stories and this awareness partially mediated the effects of CBM-I direction on interpretive bias.

The results concerning the successful change of interpretive style are in line with previous findings (Hertel, Mathews, Peterson, & Kintner, 2003; Mathews & Mackintosh, 2000; Yiend et al., 2005). The present results show that Mathews and Mackintosh's approach to modify interpretive bias in non-anxious individuals yields highly robust and clearly replicable effects. When compared to Mathews and Mackintosh's results, the effect sizes (Cohen, 1998) of induced interpretive biases were comparable for positive test items (Mathews & Mackintosh: d = 1.95 and the present study: d = 1.52; see results) and also for negative test items (Mathews & Mackintosh: d = .55 and the present authors: d = 1.01). This indicates that the two series of experiments were equally successful in changing interpretations.

However, the present results regarding the absence of effects of CBM-I on anxiety are in contrast with the significant effects reported by Mathews and Mackintosh (2000). Given the similarity of the effect sizes discussed above, it is unlikely that the discrepancy can be explained by differences in the effectiveness of CBM-I. It is possible that other subtle differences between the studies can account for this important discrepancy. Firstly, participants in the present study were initially more anxious than Mathews' participants (respectively 36.20 vs. 27.05 on the STAI state). The possibility cannot be excluded that the capacity for interpretive style to influence anxiety is affected by initial anxiety level. Another dissimilarity is that in the present study psychology students served as participants, while in the Mathews and Mackintosh study community volunteers participated. Students are relatively familiar with experiments, and their underreporting of changes in anxiety may have resulted from an unwillingness to admit that they were emotionally affected by CBM-I. Future research with anxiety measures that are less easily affected by explicit strategies could address this issue. In addition, the difference in populations probably coincides with a difference in IQ. Due to higher intelligence, the student sample might have been more conscious of the learnt rule, which might have reduced the emotional impact of CBM-I. However, the correlation between the degree of knowledge of the rule and change in anxiety was not significant, r = .07, rendering this IQ explanation less likely. It should also be noted that in earlier UK studies (Mathews & Mackintosh; Yiend et al., 2005), the effect of CBM-I on anxiety varied: significant effects of interpretive style on state anxiety were reported for some studies (Mathews & Mackintosh exp. 1, d = 1.55 and Yiend et al. exp. 1, d = .86), but Yiend et al. failed to observe any effect of interpretive style on state anxiety in her third experiment (d = .23). A power analysis based on these three previous experiments with the same set-up, design, stimulus materials etc, as our own, revealed an estimated power of .92 to observe the predicted effect of biased interpretation on anxiety, given the sample size used in the present study. Thus, it seems unlikely that the lack of significant effects resulted from power problems. Nonetheless, the possibility of a type II error always remains. The present authors are inclined to take this possibility seriously given that in yet another different and independent experiment using a comparable methodology, significant mood effects *were* found (Salemink, van den Hout, & Kindt, 2007).

In the present study, participants reported that they were aware of the fact that, the stories tended to end in a particular, emotionally relevant way (i.e., negatively or positively, depending on CBM-I condition). One may wonder if perhaps this awareness was elicited by the questioning itself, but absent during the training giving previously. It should be noted, however that the use of the knowledge scores as a covariate, significantly reduced the effects of training on recognition task responses. Any degree of awareness of the emotional relevance of the materials generated during the questioning which followed the recognition task would not have affected scores on the recognition task itself. Interestingly, results indicated that knowledge partially mediated the effect of training on the possible and foil recognition sentences. Thus, while interpretive training had direct impact on recognition performance, it had also impact on interpretations via the acquired knowledge of the emotional tone of the training stimuli. Although the degree of explicitness of the processes affected by the present modification is an interesting issue in and of itself, the mere presence of conscious knowledge does not undermine the comparison between these processes and those believed to operate in clinical anxiety. Anxious patients often provide explicit reports of their use of disambiguation rules, such as ‘if people see me blushing, they will reject me’, ‘if I feel dizzy, I may faint’ and the explicitness of such rules does not prevent the rules from being applied.

Macleod et al. (2002) argued that the crucial issue is not whether biases give rise to increases in anxiety as such, but instead how these biases may contribute to vulnerability to react anxiously to later stressors. The present results show that the absence of effects on anxiety was matched by null effects on vulnerability. It is possible that the anagram stress task was not an appropriate stress task for use in the present study. Because the stimuli used in the CBM-I procedure were specifically relevant to social anxiety, we attempted to make the stressor socially relevant. Specifically, the instructions included the threat of a meeting with other participants to discuss performance following completion of the anagrams. However, we do not know whether this was sufficient to act as a social stressor for the participants. It is also possible that the present stress task did not involve enough ambiguity for the trained interpretive bias to influence the emotional response to this task. Another possibility is that longer or multiple training sessions might be required for CBM-I to have some effect on anxiety and stress vulnerability.

Future research could focus on the generalisation of the effects of trained processing biases. First and foremost, do the trained cognitive changes generalise to changes in affect? Would the training influence, for example psychophysiological or implicit cognitive reactions that are not, or less, amenable to self-presentation strategies? Second, do trained biases generalise to the processing of other stimuli (pictures, facial expressions, behaviours), to other contexts, to active (self generated) interpretations, to implicit measures of interpretation, etc.? Finally, given the fact that biases can be modified, the exciting possibility is raised that cognitive biases in high anxious individuals may be ameliorated using these training procedures. Studies hitherto have involved unselected participants, but would training highly anxious individuals *not* to negatively disambiguate ambiguous situations or *not* to selectively attend to negative stimuli have a beneficial effect on their emotional state? Earlier it was noted that various forms of Cognitive Behaviour Therapy (CBT) modify automatic biases (Eysenck et al., 1991; Mathews, Mogg, Kentish, & Eysenck, 1995; van den Hout, Tenney, Huygens, & de Jong, 1997). What would be the clinical effects of directly targeting automatic cognitive biases? Given the magnitude of changes in anxiety symptoms brought about by CBT, it is unlikely that standard CBT procedures will be superseded by the use of training procedures to modify automatic biases, but a comparison would be highly informative. Would retraining interpretive or attentional bias reduce relapse rates? Certainly, there would be much scope for clinical investigation using these procedures.

In summary, overwhelming evidence accumulated over the last twenty years demonstrates a robust association between anxiety and the selective processing of threatening information. Surprisingly, the vast majority of these studies have used a correlational design, which leaves the causality issue undetermined. The present experimental study specifically addressed this shortcoming in existing research. Results revealed that an interpretive bias can be trained, although the modification process is not completely implicit. In contrast to previous studies, the effects of CBM-I on mood were fragile, and stress vulnerability effects were not detected. The question concerning the causal role of processing biases in the origin and maintenance of affective disorders is far from new (MacLeod & Hagan, 1992; van den Hout, Tenney, Huygens, Merckelbach, & Kindt, 1995), but thanks to recent work by Macleod et al. (2002) and Mathews and Mackintosh (2000), paradigms have become available to examine the issue experimentally, leaving room for fresh studies.

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Trained interpretive bias: Validity and effects on anxiety

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Abstract

Mathews and Mackintosh developed a clever training procedure that enables the investigation of a causal relationship between interpretive bias and anxiety (J Abnorm Psychol, 2000, Vol 109, 602-615). The present study examined the validity of this paradigm by testing 1) the effects of interpretation training on two other tasks (homograph EAST and open-ended questionnaire) that are less closely related to the interpretation training itself as in previous studies and 2) the robustness of the training effects on state and trait anxiety. Results indicated that while the two original dependent measures (i.e., a reaction time and recognition measure) showed that the training procedure was successful in changing interpretations, the two additional measures (i.e., EAST and questionnaire) did not. This might reflect a measurement artefact, but other explanations for the findings are also possible. Moreover, evidence was found for effects of biased interpretations on anxiety. This demonstrates the viability of the present paradigm, which has implications for clinical practice.

Introduction

Anxiety disorders are characterised by the selective processing of threatening information. Correlational studies evidenced that anxious individuals impose threatening interpretations on ambiguous information (Butler & Mathews, 1983) and subsequent prospective studies have indicated that maladaptive processing styles predict later emotional reactions to stress (MacLeod & Hagan, 1992). However, not until the beginning of the twenty-first century were experimental studies undertaken to determine whether or not processing biases causally contribute to anxiety (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Mathews & Mackintosh, 2000). Mathews and Mackintosh trained participants to interpret ambiguous information negatively or positively and both a reaction time measure and a recognition test revealed that interpretations were indeed altered in the direction of the training. In addition, they found congruent effects of the training on anxiety. These findings provided evidence consistent with a causal relationship between interpretive bias and anxiety.

In the Mathews and Mackintosh (2000) study, the dependent variable measuring interpretive bias closely resembled the independent variable. During the Cognitive Bias Modification of Interpretations (CBM-I, independent variable), participants read ambiguous social stories, which ended with a word fragment. Completion of the fragment resolved the ambiguity in a positive or negative way, depending on the assigned training condition. One of the dependent measures was a reaction time measurement: the time taken to solve the positive and negative word fragment. The second dependent measure was a recognition task, which followed training. Participants read social stories that remained ambiguous and were asked to indicate the level of similarity between the experimenter-provided interpretation and the original ambiguous story. Since both the training and interpretive bias test consist of social stories and are explicit tasks, the dependent and independent measures resemble each other in content and format. Due to this overlap, the effects of CBM-I might be due to participants learning a method-dependent strategy, while interpretations need not necessarily be altered. It is therefore questioned whether participants simply learnt a task-specific strategy or whether the procedure is successful in really changing interpretive bias. If the latter is true and interpretations were changed, then the effects of CBM-I on interpretations should be evidenced on other tasks less similar to the independent variables. Thus, the first aim of the present study is to examine whether CBM-I effects are observable on other tasks by adding two interpretive bias assessment tasks, which are less similar to the training than the tasks used by Mathews and Mackintosh.

First, note that Mathews and Mackintosh (2000) used *explicit* tasks to examine change in interpretations and that these tasks are open to strategic influences. Recent results showed that participants are fully aware of the valence of their interpretive bias training (Salemink, van den Hout, & Kindt, 2007). To examine more stringently the effect of CBM-I, a task that is less likely to be influenced by explicit knowledge of training or performance strategies was added. We employed a modified version of the Extrinsic Affective Simon Task (EAST, De Houwer, 2003). The EAST was developed to indirectly assess psychological constructs and attitudes by assessing the interference between valence and colour classifications. First, participants learn to associate one response key (e.g., left) with positive words and another response key (e.g., right) with negative words by classifying the positive or negative valence of words presented in white. Secondly, participants learn to classify words on the basis of a meaning-irrelevant characteristic (e.g., colour). Participants have to press, for instance, the left key for green words and the right key for blue words. In the third phase, target words are presented in colour and are mixed with white words. It can be tested whether participants are faster to respond to a target word in green (which in this example requires a press on the positive button) or in blue (which in this case requires a press on the negative button). For example, De Houwer showed that (in this example) participants are faster to respond to negative words (e.g. hostile) in blue (negative button) than in green (positive button), because of the congruency between the valence of the target word and the required response. Inferior performance is expected during valence incongruent trials, while superior performance is expected during congruent trials. We adapted this EAST paradigm to allow for an implicit test of trained interpretive bias by using coloured homographs as the target stimuli. Since homographs have multiple meanings, they allow for the testing of interpretations of ambiguous information (Richards & French, 1992). Two categories of homographs were used; homographs with a positive and neutral meaning and homographs with a negative and neutral meaning. It was hypothesised that participants trained to impose positive interpretations on ambiguous information would show speeding on coloured positive-neutral homograph trials in which they need to press the extrinsically positive key (congruent trial) and would be delayed when needing to press the negative key (incongruent trial). In a similar vein, negatively trained participants were expected to respond relatively faster on the negative key to coloured negative-neutral homographs and would be relatively slow on the positive key.

Secondly, the dependent test used by Mathews and Mackintosh (2000) was not only explicit, it was also a forced choice recognition task in which the interpretations were not generated by the participants, but provided by the experimenter. That is, after CBM-I, participants read ambiguous social stories and then received four different interpretations of each story. The level of similarity to the original story was rated on a 4-point scale ranging from 1 (*very different*) to 4 (*very similar*) for each interpretation. In this set-up, participants passively indicated the level of similarity, but it remains unclear whether participants would interpret it likewise if interpretations would have been generated by themselves. Pertinent to the present discussion is that patients with an anxiety disorder spontaneously impose threatening interpretations on ambiguous information (Mathews, Richards, & Eysenck, 1989). To test whether trained participants actively impose congruent interpretations on ambiguous information in the absence of interpretations provided by the experimenter, participants received an open-ended questionnaire concerning interpretations of ambiguous situations (Ambiguous Social Situations Interpretation Questionnaire, ASSIQ, Stopa & Clark, 2000). Two categories of questions were used; items referring to social situations and items referring to bodily sensations. We predicted that positively trained participants would impose more positive and less negative interpretations on ambiguous social information compared to negatively trained participants. No specific predictions were made for the bodily sensations items. These items were included to test exploratively whether a trained social interpretive bias generalises to ambiguous physical situations.

Besides testing the boundaries of the CBM-I effects on interpretations, the second aim was to test the effects of CBM-I on anxiety. Mathews and Mackintosh (2000) showed in three experiments that when participants were required to actively generate interpretations, CBM-I had congruent effects on anxiety. However, other experiments using the same set-up, design, stimulus materials as Mathews', had difficulty replicating these effects. Yiend, Mackintosh, and Mathews (2005) actively trained participants to make positive and negative interpretations and found effects on state anxiety in their first experiment, but not in the third one. Using the same CBM-I procedure, Salemink et al. (2007) also failed to observe effects of this training on anxiety. The effects of CBM-I on anxiety seem to be smaller than the effects on interpretations and comparison of effect sizes confirmed this (anxiety: *d* = 0.7 vs. interpretations: *d* = 1.3, Cohen, 1998) (see Salemink et al.). The influence on anxiety might be more fragile and therefore the second aim was to test the robustness of CBM-I effects on anxiety.

Method

Participants

Eighty-one students at Utrecht University, the Netherlands (*M* age = 21.1 years, *SD* = 2.8) took part in the present study for course credit.

Materials and apparatus

Interpretive bias modification. The stories used in the experiment were translations of those used by Mathews and Mackintosh (2000). During CBM-I, eight blocks of 13 stories were presented on a personal computer, with an option for rest given after each block. Each block contained eight modification stories, three filler stories, and two probes. The modification stories were created to train participants to make emotional interpretations of a particular valence. Each modification story consisted of three lines that were ambiguous in terms of valence. The final word of the story was presented as a word fragment and disambiguated the story, whose meaning had remained ambiguous until this point. In the positive CBM-I condition the stories would have a positive outcome and in the negative condition a negative outcome. Participants were asked to complete the fragment as quickly as possible after which a comprehension question with relevant feedback appeared on the screen to reinforce the interpretation imposed by the word fragment. An example of a modification story with the completed word fragment for each CBM-I condition in parentheses, is as follows:

> *A friend invites you to a dinner party that she is holding. She tells you who the other guests are, but you do not recognise any of the other names. You go anyway and on the way there, you think that the other guests will find you …*
> *ti--s--e (tiresome)/so--a-le (sociable)*

Then the comprehension question followed:

> *Were you well liked at the party?*

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

Mathews and Mackintosh's test of interpretive bias (a): Reaction time. During the training procedure, change in interpretation style was being measured with probes. Each block contained two probes, which are similar to the modification stories, but have a fixed positive and negative valence, irrespective of CBM-I condition. The speed of resolving word fragments was the dependent measure.

Mathews and Mackintosh's test of interpretive bias (b): Recognition. After the training, interpretation style was assessed. Ten ambiguous recognition test items were presented in the same way as the training items, except that each story had a title and was presented in a uniquely identifiable context, following Mathews and Mackintosh (2000). To maximise 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 story now remained ambiguous. For example, an ambiguous test item is as follows, with the completed word fragment in parentheses:

> *The evening class*
> *You've just started going to an evening class. The instructor asks a question and no one in the group volunteers an answer, so he looks directly at you. You answer the question, aware of how your voice must sound to the …*
> *oth--s (others)*

Then the comprehension question followed:

Have you been going to the evening class for a long time?

In the second part of the recognition test, participants saw the title of the ambiguous story, this time together with four interpretations of the story. These interpretations represented a) possible positive interpretation, b) possible negative interpretation, c) positive foil sentence, and d) negative foil sentence. Example sentences of the previously presented ambiguous test item are as following:

a) You answer the question, aware of the others listening attentively.
b) You answer the question, aware of how unsteady your voice sounds.
c) You answer the question and then realise what a good answer it is.
d) You answer the question, but realise that you have made a mistake.

Participants rated each sentence independently for its similarity in meaning to the original story. A 4-point scale was used, ranging from 1 (*very different in meaning*) to 4 (*very similar in meaning*).

Additional test of interpretive bias (a): EAST. In the Extrinsic Affective Simon Task (EAST), 26 words were presented in colour on a PC screen; 21 homographs: ten negative-neutral, six positive-neutral and five neutral-neutral and five unambiguous words with a single neutral meaning. In addition, five positive words and five negative words were presented in white (see Appendix). The homograph stimuli were selected from an initial pool of 58 homographs on the basis of ratings provided by 12 psychology students. All 58 candidate homograph words were presented in random order to the students. The participants had to write down the meaning of a homograph, which came to mind first. The homographs, of which both meanings were reported, were selected for the present experiment. Secondly, they received both meanings of all the homographs and rated each valence on a Visual Analogue Scale (0 = *negative*, 5 = *neutral*, and 10 = *positive*). As to the included negative-neutral homographs, the negative meanings had a mean rating less than 3.0 and the neutral meanings ranged between 5.2 and 6.4. As to the included positive-neutral homographs, the positive meanings had a mean rating more than 6.9 and the neutral meanings ranged between 4.4 and 6.3. The mean rating difference between two meanings of a homograph was at least 1.6 (M = 3.27).

Participants received two practice blocks of 20 trials. The first block consisted of white words (the ten white words presented twice) and the second of coloured words (the five neutral words presented four times, twice in each colour). The test phase consisted of two blocks with an optional rest between them. Each test block contained 102 trials during which each of the homographs and the neutral words was presented twice and each of the white words five times. The first test block started with four white practice trials and the second started with two white practice trials. In all blocks, stimuli were presented in a random order with the restriction that the required response could not be the same on four or more consecutive trials and a valenced white word could not precede a homograph.

Each trial consisted of a black background where a white fixation cross was presented for 500 ms, then a word appeared in the middle of the screen until a correct response was given. If an incorrect response was made, a red cross appeared underneath the word until the participant pressed the correct key. All participants were instructed to press the “q” key for white words with a negative meaning and the “p” key for white positive words. Half of the participants were instructed to press the negative (“q”) in response to green words and the positive key (“p”) in response to blue words. The other participants received the reversed colour-response assignment. Unlike the original EAST, a coloured homograph was not presented in both colours within a participant. This was done to avoid the possibility that pairing a homograph with a specific colour and thus with a specific valence of a response key results in the homograph being associated with that specific valence, which might affect the response when that homograph is presented in the other colour. Responses to that particular homograph in the other colour, which is associated with the other valence, might be disproportionately slow due to the first pairing between the homograph and a valence. Therefore, a homograph was presented in one colour within a participant. Half of the total set of negative-neutral homographs was presented in green and the other half in blue and similarly for the positive-neutral homographs.

Additional test of interpretive bias (b): Open-ended questionnaire. To measure participants’ self-generated interpretations of ambiguous situations, the open-ended version of the Ambiguous Social Situations Interpretation Questionnaire of Stopa and Clark (2000) was used. Participants received short descriptions of stories that ended with the question ‘Why?’ The questionnaire contained 14 ambiguous social stories, seven ambiguous physical stories and three filler stories. An example of a social story is as follows: “You join a group of colleagues for lunch at work. As you sit down, two people in the group get up to leave without saying anything.” And an example of a physical story is: “You have a sudden pain in your stomach.” Participants were asked to type in, first thing that came to mind, about what they thought what was happening. Answers were scored as positive, negative, neutral or not classifiable.

Anxiety assessment. Before and after CBM-I, anxiety was measured with the state and trait versions of the State-Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983).

Procedure

In groups of three persons, participants received detailed information about the procedure, after which they gave written informed consent. Each participant was allocated at random to the positive or negative CBM-I condition and was individually tested in a sound attenuated cubicle. The computer-program first presented the state and trait versions of the STAI (Spielberger et al., 1983). Then participants carried out the CBM-I procedure for approximately one hour, followed by the state and trait versions of the STAI for the second time. Following completion of the questionnaires, half of the participants received the EAST task, followed by the open-ended questionnaire, while the other half started with the questionnaire and received the EAST afterwards. This was followed by the completion of the recognition test and the session ended with a debriefing. The whole session took about 1.5 hours.

Results

Mathews and Mackintosh's tests of interpretive bias

a) Reaction times to solve probes. To test whether CBM-I was effective in influencing interpretations, a 2 x 2 mixed model ANOVA was performed with group (positive vs. negative CBM-I) as the between-subjects factor and probes (positive vs. negative) as the within-subject factor. There was a main effect of probe, $F(1, 79) = 3.87$, $p = .05$, with faster responses to positive than to negative probes. However, this was qualified by the predicted Group x Probe interaction effect, $F(1, 79) = 7.29$, $p < .05$. Whereas the negative training did not lead to different reactions to positive and negative probes, $t(40) = 0.43$ (*M* pos = 1347 ms, *SD* = 434 vs. *M* neg = 1318 ms, *SD* = 491), the positive training did, $t(39) = -4.62$, $p < .001$. Positively trained participants resolved the positive word fragments faster than the negative ones (*M* pos = 1326 ms, *SD* = 453 vs. *M* neg = 1513 ms, *SD* = 467).

b) Recognition ratings. A 2 x 2 x 2 mixed model ANOVA was performed with group as the between-subjects factor and valence (positive vs. negative) and target (possible interpretation vs. foil sentence) as the within-subject factors. Analysis revealed a large main effect of valence, $F(1, 79) = 91.77$, $p < .001$, and target, $F(1, 79) = 706.91$, $p < .001$, reflecting respectively greater endorsement of positive and possible interpretations. Furthermore, there was a significant Valence x Target interaction effect, $F(1, 79) = 4.03$, $p < .05$, and a Group x Valence interaction effect, $F(1, 79) = 67.84$, $p < .001$. More interestingly, these effects were qualified by the predicted three-way interaction effect of Group x Valence x Target, $F(1, 79) = 5.04$, $p < .05$. To decompose this interaction effect, we carried out separate analyses for possible interpretations and foil sentences. Both analyses revealed a Group x Valence effect: for interpretations, $F(1, 79) = 44.98$, $p < .001$, and for foils, $F(1, 79)$

= 60.19, $p < .001$. Inspection of the effects of CBM-I for each condition separately, revealed that these results are congruent with results from the reaction time data. Positive CBM-I was effective in promoting training congruent interpretations, $t(39) = 14.20$, $p < .01$ (M pos = 3.25, SD = 0.25 vs. M neg = 2.28, SD = 0.39), while the negative training was not, $t(40)$ = 0.48 (M pos = 2.83, SD = 0.45 vs. M neg = 2.78, SD = 0.51). When presented with new ambiguous information, positively trained participants endorsed the positive interpretations more than the negative interpretations, confirming the effectiveness of the positive interpretive bias training procedure in affecting interpretations.

Additional tests of interpretive bias

a) EAST. To test interpretive style with the EAST, only trials with coloured homographs were analysed. The improved scoring algorithm (so-called *D600 measure*) as described by Schmukle and Egloff (2006) was used. Trials with latencies above 10.000 ms were excluded (two trials) and error trials were included by replacing their latency with the mean latency of correct trials plus 600 ms error penalty (7.1%) (see Table 1). In addition, an EAST score was calculated separately for positive and negative homographs by deducting the latency of trials with an extrinsically positive response from trials with a negative response. This difference was then divided by the individual standard deviations of the latencies of these trials to create the D600-measure.

Table 1.
Mean reaction times in ms and percentage of errors (*SD* in parentheses) on trials with positive-neutral and negative-neutral homographs after positive and negative CBM-I

	Positive CBM-I (n = 40)		Negative CBM-I (n = 41)	
	Pos-Neu homograph	Neg-Neu homograph	Pos-Neu homograph	Neg-Neu homograph
Reaction time				
Positive response	607 (131)	640 (156)	625 (124)	652 (178)
Negative response	612 (138)	595 (118)	618 (130)	613 (145)
Percentage of errors				
Positive response	5.00 (7.96)	5.13 (6.35)	2.03 (4.07)	5.12 (7.29)
Negative response	2.08 (4.90)	2.00 (5.86)	2.24 (6.98)	1.95 (5.23)

Note. Pos-Neu homograph stands for positive-neutral homograph and Neg-Neu homograph stands for negative-neutral homograph.

Data was initially analysed with a 2 x 2 x 2 ANOVA with group and order (EAST first vs. second) as the between-subjects factors and stimulus (negative-neutral homograph vs. positive-neutral homograph) as a within-subject factor. Since, neither the main effect of order, nor any interaction effects with order were significant, all *F*'s < 1.31, the analyses were continued without the factor order resulting in a 2 x 2 repeated measures ANOVA. A main effect of stimulus was found, $F(1, 79) = 10.56$, $p < .05$, when a negative-neutral homograph was presented, negative responses were given more quickly than positive responses, $t(80) = -4.32$, $p < .001$ and when a positive-neutral homograph was presented, no differences between a positive and negative response emerged, $t(80) = .63$. The main effect of group was not significant, F (1, 79) = 0.22, neither was the predicted crucial Group x Stimulus interaction effect, F (1, 79) = 0.51, $f = .14$ (Cohen, 1998). Given an alpha level of .05 and total sample size of 79, the power of the *F*-test to detect large effect sizes in this study was .94, the power to detect medium effect sizes was .59, and the power to detect small effect sizes was .14. In sum, although the EAST interference effect was confirmed for negative-neutral homographs, no training effects were found[1].

b) Open-ended questionnaire. All the interpretations given to the open-ended questions were rated by the same research assistant. In addition, interpretations of a subset of 15 participants were also rated by the experimenter (E.S.) to be able to calculate the inter-rater reliability. Both the research assistant and the experimenter were blind with respect to the training that the participants had received. Analyses revealed that the mean kappa value per item was .83 (range .42 to 1.0), indicating good inter-rater reliability.

To test whether the effect of CBM-I on interpretations could be observed on self-generating interpretations, a 2 (group) x 2 (valence: positive vs. negative interpretations) x 2 (order) ANOVA was carried out. Since, results revealed no main or interaction effects with order, the ANOVA analyses were continued without the factor order. Results indicated neither a Group x Valence interaction effect on the social items, F (1, 79) = .12, $f = .04$, nor on the physical items, $F = 0.69$, $f = .09$. On the social items, positively trained participants gave in total 2.18 ($SD = 1.15$) positive and 2.58 ($SD = 1.96$) negative interpretations, whereas negatively trained participants gave 2.15 ($SD = 1.11$) positive and 2.76 ($SD = 2.05$) negative interpretations. Concerning the physical items, participants gave .75 ($SD = .67$) positive and 4.22 ($SD = 1.29$) negative interpretations after positive training, whereas .44 ($SD = .71$) positive and 4.24 ($SD = 1.51$) negative interpretations were given after negative

[1] The same results were obtained when the reaction time and error data was analysed using the conventional scoring procedure (*log measure*) described by De Houwer (2003). The 2 (Group) x 2 (Stimulus) x 2 (Response) ANOVA revealed a significant Stimulus x Response interaction effect in the reaction time data, $F(1, 79) = 4.39$, $p < .05$ and a trend in the error data, $F(1, 79) = 3.12$, $p = .08$. Note, that the predicted crucial three-way Group x Stimulus x Response interaction effect was not significant; reaction time data $F(1, 79) = 1.33$, $p = .25$ and error data $F(1, 79) = 2.44$, $p = .12$.

training. In sum, there is no evidence of differential CBM-I effects on self-generated interpretations.

Anxiety scores

To specifically test whether changes in interpretations lead to change in state anxiety, a 2 x 2 ANOVA was carried out with group as the between-subjects factor and time (before and after CBM-I) as the within-subject factor. Results indicated a significant Group x Time interaction effect, $F(1, 79) = 16.60$, $p < .001$. The nature of this interaction effect was consistent with the prediction that negatively trained participants would become more anxious, $t(40) = -2.57$, $p < .05$ (*M* before = 33.1, *SD* = 4.9 vs. *M* after = 35.7, *SD* = 7.6) and the positively trained participants would get less anxious, $t(39) = 3.28$, $p < .01$ (*M* before = 35.9, *SD* = 9.0 vs. *M* after = 33.0, *SD* = 6.7).

For trait anxiety, a 2 x 2 ANOVA revealed a significant main effect of time, $F(1, 79) = 7.70$, $p < .05$ and the predicted Group x Time interaction effect, $F(1, 79) = 3.67$, $p = .06$. Trait anxiety was reduced in all participants, but analysis of the separate CBM-I conditions revealed that the reduction was significant after positive interpretive bias training, $t(39) = 3.39$, $p < .01$ (*M* before = 34.9, *SD* = 6.6 vs. *M* after = 33.3, *SD* = 6.6) and not significant after negative training, $t(40) = 0.60$ (*M* before = 34.2, *SD* = 5.9 vs. *M* after = 33.9, *SD* = 6.4). Thus, the positive interpretive bias training seems to have congruent effects on state and trait anxiety.

Discussion

First of all, the present results confirmed previous findings (Mathews & Mackintosh, 2000; Salemink et al., 2007; Yiend et al., 2005) that the training procedure was successful in differentially affecting interpretations on tasks that are rather similar to the training procedure itself. Both the reaction time and recognition data indicated that positively trained participants interpreted ambiguous information as more positive than negative, confirming the effectiveness of the positive CBM-I condition. No evidence of training congruent changes in interpretations was found for the negative CBM-I condition. The data from the two other, less similar assessments of interpretive bias, the EAST and open-ended questionnaire, revealed no effect of CBM-I. With respect to the second aim of the present study, we replicated the observation (Mathews & Mackintosh; Yiend et al.) that induction of an interpretive bias has significant effects on anxiety. State anxiety decreased after positive CBM-I and increased after negative CBM-I. Also the reported levels of trait anxiety were affected by CBM-I. That is, trait anxiety decreased in general after CBM-I, but this effect was more marked after positive CBM-I.

The finding that the effect of trained positive interpretations was only observable on the measures that resemble the training procedure casts some doubt on the generality and external validity of previously reported findings on trained interpretations. Participants may have merely learnt a method-dependent strategy to respond fast to positive words and endorse positive sentences, while the 'true' interpretive style may have remained unaltered. Other explanations for the lack of change in interpretations on the EAST and on the interpretation questionnaire will be discussed.

First, the present training procedure may have been effective in changing interpretations, but the change might have been too weak to be observed by the EAST. A power analysis confirmed this suggestion. Furthermore, effects on an implicit measure such as the EAST might only be found when the CBM-I effects are fully automatised. Another explanation might be that the homograph EAST, a newly developed task, is not capable of detecting anxiety related differences in interpretive bias. Future research is needed to clarify this issue. Yet, it should be borne in mind that although no group effects were found, the EAST homograph task did reveal interference effects between the presented homograph and the required response, attesting to the validity of the task. It is possible that the fact that a homograph was consistently paired with a positive or negative response (a homograph was presented in only one colour) affected the results. The Dutch negative-neutral homograph 'dom' means stupid and tower, when the negative key has to be pressed in response to 'dom' in the first trial, negative interpretations of that homograph might become more accessible in subsequent trials. Pressing the positive key on the other hand seems unlikely to influence the interpretation of a negative-neutral homograph. Thus, the pairing of a homograph with a specific valence might differentially influence interpretations. Pairing a negative-neutral homograph with a negative response during the first presentation might lead to disproportionately fast negative responses to that homograph in subsequent presentations. A new analysis with the factor presentation (first, second, third, fourth) added to the EAST analysis showed that the consequent pairings between a homograph and a certain valence did not affect the results[2].

The absence of a differential group effect on the EAST is in line with the results obtained by the open-ended questionnaire. On the one hand, these findings may indicate that the trained interpretations are only observable on dependent variables that strongly overlap with the independent variables. On the other hand, alternative explanations are conceivable for the lack of training effect on this measurement. Firstly, this questionnaire (Stopa & Clark, 2000, based on Butler & Mathews, 1983) may not be sensitive enough to

[2] The 2 x 2 x 4 mixed model ANOVA with group as the between-subjects factor and stimulus (negative-neutral homograph vs. positive-neutral homograph) and presentation (first, second, third, and fourth) as within-subject factors revealed no significant interaction effects with presentation; Group x Presentation interaction effect $F(3, 77) = .94$, Stimulus x Presentation interaction effect $F(3, 77) = .25$, and Group x Stimulus x Presentation interaction effect $F(3, 77) = .39$.

detect non-clinical interpretive bias, since it has been based on and validated with patient groups. A second explanation might be that students are unwilling to admit that the experiment (temporarily) altered their processing style, leading to no effects when asked to report interpretations explicitly. Future research should clarify the validity of the current training procedure by testing whether effects are observable on other interpretive bias tasks that are sensitive to sub-clinical levels of biased information processing.

As to the effects of CBM-I on anxiety, first of all, results from the online reaction time measurement, the recognition test and trait anxiety seem to indicate stronger effects of the positive training procedure than of the negative training. While it is unclear why this difference emerged, it seems encouraging for possible clinical applications of training biases. Since earlier studies did not find such an asymmetry, the authors prefer not to discuss it further. Turning to the effects of CBM-I on anxiety, both state and trait anxiety were affected by CBM-I. Effective positive CBM-I was followed by a decrease in state and trait anxiety. Concerning the effect on trait anxiety, while it might be that the present training affected this more enduring measure of anxiety, another possibility is that the effects might be due to priming effects of the state questionnaire to the trait questionnaire, since state anxiety was consistently assessed before trait anxiety. A second point concerning the effects of CBM-I on anxiety is the finding that successful positive interpretive bias training corresponds with a decrease in anxiety, while negative interpretive bias training was not effective in changing interpretive bias, but still state anxiety increased. An explanation might be that there was a general increase in negative mood, but there is no reason to see this as a likely explanation. A possibility is that negative training did have cognitive effects, which had anxiolytic effects, but that the cognitive effects were not detectable. Finally, these results might be caused by a direct effect of training on mood. While interpretations were modified and anxiety before training differed from anxiety after, we cannot rule out the possibility that interpretive bias training influenced mood directly. Two options seem to be possible. First, change in anxiety leads to change in interpretations. This possibility has been disproved by Mathews and Mackintosh (2000): while all traces of anxiety change were dissipated after a long break (experiment 4), the interpretive bias effects remained. Possibility two is that interpretive bias and anxiety were changed simultaneously. We assessed interpretive bias online, future research might include online measures of mood. As a consequence we cannot guarantee that change in interpretive bias preceded change in anxiety, therefore strong causal conclusions cannot be drawn.

Apart from the issue of causal roots, CBM-I does appear to affect anxiety, either directly or indirectly. When taking into account earlier findings (Mathews & Mackintosh, 2000; Salemink et al., 2007; Yiend et al., 2005), five experiments out of seven showed effects of CBM-I on state anxiety. Since the majority of studies observed an effect of trained interpretations on subsequent anxiety levels, the weight of the evidence does indicate that the present training procedure affects anxiety. Besides having theoretical implications, these findings might also pave the way for more treatment-oriented investigations using the positive interpretive bias training procedure. Would the induction of a positive interpretive bias have beneficial effects on the negatively biased information processing in anxious patients and on anxiety? There seems to be room for exciting clinical research.

Appendix

Homographs and unambiguous words presented in the EAST

Homographs presented in the EAST

	Negative-Neutral homographs	**Positive-Neutral homographs**	**Neutral-Neutral homographs**
1.	eikel (swearword or acorn)	hoop (hope or heap)	pad (path or toad)
2.	zak (swearword or bag)	rijk (rich or realm)	bank (bank or couch)
3.	link (dicey or association)	maat (buddy or size)	kanaal (canal or channel)
4.	lak (not care a hoot about or lacquer)	klapper (hit the jackpot or folder)	veer (feather or spring or ferry)
5.	dom (stupid or a tower in Utrecht)	rap (nimble or sort of music)	klinker (brick or vowel)
6.	lijken (several dead bodies or to appear)	lof (praise or vegetable)	
7.	arm (poor or arm)		
8.	mat (languid or mat)		
9.	slang (snake or hose pipe)		
10.	week (weak or week)		

Unambiguous words presented in the EAST

	Negative words	**Positive words**	**Neutral words**
1.	verkrachting (rape)	liefde (love)	streep (line)
2.	incest (incest)	vriend (friend)	Microscoop (microscope)
3.	moord (murder)	vakantie (holiday)	stoep (pavement)
4.	oorlog (war)	lach (laugh)	vierkant (square)
5.	aids (aids)	kus (kiss)	boog (bow)

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3

Generalisation of modified interpretive bias across tasks and domains

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Abstract

Patients with an anxiety disorder are characterised by a tendency to impose threatening interpretations on ambiguous information. Past research has examined the causal relationship between experimentally modified interpretive bias and its effects on anxiety. Effective modification of interpretation bias is typically shown on two specific tasks: an on-line reaction time task and a post-training “recognition task”. Both tasks measure accessibility of negative or positive interpretations in a specific domain (social anxiety). From a theoretical and clinical perspective, it is important to know whether the effect of altered interpretation bias generalises to other tasks or domains. Therefore, in the present experiment, both the generalisation of Cognitive Bias Modification (CBM) to other tasks (a vignette and a video task) and the transfer to another domain (academic performance) were investigated. Results showed that the modified interpretive bias did not generalise to the other tasks, while it did transfer to another domain.

Introduction

Anxious individuals tend to interpret ambiguous information in a threatening way (Mathews, Mackintosh, & Fulcher, 1997). Cognitive Bias Modification of Interpretations (CBM-I) procedures have been developed to examine the causal relationship between such an interpretive bias and anxiety (Mathews & Mackintosh, 2000). Modification of interpretive bias has been effectuated by having non-anxious individuals read short ambiguous social stories that end with a word fragment requiring solution. Fragment completion resolved the ambiguity resulting in either a positive or negative valence of the story. In this way, participants are trained to impose positive (or negative) interpretations on ambiguous information. Indeed, studies involving CBM-I have shown its effectiveness in modifying interpretive bias measured at two tasks. The first task is a reaction time task; time taken to solve the word fragment in a way that is congruent or incongruent with the training. The second is recognition task; after CBM-I, participants read a new set of ambiguous stories and subsequently indicate the level of similarity between experimenter-provided interpretations and the original story (Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Salemink, van den Hout, & Kindt, 2007ab; Yiend, Mackintosh, & Mathews, 2005).

While there is ample evidence that CBM-I is successful in changing interpretations based on those two specific tasks, there is considerable overlap in the dependent (reaction time and recognition task) and independent (CBM-I) measures. The manipulation check tasks are highly similar to the format of the modification procedure. In both the dependent and independent measure the ambiguous information is presented lexically as a short story. The question arises whether the modified bias generalises beyond the *tasks* in which it was initially practiced. Furthermore, interpretive bias effects have only been examined within the social domain and one wonders whether the interpretive bias transfers to other potential *domains* of fear. Obviously, generalisability is relevant for understanding the boundaries of the CBM-I model and for potential clinical application that requires generalisation of the altered interpretive bias to daily life. Studies regarding generalisation to other *tasks* within the social domain, or generalisation to another *domain* are limited and will be discussed.

Generalisability to other modes of delivery has already been demonstrated. Mathews and Mackintosh (2000) showed that the modified interpretive bias generalised from a computer program to a paper and pencil task. Mackintosh et al. (2006) found that it also generalises from auditory to visual modes and vice versa. In addition, Mackintosh et al. showed that the modified interpretive bias endured change in environmental context; it survived changes in room, experimenter, and change from an individual to a group setting. These results seem encouraging, however the same reaction time and recognition tasks were used as measures for interpretive bias.

Generalisation to other tasks has also been studied (Hertel, Mathews, Peterson, & Kintner, 2003). For the modification of interpretive bias, 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 tested on another task in which participants had to form a mental image of a given homograph. Though this might seem evidence for task generalisability, both the modification as well as the test task contained homographs as stimuli.

Using two distinctly different tasks, Salemink et al. (2007b) also examined task generalisation and failed to find transfer. First, an implicit measure of interpretive bias was added. The Extrinsic Affective Simon Task (EAST, De Houwer, 2003) was presented with homographs as stimuli. The EAST is an indirect measure of interpretive bias; participants do not respond to the meaning of the homographs, but classify them on a meaning-irrelevant characteristic (colour). As a result, the format of the EAST was very different from the Mathews and Mackintosh (2000) CBM-I procedure, while the homographs covered the social domain. No evidence of modified interpretations was observed on this implicit task, whereas effects were observed on the standard reaction time and recognition task. A second interpretive bias measure was added; an open-ended questionnaire. Participants received short ambiguous descriptions of social interactions that ended with the question "Why?" (Stopa & Clark, 2000). Participants were asked to indicate what they thought was happening and their answers revealed their interpretations. Again, no effects of the training were evident on this new task. While these findings seem to suggest that there is no generalisability to other tasks, alternative explanations are possible. For example, the implicit measure was a newly developed task that might not be able to detect differences in interpretive bias. Additionally, effects on an implicit measure may only be observed when the effects are fully automatised. The null finding on the questionnaire seems more puzzling, because it bears many similarities to the original manipulation check (the recognition task). A crucial difference might be that participants had to actively generate interpretations to respond to the questionnaire, whereas the recognition task only tap passively generated interpretations.

Both Mathews and Mackintosh (2000) and Salemink et al. (2007b) explored whether CBM-I generalised beyond the social *domain*. The former included physical items (e.g. feeling dizzy) in the recognition task and found some effects, whereas the latter included such items in the open-ended questionnaire and found no evidence of interpretive bias effects on those physical items. Thus, there are inconsistent findings. The latter finding might indicate lack of generalisability to another domain, although it could also be that physical complaints are no common feature of the concerns of the research population (i.e. students) under study.

In brief, both the results concerning generalisability to other *tasks* as well as *domain* generalisability seem inconclusive and the present experiment was designed to add to our knowledge about both types of generalisability. In order to discover the boundaries of possible generalisability of CBM-I, two other tasks measuring social interpretive bias were included. The first being relatively close to the CBM-I procedure, while the other diverges much more. Regarding the first, a vignette interpretive bias task was added, which consists of an ambiguous social story (Constans, Penn, Ihen, & Hope, 1999). Afterwards, different interpretations are presented to the participants and they chose which of those fitted the content of the story. As a second task, video fragments were presented that involved an actor or actress who approached the camera and commented on some aspects of the individual's belongings or actions in an ambiguous way (Amir, Beard, & Bower, 2005). Since ambiguous information is not presented in a written format, this task bears less resemblance to the original modification procedure. Finally, generalisability of CBM-I to another *domain* was examined within the standard recognition task. Since our research sample consists of students, the newly developed items concerned academic performance, as this seems a likely area of concern.

In sum, the aim of the present experiment was to examine 1) the generalisability of CBM-I to other tasks within the social domain (vignette and video task) as well as 2) the generalisability to another domain using the same task (academic performance measured with the recognition task).

Method

Participants

The Dutch trait version of the State-Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983; Van der Ploeg, Defares, & Spielberger, 2000) was administered to a group of students (N = 188). To obtain a group with an average anxiety level, students with a score between the 10^{th} and 90^{th} percentile were invited to participate. A total of 82 (64 female/18 male) participated for course credit or a small remunerative reward. Their mean age was 20.7 years (SD = 2.9) and the positive and negative CBM-I groups were matched at the outset on both state anxiety, $t(80) = 0.74$, *ns* (M positive group = 32.5, SD = 5.1 vs. M negative group = 31.6, SD = 6.2) and trait anxiety, $t(80) = 1.76$, *ns* (M positive group = 34.5, SD = 5.7 vs. M negative group = 32.2, SD = 6.2).

Materials

Cognitive Bias Modification of interpretations. Participants were trained to make either positive or negative interpretations. The stories used to modify interpretive bias were translations of those used by Mathews and Mackintosh (2000). Eight blocks of 13 stories were presented on a personal computer, with a possibility to rest after each block. Each block contained eight modification stories, three filler stories, and two probes. The modification stories consisted of three lines that were ambiguous in valence. The final word of the story was presented as a word fragment and disambiguated the story in a positive or negative direction (depending on modification condition). Participants were asked to complete the fragments as quickly as possible. Subsequently, a comprehension question with relevant feedback appeared on the screen to reinforce the interpretation imposed by the word fragment. The following is an example of a modification story, with the completed word fragment for the negative and positive condition in parentheses:

> *You have just moved to a new area and your neighbour asks if you would like to go to the local pub that evening. When you arrive, they are not yet there. After your earlier conversation, they probably thought you were …*
> *d--l (dull)/lik----e (likeable).*

Then the comprehension question followed:

> *Did you make a bad impression on your new neighbour?*

The filler stories had no emotional content, nor did they contain any ambiguity. They were inserted to make the modification procedure less obvious.

Reaction time manipulation check. Time taken to solve probe fragments was used as a manipulation check (Mathews & Mackintosh, 2000). The probes were similar to the modification stories, but they had a fixed positive and negative valence, irrespective of condition. Both groups received the same word fragments as probes. These probes were inserted to examine differences in speed of resolving word fragments of different valence across the modification phase.

Recognition task manipulation check. The recognition task (Mathews & Mackintosh, 2000) consisted of another set of ten ambiguous social stories. The stories were presented in the same way as the CBM-I items. This time, however, every story had a title and the valence of the story remained ambiguous. Participants were asked to resolve the word fragment and to answer a question to assess their comprehension of the story. An example of these ambiguous test items is presented here (with the completed word fragment in parentheses):

> *The house-warming party*
> *Your neighbour has a house warming party and you are invited. You arrive to find many other guests whom you do not know. You try talking to some of them, and can see how much they are interested in your …*
> *c--ver--ti-n (conversation).*

The comprehension question immediately followed:

Was the party thrown by a relative of yours?

To assess the interpretations that were made of these stories, participants received the titles of the stories, together with four interpretations. These interpretations represented a possible positive interpretation, a possible negative interpretation, and a positive and negative foil sentence. Participants rated each interpretation independently for its similarity in meaning to the original story. A 4-point scale was used, ranging from 1 (*very different in meaning*) to 4 (*very similar in meaning*). Four interpretations of the previously presented recognition item follow.

(a) You talk to some guests and can tell that they find you interesting.
(b) You talk to some guests but they think what you say is boring.
(c) You meet some guests whom you know and enjoy talking to them.
(d) You don't know any one there and everyone ignores you completely.

Task generalisability: Ambiguous social vignette. The ambiguous social vignette task, developed by Constans et al. (1999), was used as an interpretive bias measure to examine generalisation of CBM-I to another task. It was a paper and pencil task with different versions for male and female participants (differing in sex of the central person and the blind date). The vignette consisted of an ambiguous social story that is 1.5 page in length, depicting a blind date between two college students. It contained information related to the couple's initial meeting, dining at a restaurant and attendance at a party. Interspersed was ambiguous information that concerned interpersonal evaluation (e.g. When meeting her date, Lisa said "You're certainly not what I expected.") as well as evaluation of non-personal stimuli (e.g. Upon entering the restaurant, Lisa said "this is an unusual place."). The next part of the task was the test phase and consisted of 19 questions. Eight questions concerned the interpretation of ambiguity, of which five were related to interpersonal events ("When Lisa said to Steve, "You're certainly not what I expected", she was impressed") and three are related to non-personal events ("Lisa had a positive first impression of the restaurant."). Participants indicated how strongly they agreed with those statements on a 7-point scale, ranging from 1 (*strongly disagree*) to 4 (*neutral*) to 7 (*strongly agree*). Items that contained a negative interpretation were reverse scored to ensure that scores greater than the scale midpoint (4) would reflect a positive interpretation. Seven questions were included as a memory test, to inspect whether both groups were comparable in their accuracy of recollecting non-emotional details. The remaining four questions were filler items.

Task generalisability: Video fragments. A second task to examine task generalisability was a video task. Brief video clips depicted two actors and two actresses, who commented on six aspects of the individual's actions or belongings. Each aspect was given a positive remark (e.g. "That is a pretty good looking shirt"), a negative remark (e.g. "That shirt is awful"), and an ambiguous remark (e.g. "That is an unusual shirt"), resulting in 72 different clips[3]. Participants rated their emotionality for each video clip according to how they would feel if they were in that situation (Amir et al., 2005). A 7-point scale ranging from 1 (*very negative emotion*) to 7 (*very positive emotion*), with 4 meaning *neutral/no emotions* was presented after each clip. The videos were presented in a random order with the restriction that a comment could not be similar on two or more consecutive trials. During the playing of the video clips, participants were offered a rest period twice. Clips were given English subtitles to enhance the understanding for the Dutch participants.

Domain generalisability: Academic performance recognition task. To examine generalisability to another domain with a similar task, ten ambiguous recognition stories concerning academic performance were created in the same way as the standard recognition test. The following is an example:

> *Thesis supervisor*
> *You have an appointment with your thesis supervisor to talk about your first draft. You did not do much in the beginning, but you have worked hard and seriously the last week. When entering the room, you can see her opinion from her …*
> *f-c- (face).*

Then the irrelevant comprehension question followed:

> *Did you have an appointment concerning your exam?*

In the second part, participants received four different interpretations of each story in a random order; a positive and negative possible interpretation and a positive and negative foil sentence. Again, participants rated each interpretation for its similarity in meaning to the original story on a 4-point scale. Sentences, corresponding to the previously given story, follow.

[3] Due to technical problems, one video clip containing an ambiguous comment could not be played. Hence, 71 clips were presented.

a) *When entering, you observe that your supervisor is positive about your thesis.*
b) *When entering, you observe that your supervisor is dissatisfied with your thesis.*
c) *When entering, your supervisor compliments you on your new hair cut.*
d) *When entering, it appears that your supervisor is grumpy and has little time for you.*

Questionnaires. Anxiety is related to interpretive bias, therefore pre-CBM-I anxiety was measured with the Dutch state and trait versions of the STAI (Spielberger et al., 1983; Van der Ploeg et al., 2000).

Procedure

At the start of the session participants signed consent forms and were then individually seated in front of a computer screen in a sound attenuated cubicle. The computer program started with the state and trait versions of the STAI and then continued with CBM-I (see Figure 1 for an overview of the experimental design).

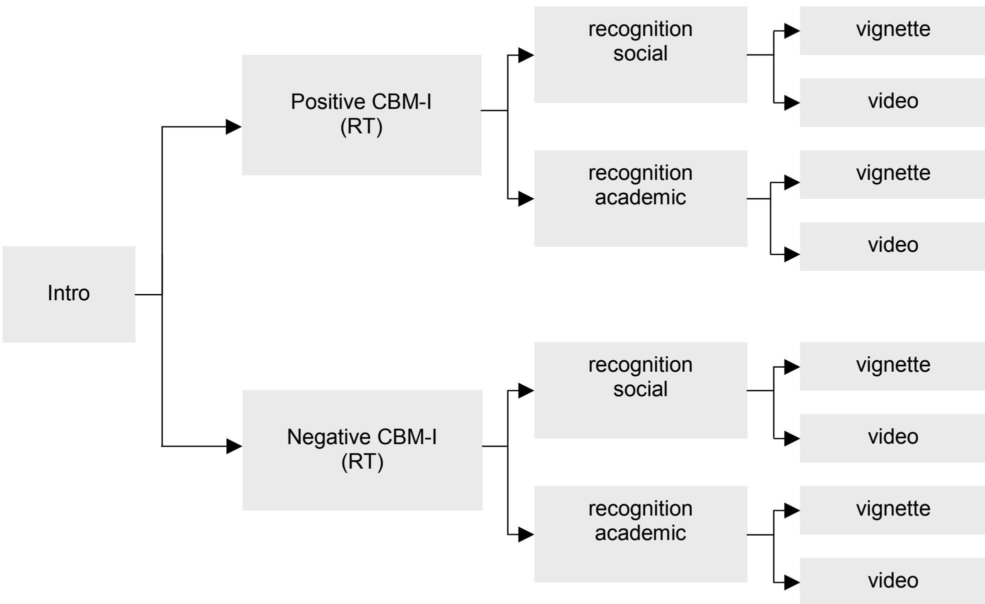

Figure 1.
Overview of the experimental design
Note. CBM-I stands for Cognitive Bias Modification of Interpretations and RT stands for reaction time measure.

Participants were randomly allocated to the positive or negative modification condition. After CBM-I, half of the participants of each condition received the standard social recognition task, whereas the other half received the new academic performance recognition task. Subsequently, these groups were again split into half with participants receiving the vignette, while the others received the video clips. At the end of the session, participants were debriefed.

Results

Reaction times to probes

To test the effectiveness of CBM-I in modifying interpretive style, reaction times were analysed with a 2 (group) x 2 (probe) mixed model ANOVA. There was a significant main effect of probe, $F(1, 80) = 12.8$, $p < .001$, $\eta_p^2 = .14$, indicating that positive fragments were resolved faster than negative ones (see Table 1 for the relevant means and standard deviations). The significant Group x Probe interaction effect, $F(1, 80) = 5.9$, $p < .05$, $\eta_p^2 = .07$ revealed that positively trained participants were faster to resolve positive than negative fragments, $t(40) = 4.6$, $p <$ 001. The negatively trained participants did not differ in their responses, $t(40) = 0.5$, *ns*.

Table 1.
Mean latencies to solve probe fragments with standard deviations in parentheses

Probe fragments in reaction time task	CBM-I	
	Positive	Negative
Positive fragment	1221 (327)	1374 (363)
Negative fragment	1445 (456)	1417 (380)

Standard recognition task

The second standard manipulation check of modified interpretations was the recognition test. A mixed model ANOVA with group as the between-subjects factor and valence (positive vs. negative) and target (possible interpretation vs. foil sentence) as the within-subject factors was conducted. The analysis revealed a main effect of valence, $F(1, 40) = 28.8$, $p < .001$, $\eta_p^2 = .42$, with positive sentences being endorsed more than negative sentences. Also a main effect of target was found, $F(1, 40) = 507.7$, $p < .001$, $\eta_p^2 = .93$, indicating greater endorsement of possible interpretations than of foils. Furthermore, the Group x Valence interaction effect was significant, $F(1, 40) = 43.1$, $p < .001$, $\eta_p^2 = .52$, as well as the predicted Group x Valence x Target interaction effect, $F(1, 40) = 6.5$, $p < .05$, $\eta_p^2 = .14$. To decompose this interaction effect, separate analyses for possible interpretations and foil sentences were carried out. Both analyses revealed a Group x Valence interaction effect; for interpretations, $F(1, 40) = 37.8$, $p < .001$, $\eta_p^2 = .49$ and for foils, $F(1, 40) = 28.2$, $p < .001$, $\eta_p^2 = .41$. The relevant means are shown in Table 2. Inspection of the effects of CBM-I for each condition revealed that participants who had followed positive modification interpreted new ambiguous information in a more positive than negative way, $t(20) = 7.7$, $p <$ 001, while participants who had followed the negative training did not differ in their interpretations, $t(20) = 1.0$, *ns*. These effects were also observed for the foil items, though less marked.

Table 2.
Mean recognition ratings with standard deviations in parentheses

Task			CBM-I	
			Positive	Negative
Social	Targets	Positive	3.2 (0.4)	2.8 (0.5)
		Negative	2.2 (0.4)	2.9 (0.4)
	Foils	Positive	2.0 (0.4)	1.7 (0.3)
		Negative	1.4 (0.3)	1.7 (0.3)
Academic	Targets	Positive	2.8 (0.4)	2.2 (0.4)
		Negative	2.1 (0.5)	2.7 (0.5)
	Foils	Positive	1.6 (0.3)	1.5 (0.3)
		Negative	1.4 (0.3)	1.5 (0.3)

Note. Recognition ratings ranged from 1 (*very different*) to 4 (*very similar*).

Generalisability to other tasks

Ambiguous social vignette. To examine whether the positive and negative CBM-I conditions differ in the comprehension of the vignette, the total number of correct memory items was entered into an independent-samples t-test. This analysis showed that, as intended, there was no indication that the groups differed in general memory accuracy, $t(39) = 0.2$, *ns* (*M* positive CBM-I = 6.1, *SD* = 0.9 vs. *M* negative CBM-I = 6.1, *SD* = 0.9).

To examine whether interpretive bias generalised to this task, a 2 (group) x 2 (item-type: non-personal vs. interpersonal) mixed model ANOVA was performed. It revealed a main effect of item-type, $F(1, 39) = 28.2$, $p < .001$, $\eta_p^2 = .42$. The non-personal items were interpreted more positively than the interpersonal items (*M* interpersonal = 5.0, *SD* = 0.9 vs. *M* non personal = 5.9, *SD* = 0.7). Furthermore, the two-way interaction effect was not significant, $F(1, 39) = 0.7$, *ns*, indicating no differences between the CBM-I groups in interpretation of the vignette[4]. See Table 3 for relevant means and standard deviations.

Table 3.
Mean ratings with standard deviations in parentheses in vignette and video task

Task		CBM-I	
		Positive	Negative
Vignette	Personal	4.9 (1.1)	5.1 (0.8)
	Nonpersonal	5.9 (0.8)	5.9 (0.6)
Video	Positive	5.7 (0.5)	5.8 (0.5)
	Ambiguous	3.9 (0.4)	3.9 (0.5)
	Negative	2.9 (0.6)	2.7 (0.6)

Videos. Similarly, to investigate generalisation to the video task, a 2 (group) x 3 (video type: positive, ambiguous, and negative) mixed model ANOVA was performed. The analysis yielded a significant main effect of video type, $F(2, 38) = 241.8$, $p < .001$, $\eta_p^2 = .93$, indicating that videos types were differentiated. Follow-up post hoc analyses revealed that participants rated positive videos ($M = 5.8$, $SD = 0.5$) as more positive than ambiguous videos (M ambiguous = 3.9, $SD = 0.4$, $t(40) = 21.8$, $p <$ 001), negative videos (M negative = 2.8, $SD = 0.6$) as more negative than ambiguous videos, $t(40) = 14.3$, $p <$ 001, and negative videos as more negative than positive videos, $t(40) = 21.3$, $p <$ 001. The main effect of group as well as the interaction effect of Group x Video type, that was our main interest, were not significant, $F(1, 39) = 0.01$, *ns* and $F(2, 38) = 0.6$, *ns*, respectively (see Table 3).

Generalisability to another domain

Academic performance recognition task. To examine generalisability to another domain, the academic performance recognition data was analysed with a 2 (group) x 2 (valence) x 2 (target) mixed model ANOVA. A main effect of valence, $F(1, 38) = 4.2$, $p < .05$, $\eta_p^2 = .09$ and of target, $F(1, 38) = 547.1$, $p < .001$, $\eta_p^2 = .94$ was found. This reflects greater endorsement of positive and possible interpretations. In addition, a significant Group x Valence interaction effect was found, $F(1, 38) = 36.1$, $p < .001$, $\eta_p^2 = .49$ and a significant Group x Valence x Target interaction effect, $F(1, 38) = 22.9$, $p < .001$, $\eta_p^2 = .38$. The relevant means are reproduced in Table 2. Further decomposing by possible and foil interpretations

[4] We found this finding counterintuitive, since the vignette task only differs from the recognition task to a small extent. A second experiment was conducted to replicate this null finding and the results were identical. The same main effect of item-type was found, $F(1, 66) = 47.4$, $p < .001$, $\eta_p^2 = .42$, while the Group x Item-type interaction effect again failed to be significant, $F(1, 66) = 2.0$, $p = .16$.

revealed an interaction effect between Group x Valence, for possible interpretations $F(1, 38) = 34.2$, $p < .001$, $\eta_p^2 = .47$, but not for foils, $F(1, 38) = 3.3$, *ns*. That is, regarding possible interpretations, positively trained participants found positive interpretations more similar to the original story than negative interpretations, $t(19) = 4.4$, $p <$ 001. The reverse was true for negatively trained participants; they found the negative interpretations more similar, $t(19) = 3.0$, $p <$ 001.

Discussion

In the present study it was shown that CBM-I is successful in altering interpretations. Both standard manipulation checks, that is the reaction time and the recognition task, revealed interpretive bias effects. The aims of the present study were to examine generalisability of the modified interpretative bias to 1) other tasks and 2) another domain. One of the main findings was that modified interpretive bias did not generalise to other tasks within the social domain. This is consistent with earlier findings (Salemink et al., 2007b, but see Hertel et al., 2003). The other main finding was that effects of CBM-I transferred from the social domain to another domain, that is, academic performance.

Somewhat unexpected, the vignette task did not reveal any CBM-I effects even though its format is quite similar to the modification procedure and the recognition task. It seems that the particular measurement of interpretive bias is important; a small deviation results in a failure to find the predicted effect. Therefore, it is hardly surprising that the video fragments, differing considerably from the CBM-I format, also failed to show CBM-I effects. Note however that differential *emotional* responses to video fragments have been observed following CBM-I (Mackintosh et al., 2006; Wilson, Macleod, Mathews, & Rutherford, 2006). In the present study, participants did differentiate between the positive, ambiguous and negative valence of the fragments, attesting to the validity of the video fragments. Hence, it seems that generalisability to other tasks is limited, but this conclusion is not corroborated by earlier findings of CBM-I effects on mood as was measured with a questionnaire (Mathews & Mackintosh, 2000; Salemink et al., 2007b; Yiend et al., 2005). As the questionnaire contains ambiguous items, it could be considered a different interpretive bias task. CBM-I effects on the questionnaire scores are then an example of task generalisability. Meanwhile these findings of CBM-I effects on mood also reflect the observed domain generalisability. This leaves us with the following pattern of data: there is converging evidence that CBM-I generalises across domains. This might be explained by the fact that participants are also trained to make specific interpretations across a range of situations. A more puzzling question concerns the inconsistent findings with respect to task generalisability. No effects were observed on the vignettes and video fragments in the present experiment, while effects on mood questionnaires have been observed repeatedly in other experiments (Mathews & Mackintosh, 2000; Salemink et al., 2007b; Yiend et al., 2005). Several possible methodological and theoretical explanations will be given for these inconsistencies.

Firstly, the effect of trained interpretation may fade away with the passage of time. Note that the assessment of interpretive bias with the different tasks mostly takes place at the end of the test session (see Figure 1 for the design of the present study). On the other hand, it has been demonstrated that interpretive bias effects last for 24 hours (Yiend et al., 2005). Moreover, the studies that showed task generalisation also tested it at the end of the session. Therefore, this seems an unlikely explanation. A possible explanation for the lack of effects on the video fragments task might be that we added subtitles to the video fragments and thus altered the original video task. This also seems an unlikely explanation, since more written information was presented and thus the resemblance with the modification procedure was increased. If anything, the chances of finding interpretive bias generalisation effects on this video task were increased due to the alteration. Thirdly, ambiguous video fragments were mixed with fragments with a clear positive or negative content. This is in contrast with the modification procedure, the standard manipulation checks, and with the mood questionnaires where only ambiguous information is presented. It cannot be ruled out that including clear valenced information created a contrast effect and caused initially ambiguous information to be regarded as more neutral. As a consequence, this might have decreased the sensitivity to detect small differences in interpretations and thus generalisation to this video task.

At a more theoretical level, it might be speculated that imagery plays an important role in the discrepant findings. As has been put forward by Holmes, Mathews, Dalgleish and Mackintosh (2006) the instruction to image the described events seem to be a crucial component of the CBM-I procedure. They showed that self-generated imagery is an active ingredient in producing effects of cognitive training. Moreover, the tasks that successfully demonstrated interpretive bias effects seem to share this self-generated imagery feature, while that is absent in the tasks failing to observe effects. That is, in the reaction time and recognition task participants are specifically instructed to imagine themselves in the numerous situations. Likewise, the mood questionnaires also require self-representational strategies, as one tries to reconstruct past mood states. In contrast, the tasks that have failed to reveal generalisation effects are the ones where the need to imagine oneself in the situation is minimal. Rather, the narratives were about a blind date presented in the third-person (vignette task) instead of first- or second-person perspective. During the video fragments task, participants directly received images, thus diminishing the need to self-generate them. It might be that self-generated imagery is a crucial aspect to reveal an effect of trained interpretive bias on emotions and it might explain the inconsistent findings regarding task generalisability.

In sum, while in the present study effects were only observed on tasks that mimic the modification procedure, other studies have shown CBM-I effects on mood questionnaires. As it is difficult to explain this finding, further research is warranted to examine task dependency and the role of imagery. In addition, it was found that modified interpretive bias generalised beyond the trained domain. As interpretive bias is linked with neuroticism, a higher order trait, the finding that CBM-I generalises across domains is encouraging.

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4

How does cognitive bias modification affect anxiety? Mediation analyses and experimental data

Submitted for publication as:
Salemink, E., van den Hout, M. A., & Kindt, M. How does Cognitive Bias Modification affect anxiety? Mediation analyses and experimental data.

Abstract

There is overwhelming evidence that anxiety is associated with the tendency to interpret information negatively. The causal relationship between this interpretive bias and anxiety has been examined by modifying interpretive bias and examining effects on anxiety. A crucial assumption is that the modified bias affects anxiety, instead of the procedure affecting anxiety. Surprisingly, this had not previously been tested. Results from mediation analyses suggested that changes in trait anxiety, after performing Cognitive Bias Modification of Interpretations (CBM-I), were indeed caused by an altered interpretive bias, whilst changes in state anxiety appear to be caused by the procedure itself. A subsequent experiment showed that state anxiety effects could be due to exposure to valenced materials. The modification procedure itself could thus have functioned as a mood induction procedure. Therefore, changed state anxiety observed after CBM-I is not a valid indicator of a causal relationship. The finding that CBM-I affected interpretive bias, which in turn affected trait anxiety, supports the assumption of a causal relationship between interpretive bias and trait anxiety. This is promising in light of possible clinical implications.

Introduction

Patients with anxiety disorders tend to impose threatening interpretations on ambiguous information. Research by Amir, Foa, and Coles (1998) has demonstrated that patients with a social phobia, when compared to non-anxious individuals, tend to favour negative interpretations of ambiguous social scenarios. This negative interpretive bias has also been found in patients with a generalised anxiety disorder (Eysenck, Mogg, May, Richards, & Mathews, 1991) and in patients with a panic disorder and agoraphobia (Stoler & McNally, 1991). There is overwhelming evidence that biased interpretations and anxiety are associated, yet the causal direction remains unclear. Does anxiety cause interpretive bias or, is interpretive bias a vulnerability factor in developing anxiety? Or, are they both being influenced by a third factor? Mathews and Mackintosh (2000) examined this issue of causality by inducing a negative or positive interpretive bias and measuring the effects on anxiety. Interpretive bias was modified by having participants read ambiguous stories that ended with a word fragment requiring a completion. Fragment completion resolved the ambiguity resulting in either a positive (positive interpretive bias condition) or negative (negative condition) meaning of the preceding story. Results showed that the modification of interpretive bias successfully resulted in a concomitant change of anxiety. That is, participants in the negative condition became more anxious while anxiety dropped in the positive condition. This Interpretation Cognitive Bias Modification (CBM-I) method fuelled many new experiments and the original findings have been replicated in several independent studies (Holmes, Mathews, Dalgleish, & Mackintosh, 2006; Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Salemink, van den Hout, & Kindt, 2007b; Yiend, Mackintosh, & Mathews, 2005). The data seems to support the idea that a negative interpretive bias causally contributes to the occurrence and/or maintenance of anxiety. The clinical implications are obvious. Given that interpretive bias affects anxiety, inducing a positive interpretive bias in patients with an anxiety disorder should have beneficial effects on their anxiety level. Steps are being taken to examine whether the CBM-I method can be used as a tool in treating anxious individuals (Mathews, Ridgeway, Cook, & Yiend, 2007; Murphy, Hirsch, Mathews, Smith, & Clark, 2007).

Mathews and Mackintosh’s (2000) seminal work boosted exciting new research and opened fresh clinical possibilities. Yet, the conclusions that have been drawn about causality are based on the crucial assumption that the CBM-I procedure affects interpretive bias, and that the changed interpretive bias *then* affects anxiety (Mathews & Mackintosh, 2000; Salemink et al., 2007b; Yiend et al., 2005). In other words, the assumption is that there is an *indirect* relationship between the CBM-I procedure and anxiety, mediated by an altered interpretive bias. As far as we know, this critical assumption has never been tested. Note however that this hypothetical cascade of CBM-I → interpretative bias → changed anxiety represents only one of several possible interpretations of the observed data. For instance, the CBM-I procedure could have a *direct* effect on anxiety by changing mood through abundant exposure to either positive or negative information. Yet this direct effect could also be an additional effect, added to the indirect one. Or, finally it could also fully explain the effects on anxiety. Hence, the CBM-I procedure might have functioned as a complex mood induction procedure, similar to the Velten mood induction (Velten, 1968). Figure 1 depicts both the indirect path (represented by arrows a and b) as well as the alternative direct path (represented by arrow c).

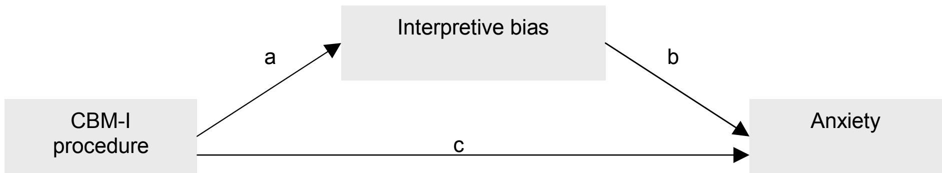

Figure 1.
Visual representation of the direct and indirect effect of CBM-I on anxiety

How CBM-I affects anxiety is an empirical issue. In the present paper this is examined in two studies. The first study uses a mediation analysis to examine the relationship between CBM-I, changes in interpretive bias and anxiety and uses data from an earlier study (Salemink et al., 2007b) on modification of the interpretative bias. The second study was designed to test a possible direct effect of CBM-I on anxiety using an experimental design.

Study 1

Introduction

To get a first impression of the possible relationships between CBM-I and anxiety, we re-analysed data from an earlier study (Salemink et al., 2007b) using a mediation path analysis. There are three possibilities (see Figure 1), namely: 1) CBM-I affects the interpretive bias, which in turn affects anxiety. Changes in anxiety are then caused by altered interpretations and not by the modification procedure itself (paths a and b are significant; c is not); 2) There is both a direct and an indirect effect of CBM-I on anxiety (all paths are significant); 3) CBM-I directly affects anxiety. That is, the modification procedure directly causes changes in anxiety due to mood induction, with no mediating role for interpretive bias (path a and c are significant; b is not). Only the first option fits with the hypothesis that an interpretive bias is causally related to anxiety.

Method

Data by Salemink et al. (2007b) was re-analysed. The study consisted of a CBM-I study where effects on anxiety were found. A summary is provided describing the highlights that are relevant for the present study.

Materials and results

CBM-I. A positive and negative CBM-I was performed using Mathews and Mackintosh's (2000) social story paradigm. Participants read ambiguous social stories, which ended with a word fragment. Solution of the fragment resolved the ambiguity in a positive or negative way, depending on the assigned condition (n = 40 in the positive condition and n = 41 in the negative condition). An example story with the completed word fragment for each condition in parentheses, is as follows:

> *A friend invites you to a dinner party that she is holding. She tells you who the other guests are, but you do not recognise any of the other names. You go anyway and on the way there, you think that the other guests will find you …*
> *ti--s--e (tiresome) / so--a-le (sociable).*

Interpretive bias measure: Reaction times. During CBM-I, 'probes' were presented that are similar to the modification stories, but have a fixed positive and negative valence, irrespective of modification condition. Time taken to solve these probe word fragments was used as a reaction time measure for interpretive bias and results showed that compared to the negatively trained participants, positively trained participants were faster in solving positive continuations of the story than negative continuations.

Interpretive bias measure: Recognition task. After CBM-I, interpretive bias was also measured using a "recognition task". Participants were asked to read another set of social stories (ten in total) and part of the last sentence was presented as a word fragment. However, solving the fragment did not solve the ambiguity. A recognition story is as follows:

> *You've just started going to an evening class. The instructor asks a question*
> *and no one in the group volunteers an answer, so he looks directly at you.*
> *You answer the question, aware of how your voice must sound to the …*
> *oth--s (others)*

To assess the interpretations that were made of these ten stories, participants received four interpretations of each story. These interpretations represented (a) *possible* positive and (b) *possible* negative interpretation (targets), and (c) positive and (d) negative *foil* sentence, which were presented in random order. Participants rated each interpretation independently for its similarity in meaning to the original story on a four-point scale ranging from 1 (*very different in meaning*) to 4 (*very similar in meaning*). Interpretations, corresponding to the previously given story, follow.

(a) You answer the question, aware of the others listening attentively.
(b) You answer the question, aware of how unsteady your voice sounds.
(c) You answer the question and then realise what a good answer it is.
(d) You answer the question, but realise that you have made a mistake.

This interpretive bias measure also showed that the CBM-I was successful; again positively trained participants interpreted the new ambiguous information more positively in comparison to negatively trained participants.

Mood. Change in anxiety was measured with the Dutch state and trait versions of the State-Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983; van der Ploeg, Defares, & Spielberger, 2000) which was administered prior to and after the modification procedure. Participants in the negative condition became more state anxious, while positively trained participants got less anxious. Concerning trait anxiety, positively trained participants also reported less trait anxiety compared to the negatively trained group.

Statistical analyses

Mediation analyses were carried out separately for the two indices of induced interpretative bias: reaction time data and recognition data. The reaction time interpretive bias index was calculated by subtracting the mean reaction time for solving negative word fragments from that of positive word fragments. Similarly, the recognition interpretive bias index was computed by subtracting mean recognition ratings of negative interpretations from that of positive interpretations. An index of change in anxiety was calculated by subtracting pre-CBM STAI scores from post-CBM scores. Analyses were conducted separately for state and trait anxiety.

A stepwise procedure was used to test two models. Based on the theoretical framework, the first model represents the indirect effect, with the interpretive bias mediating the relationship between CBM-I and anxiety. It consists of a path from CBM-I to the interpretive bias (path a in Figure 1) and a path from the interpretive bias to change in anxiety (path b). Model 2 includes a direct path from CBM-I to anxiety (path c)[5]. We used Amos 7.0 to test these models (Arbuckle, 2006). The fit of the models was evaluated using the chi-square goodness-of-fit test. Considering that the chi-square test has been criticised for its dependence on sample size, it has been recommended to include absolute and incremental fit indices (Hu & Bentler, 1999). The root mean square error of approximation (RMSEA) (values <0.08 indicate acceptable fit) was used as an absolute fit index. The comparative fit index (CFI) (values >0.90 indicate reasonably good fit) was used as an index of incremental fit (Kline, 2005). These fit indices assess the adequacy of the theorised model's covariance matrix in comparison to the observed covariance matrix. Chi-square difference tests were used to evaluate the relative fit of competing models.

As the sample size was relatively small for structural equation modelling (SEM, Kline, 2005), a bootstrap method was performed to examine whether the statistics under consideration were unbiased (i.e. robust) (Efron & Tibshirani, 1993). A general bootstrap with 5000 iterations performed on the final models revealed no significant discrepancy between the results of the bootstrap analysis and the original normal theory-based analysis.

Results

State anxiety

First, the model representing the indirect effect between CBM-I and state anxiety through interpretive bias (Model 1) was analysed using the reaction time index. This model did not fit the data (χ^2 (1) = 11.9, $p < .001$, CFI = .48, RMSEA = .37). The second model (including a direct path from CBM-I to anxiety) resulted in a fully saturated model, hence with no degrees of freedom left (χ^2 (0) = 0). This model had a significantly better fit ($\chi^2_{\text{difference}}$ = 11.9, $\Delta df = 1$, $p < .001$). The CBM-I procedure was a significant predictor of change in anxiety (path c in Figure 1, $\beta = -0.38$, $p < .001$) with positive modification resulting in a reduction of anxiety[6]. Furthermore, CBM-I was a significant predictor of interpretive bias (path a, $\beta = -0.29$, $p < .01$), while the interpretive bias was not a significant predictor of anxiety (path b, $\beta = 0.14$, $p = .19$). The final model accounted for a total of 19% of the variance in anxiety and 8% of the variance in interpretive bias.

Using the recognition data as an indicator of interpretive bias, Model 1 (containing only the indirect effect), again, did not fit the data (χ^2 (1) = 5.38, $p < .05$, CFI = .91, RMSEA

[5] One of the assumptions of estimating a mediational model is that the dependent variable (change in anxiety) does not cause the mediator (interpretive bias) (Baron & Kenny, 1986). Therefore, the analyses were repeated after interchanging the mediator and outcome variables. Results revealed that there were no indications that change in anxiety mediates the relationship between CBM-I and interpretive bias.

[6] CBM-I was coded with 0 being the negative condition and 1 being the positive condition.

= .23). Model 2 (including the direct path between CBM-I and change in state anxiety) was then examined. This fully saturated model fit significantly better (χ^2 (0) = 0, $\chi^2_{difference}$ = 5.38, Δdf = 1, p < .05). Again, the CBM-I procedure was a significant predictor of anxiety (path c, β = -0.30, p < .05) and interpretive bias (path a, β = 0.60, p < .001). Interpretive bias did not predict change in anxiety (path b, β = -0.20, p = .11). The final model accounted for 20% of the variance in anxiety change and 36% of the variance in interpretive bias.

In sum, changes in state anxiety were not related to the interpretive bias, they were caused by direct effects of the CBM-I procedure. This was found both for the reaction time index and for the recognition index of interpretive bias. Thus, the interpretive bias did not mediate the relationship between CBM-I and changes in state anxiety. Figure 2 shows the final path model (each arrow denotes a significant path coefficient).

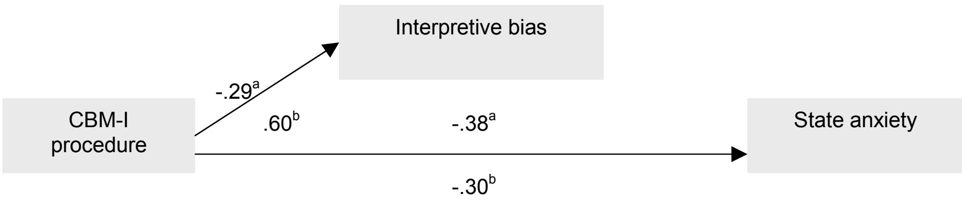

Figure 2.
The direct effect of CBM-I on interpretive bias and on state anxiety
Note. Values on the paths are path coefficients (standardised betas).
[a] Standardised beta for the reaction time interpretive bias measure.
[b] Standardised beta for the recognition interpretive bias measure.

Trait anxiety

Similar analyses were performed using trait anxiety as the dependent variable. The first model tested the indirect effect of CBM-I on trait anxiety with interpretive bias as a mediating factor (reaction time measure). This model provided a good fit to the data (χ^2 (1) = 1.7, p = .19, CFI = .94, RMSEA = .09). Model 2 included the direct path between CBM-I and trait anxiety (path c), but this did not result in a significant improvement of the model ($\chi^2_{difference}$ = 1.7, Δdf = 1, p = .19). The model consisting only of indirect effects represented the trait anxiety data most accurately, with CBM-I being a significant predictor of interpretive bias (path a, β = -0.29, p < .01) and interpretive bias predicting change in trait anxiety (path b, β = 0.27, p < .05). This model accounted for 8% of the variance in interpretive bias and 7% of the variance in trait anxiety.

When the recognition data was used as an index for interpretive bias, similar results were obtained. The first model resulted in a good fit to the data (χ^2 (1) = 0.24, p = .62, CFI = 1.00, RMSEA = .00). The second model did not significantly improve the model's fit ($\chi^2_{difference}$ = 0.24, Δdf = 1, p = .62). In the first model, CBM-I was a significant predictor of interpretive bias (path a, $\beta = 0.60$, $p < .001$) and interpretive bias was a significant predictor of changes in trait anxiety (path b, $\beta = -0.28$, $p < .01$). The CBM-I accounted for 36% of the variance in interpretive bias, which in turn explained 8% of the variance in trait anxiety.

Considering that the CBM-I procedure directly influenced state anxiety, we now had to consider the possibility that changes in state anxiety could have caused changes in trait anxiety. To examine this possibility a new model was construed again using CBM-I again as the independent variable and changes in trait anxiety as the dependent variable. Two indirect paths were tested: a path through interpretive bias and another through changes in state anxiety. This model fit the data for both indices of interpretive bias (reaction time: χ^2 (2) = 2.35, p = .31, CFI = .99, RMSEA = .05, recognition: χ^2 (2) = 2.58, p = .28, CFI = .99, RMSEA = .06), but change in state anxiety did not predict change in trait anxiety (reaction time model: $\beta = 0.16$, p = .13, recognition task model $\beta = 0.13$, p = .24). Thus, no evidence was found for the possibility that changes in trait anxiety were due to changes in state anxiety.

In sum, changes in trait anxiety observed after a CBM-I procedure are due to the modified interpretive bias. The CBM-I affected interpretive bias, which in turn affected trait anxiety (depicted in Figure 3).

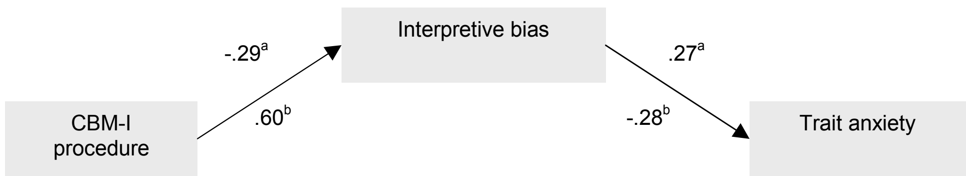

Figure 3.
The indirect relationship between CBM-I and trait anxiety through interpretive bias
Note. Values on the paths are path coefficients (standardised betas).
[a] Standardised beta for the reaction time interpretive bias measure.
[b] Standardised beta for the recognition interpretive bias measure.

Discussion

The results of the mediation path analyses can be summarised as follows: changes in state anxiety seem to be directly caused by the CBM-I procedure itself, while changes in trait anxiety seem to be due to changed interpretations. Results concerning trait anxiety are consistent with the proposition that interpretive bias is causally related to anxiety vulnerability (see the General discussion for further elaboration).

However, a different picture emerged when effects on state anxiety were examined. These results suggest that the CBM-I procedure directly affects state anxiety and that it, thus, served as a mood induction procedure. Apparently, interpretive bias does not play an important part in affecting anxiety. The question arises which elements of the CBM-I procedure are then responsible for changes in state anxiety. Are the ambiguous stories that precede the word fragment necessary, or is a negative or positive completion of the word fragment sufficient? Or even the exposure to valenced complete words might be sufficient. To examine this, the effects of merely completing the word fragments and mere exposure to the complete words were examined, extending the findings obtained with the mediation analyses.

Study 2

Introduction

Mediation analyses suggested that the changes in state anxiety were not due to altered interpretations, but appeared to be caused by the modification procedure itself. Given the widespread use of the CBM-I procedure and observed effects on state anxiety (Mathews & Mackintosh, 2000; Salemink et al., 2007b; Yiend et al., 2005), it appeared worthwhile to further study what elements of the procedure are responsible for the observed effects on state anxiety. In the discussion section of the first study, it was suggested that CBM-I might serve as a mood induction procedure. If so, the disambiguation of the ambiguous stories after completing the word fragments may not be necessary and negative or positive completions themselves may affect anxiety. One might even speculate that active completion of the fragments is unnecessary and that mere exposure to the words, presented in a non-fragmented and unambiguous way, may be sufficient to change anxiety. Considering the degree to which the CBM-I affected anxiety by exposure to valenced information suggests that effects on state anxiety will be seen after completing word fragments or even after mere exposure to the complete words.

In the present experiment, participants were exposed to positive or negative words or word fragments much as they were in the original CBM-I procedure, but this time the words/word fragments were not preceded by an ambiguous social story. Half of the participants was asked to complete word fragments; completion yielded positive words for one sub-group and negative words for the other. The other half was exposed to complete words that had either a positive or negative valence. Using the argument that CBM-I affects state anxiety through exposure to valenced information, it was predicted that the exposure to positive information (i.e. words and word fragments) would result in a decline in anxiety and the exposure to negative information would result in an increase in anxiety.

Method

Overview

A mixed between-within subjects design was used with exposure valence (positive vs. negative) and word-type (complete vs. fragmented) as between-subjects factors and time (before vs. after exposure) as a within-subject factor. The crucial dependent variable was state anxiety.

A recognition task to measure interpretive bias was administered to examine the possibility that exposure could unintentionally have affected interpretive bias. The sequence of the recognition task and the anxiety measurement was counterbalanced. Since this factor did not influence the relevant findings, it was not included in the final analyses.

Participants

A total of 91 students participated in the experiment. Two were excluded from the final analysis for having left the experiment too early thinking that they had already finished the experiment. The final analysis included 89 participants (74 female / 15 male). Forty-five participants were in the positive exposure condition (23 in the complete words vs. 22 in the fragmented words condition) and 44 in the negative exposure condition (22 in both the complete and fragmented words condition). Their mean age was 21.5 years (*SD* = 2.8). The participants did not differ significantly across groups in gender, χ^2 (3) = 4.12, *p* = .25; age, *F*(3, 84) = 1.56, *p* = .21; trait anxiety scores, *F*(3, 85) = 0.30, *p* = .82; or initial state anxiety scores, *F*(3, 85) = 0.30, *p* = .82.

Materials and apparatus

Exposure stimuli. The words used in the present study were translations of the words used by Mathews and Mackintosh (2000), also used in other studies by Salemink et al. (2007ab). In some cases removing the ambiguous story resulted in words that lacked the intended modification valence. For example, ‘unwell’ was used in the Mathews and Mackintosh experiment as a non-negative interpretation for having a friend cancel dinner (as opposed to ‘angry’ in the negative condition). Removing the ambiguous story leaves only the word ‘unwell’ that, without a prior story will easily be experienced as negative. A pilot study was performed to examine the valence of single words without the story. All words were rated on a 3-point scale; 1 (*positive*), 0 (*neutral*), and -1 (*negative*). If half or more than half of the ratings were inconsistent with the intended valence, the words were replaced (27.1%

of the words) with words from two other blocks that were not used in the present experiment. In addition, the fragments were required to have only one solution. In the original experiment fragments were constructed so that there was only one solution that *fit a possible interpretation* of the story. Fourteen words had to be replaced to fulfil the requirement of having only one possible solution.

The number of trials was similar to that of the studies of Mathews and Mackintosh (2000) and Salemink et al.'s (2007ab). Participants received eight blocks, each containing 13 words. Eight words were the so-called (mood) induction words. These are the crucial words with a positive ('enthusiastic') or negative ('embarrassed') valence that correspond to the positive or negative condition. Three other words were neutral and included as fillers. Two words were the so-called probe words. These had a fixed positive and negative valence and were similar for both the positive and negative condition (see Study 1). Stimuli were presented in a random order in each block.

Participants in the fragment completion condition were asked to complete the fragments as quickly as possible by pressing the spacebar as soon as they could think of the correct completion. They were then asked to type in the first missing letter of the fragment. When the correct letter was typed in, the completed word was displayed for 1 s. Trials in this condition had a duration of approximately 2880 ms. For this reason participants in the complete word condition were asked to read words that were each presented on the screen for 2880 ms.

Recognition stimuli. Interpretation style was assessed using a recognition task (Mathews & Mackintosh, 2000). This was done to check whether interpretations were inadvertently changed. See Study 1 for a detailed description of this recognition task.

STAI questionnaire. The Dutch state and trait scales of the State-Trait Anxiety Inventory (STAI-ST, Spielberger et al., 1983; van der Ploeg et al., 2000) were administered before exposure, the state scale was also administered afterwards. Both subscales contained 20 items and answers were provided on a 4-point scale.

Experimental software. The experiment was carried out on a PC compatible computer and programmed using E-prime version 1.1 (Schneider, Eschman, & Zuccolotto, 2002).

Procedure

Participants were tested individually. After the experimenter explained the procedure in sufficient detail, participants gave written informed consent. Each participant was allocated at random to one of the experimental conditions. The computer-program was initiated by pressing the spacebar and started with the state and trait versions of the STAI (Spielberger et al., 1983). Then participants either carried out the positive exposure condition or the negative condition and either the complete word condition or the fragmented word condition. This was followed by the second STAI-state questionnaire and the recognition task (or vice versa, depending on the assigned condition). At the end of the testing session, participants were debriefed.

Results

Anxiety

To examine the direct effect of exposure on anxiety, a 2 x 2 x 2 mixed model ANOVA with exposure valence (positive vs. negative) and word-type (complete vs. fragmented) as the between-subjects factors and time (before vs. after) as the within-subject factor was performed. Results indicated a Valence x Time interaction effect, $F(1, 85) = 4.21$, $p < .05$, $\eta_p^2 = .05$. There was a trend in the predicted direction for anxiety to decrease in the group who had processed positive information, $t(44) = 1.70$, $p < .10$ as opposed to a non-significant increase in the group who had processed negative information, $t(43) = -1.2$, *ns*. Thus, independent of word type, mere exposure to valenced information had congruent effects on state anxiety (see Table 1 for means and standard deviations). The predicted Valence x Word-type x Time interaction effect was not significant, $F(1, 85) = 0.51$, *ns*. That is, the influence of exposure on anxiety does not differ between presenting the valenced information in a complete form or fragmented.

Table 1.
Mean (and *SD*) state anxiety scores before and after different exposures

Exposure valence	Word type	Before	After
Positive	Fragmented	32.6 (7.3)	32.0 (6.8)
	Complete	34.2 (9.2)	32.2 (6.6)
	Mean	33.4 (8.2)	32.1 (6.6)
Negative	Fragmented	32.8 (9.0)	33.8 (7.7)
	Complete	34.6 (8.2)	35.8 (8.1)
	Mean	33.7 (8.6)	34.8 (7.9)

Test of changed interpretations

To inspect whether the groups unexpectedly differed in interpretive bias, a 2 x 2 x 2 x 2 mixed model ANOVA was performed on the recognition data with exposure valence (positive vs. negative) and word-type (complete vs. fragmented) as the between-subjects factors and sentence (possible vs. foil) and valence of recognition items (positive vs. negative) as the within-subject factors. Main effects of sentence, $F(1, 85) = 1052.4$, $p < .001$, $\eta_p^2 = .93$, and valence of recognition items were found, $F(1, 85) = 16.40$, $p < .001$, $\eta_p^2 = .16$, indicating greater endorsement of the possible and positive items. All other results, including any effects with exposure valence or word-type, were not significant, *F*'s < 1.55. Thus as intended, there are no indications of differences in interpretations between participants who received positive or negative information.

Discussion

As a sequel to the mediational finding that changes in state anxiety after a CBM-I procedure appear not to be due to the altered interpretations, the present experiment was designed to directly test whether the element of exposure is sufficient to affect anxiety. While the mere exposure to positive or negative information did not induce an interpretive bias, congruent effects on state anxiety were found. Exposure to positive or negative words or fragments seems sufficient to cause changes in mood.

General discussion

CBM-I procedures have been used to test the causal nature of the relationship between interpretive bias and anxiety by modifying interpretive bias and examining direct effects on anxiety (as opposed to examining effects on stress responses). In previous studies changes in state anxiety, directly found after a successful CBM-I, have been taken as evidence that interpretive bias plays a causal role in the occurrence of state anxiety (Mathews & Mackintosh, 2000; Salemink et al., 2007b; Yiend et al., 2005). While it is evident that the procedure induces an interpretive bias, it was argued that this does not necessarily imply that the induced interpretive bias in fact causes changes in anxiety. The modification procedure itself could affect mood due to other processes, such as the exposure to valenced information. This direct effect could be additional to those effects of the induced interpretive bias, but it could also fully explain the observed effects on anxiety. These other possibilities have received little attention (but see Mathews & Mackintosh, 2000, p. 614, General Discussion section). Mediation analyses were performed (on data by Salemink et al., 2007b) as a first step to elucidate this issue. Analyses suggested that, for trait anxiety, the modification procedure affected interpretations, which in turn affected anxiety. Thus, it appears that changes in trait anxiety were caused by the altered interpretive bias.

Changes in *state* anxiety directly after completing CBM-I have been taken as evidence of a causal relationship between interpretive bias and anxiety (Mathews & Mackintosh, 2000; Salemink et al., 2007b; Yiend et al., 2005). Interestingly, the mediation analysis suggested that there was, in fact, no causal relationship between an altered interpretive bias and changes in state anxiety, while the CBM-I did affect interpretive bias and anxiety independently. Given that the initial findings were only based on statistical analyses, an experiment was designed to directly test whether the CBM-I procedure itself could directly affect anxiety through mere exposure to valenced materials. This study showed that the mere exposure to positive or negative words was sufficient to produce (small) changes in state anxiety, even when no difference in interpretive style was observed. In sum, the first study showed that altered interpretations are not necessary for the observed changes in state anxiety directly after CBM-I. The second study added to this observation by revealing that the mere exposure to positive or negative words is sufficient to affect state anxiety.

One might argue that completion of the word fragments in Study 2 still involves an interpretive process. The fragments could be considered as ambiguous information that requires interpretation. Yet, no interpretive bias effects were observed on the recognition task, showing that the procedure did not induce an interpretative bias typically found in CBM-I. More importantly, the reading of complete words also resulted in anxiety change. It therefore seems safe to conclude that the observed effects on state anxiety were not due to the training of negative or positive disambiguations.

The observed lack of differences between complete and fragmented word conditions (study 2) is consistent with the hypothesis that mere exposure to valenced information is sufficient to obtain anxiety effects. Yet, simultaneously, the lack of differences between these conditions seems at odds with findings from Mathews and Mackintosh (2000) and Yiend et al. (2005). These studies also induced an interpretive bias by presenting ambiguous social stories with a final word, presented in its complete form that disambiguated the emotional meaning (passive CBM-I). These studies did not observe a change in anxiety, while in our study the presentation of complete words, without the ambiguous story, did affect anxiety. An explanation might be that removal of the social story entailed removal of neutral information and as a result, there was *relatively* more emotional information, which might have caused the mood effects. Though note that the present findings for non-fragmented words are in line with findings from Holmes and Mathews (2005). They observed effects on anxiety after imagery and a verbal bias modification with complete words; the effects being greater for imagery.

A weakness of the present study is that the original CBM-I procedure was not incorporated in the experiment. Thus a direct comparison between anxiety changes instigated under CBM-I and present conditions is not possible. Conversely, it is possible to compare the effect sizes of changed anxiety of the different studies. While the present study found an effect of d = 0.44, Mathews and Mackintosh (2000) found an effect of d = 1.55 in their first experiment. In the meantime, Salemink et al. (2007b) and Yiend et al. (2005) found large effects of CBM-I on anxiety (respectively d = 0.92 and d = .86), but Salemink et al. (2007a) and Yiend (3rd experiment) found small effect sizes; d = 0.27 and d = 0.23). In the present case, comparing effect sizes seems of little help, since the magnitude of the effect sizes in the standard CBM-I studies fluctuates strongly. The effect size of the present study does fall in the range of the standard CBM-I effects, though a direct comparison between the full CBM-I and a dismantled version remains an issue for further research.

The SEM-finding that interpretive bias seems to affect trait, but not state anxiety is surprising as trait anxiety is a measure of the frequency of state anxiety. Furthermore, the trait and state anxiety scores are generally highly correlated (in the present study: r = .66). One possibility is that questions about one's present state may be answered by a simple introspection of one's current mood. Whereas inferring your feelings of general anxiety (trait anxiety) seems more of an elaborative process involving activation of the autobiographical data set, scanning it and evaluating it against the question being asked. This process might, thereby, leave more room for the interpretive bias to exert its influence.

Altered interpretations are not essential for inducing changes in mood. In the present study, it was shown that mere exposure to valenced verbal materials is sufficient. Others (Holmes & Mathews, 2005) found more change in anxiety in an *imagery* CBM-I condition than in a *verbal* modification condition. This supports the idea that other ingredients (e.g. imagery, exposure) are important for affecting a mood state. Therefore, a change in state anxiety directly observed after a CBM-I procedure is not a valid indicator of a causal relationship between the cognitive bias and anxiety. This bears implications for previous CBM-I experiments where conclusions about causality have been drawn after observing such changes in state anxiety.

The finding that CBM-I affected interpretive bias, which in turn affected trait anxiety, is promising in light of possible clinical implications. Especially because trait anxiety is considered a long lasting vulnerability factor for developing anxious mood. Furthermore, it underscores the importance of measuring the effects of a CBM-I procedure on trait anxiety or on the tendency to react anxiously to a stressor. The latter has recently been done by Mackintosh et al. (2006) and Wilson, Macleod, Mathews, and Rutherford (2006).

In past years many experiments have been conducted to unravel the causal nature of cognitive biases by modifying these biases. These studies reveal that cognitive bias can indeed be modified and that it is associated with changes in mood. It is easy to conclude that the bias causes observed changes in affect. Mediation analyses and experimental data from the present studies imply that this is not necessarily the case. While the relationship between CBM-I and changes in trait anxiety is mediated by the interpretive bias, this was not the case for state anxiety. The CBM-I procedure may directly affects mood in other ways disregarding the crucial influence of the interpretive bias.

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Effects of positive interpretive bias modification in highly anxious individuals

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Abstract

Over the past 20 years evidence has accumulated that individuals suffering from anxiety tend to interpret ambiguous information as threatening. Considering the causal role of this interpretive bias in anxiety, it was recently established that modifying interpretive biases influences anxiety. This suggests that anxiety can be clinically treated by directly targeting this interpretive bias. The present study was designed to modify a negative interpretive bias in highly anxious individuals, and subsequently assess the hypothesised beneficial effects on clinical measures. High trait-anxious participants were randomly assigned to one of two conditions: a positive interpretational Cognitive Bias Modification (CBM-I) or a control condition (n = 2 x 17). The program was offered online for eight consecutive days. Upon completing the program, participants who had followed positive CBM-I were less state and trait anxious compared to the control group. Additionally, positively trained participants scored lower on a measure of general psychopathology (SCL-90). No effects were observed on social anxiety and stress vulnerability. The mixed pattern of findings renders them rather inconclusive, leaving interpretations of the potential therapeutic merits of CBM-I open for future research.

Introduction

There is overwhelming evidence that anxiety is associated with a maladaptive tendency to interpret ambiguous information in a threatening way (e.g. Amir, Foa, & Coles, 1998; Eysenck, Mogg, May, Richards, & Mathews, 1991; MacLeod & Cohen, 1993). The studies that yield these conclusions all have cross-sectional designs: anxious participants are compared to non-anxious control groups. As a result, a shortcoming of these studies is that they shed no light on the issue of causality. Does anxiety cause the interpretive bias? Or does the interpretive bias contribute to anxiety? Are anxiety and the interpretive bias mutually reinforcing and/or is a third variable driving both anxiety and the interpretive bias?

In order to resolve the question of causality, Mathews and Mackintosh (2000) developed a program designed to modify interpretive bias: Cognitive Bias Modification of Interpretations (CBM-I). Biases were modified by presenting a series of ambiguous social stories, each ending in a word fragment, to non-anxious participants (individuals with a mid range level of anxiety). Correct resolution of the fragment disambiguated the story either positively or negatively, depending on the assigned modification condition. Subsequently, Mathews and Mackintosh tested whether the modification of the interpretive bias resulted in a corresponding change in anxiety. A "recognition test" (see below) confirmed that CBM-I effectively induced an interpretive bias. Negatively trained participants interpreted new ambiguous information in a threatening way. Conversely, positively trained participants made more non-threatening interpretations. More importantly, CBM-I effected congruent changes in anxiety. Positively trained participants became less anxious, while negatively trained participants became more anxious. The main findings observed in this study were replicated various times (Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Salemink, van den Hout, & Kindt, 2007b, Yiend, Mackintosh, & Mathews, 2005). Consequently, the data indicate that the interpretive bias plays a causal role in anxiety and that it can be modified through training.

All of the abovementioned studies trained individuals with a mean level of anxiety. It has thus been established that the interpretive bias is trainable and that it affects anxiety. Therefore, it seems that there would be a high clinical relevance in training individuals with high anxiety levels, such as patients suffering from an anxiety disorder, to interpret information positively[7]. An important first step was taken by Mathews, Ridgeway, Cook, and Yiend (2007), who performed a positive CBM-I study in an analogue sample of highly anxious community volunteers (*N* = 39). Half of the participants received training to interpret information in a positive way, while the other half was assigned to a test-retest control

[7] Amir and Beard (2007, July) already performed a CBM program using participants with clinical levels of anxiety, though no formal paper is (yet) available.

condition. Individuals in the positive group received four CBM-I sessions over a two-week period. Each session consisted of 100 stories. Along the course of the sessions, the stories became more positive; i.e. the first session involved stories with non-negative interpretations, while in later sessions the interpretations of these 100 stories became gradually more positive. Pre- and post-measurement of the interpretive bias showed that the positive CBM-I was successful: positive interpretations increased, while negative interpretations decreased. More importantly, the positive CBM-I resulted in a significant reduction in trait anxiety scores. Thus, this evidence supports the proposed beneficial effects of positive CBM-I on trait anxiety. No effects on state anxiety were found.

While the results from the Mathews et al. study (2007) are encouraging, several issues demand clarification. First of all, the control group did not receive any training and was only tested twice. Consequently, it is unclear whether reported results are caused by the intervention or are due to mere exposure to valenced material, demand characteristics, etc. To rid the results of this ambiguity, a control *training* condition is warranted. Secondly, the measured effects on trait anxiety were moderate. While no effects were found on state anxiety, the changes observed on trait anxiety were relatively small (a decrease of 4.2 on the trait version of State-Trait Anxiety Inventory, STAI, Spielberger, Gorsuch, Lushene, Vagg, and Jacobs, (1983)). In order to ensure the CBM-I's clinical relevance, the effects should be larger. In Mathews et al.'s format, individuals were succumbed to a mere four training sessions in a two-week period. In other words, participants had more training-free days than training days. Participants may benefit from an intensified CBM-I, by having, for example, more training than training-free days, and/or by increasing the total number of different trials and sessions.

The present experiment was designed with two objectives in mind; to assess the robustness of previous findings, considering the effects of induced positive interpretations on the reduction of anxiety, and to optimise the CBM-I program. First of all, we ensured an intensive CBM-I program by developing an *eight-day* program, in which participants were not allowed to skip a single day. Secondly, we increased the total number of new trials. Each day consisted of 104 new trials. The total number of trials amounted to 832 (cf. four different versions of the original 100 trials in Mathews et al.'s (2007) study). Thirdly, we developed a control training condition. Participants in this condition also received an eight-day program, but now half of the stories ended positively while the other half ended negatively. Thus, these participants were not trained to interpret information either positively or negatively, but were simply engaged in an intensive program for several days. A fourth aspect is that we decided to train participants in their own environment. An internet CBM-I program was developed that could be accessed at home. State and trait anxiety were measured by the same means as in the Mathews et al. study. However, to further explore the range of effects of an induced positive interpretive bias, we also assessed the effects on general psychopathology (SCL-90: Arrindell & Ettema, 1986; Derogatis, 1977) and social anxiety

(Fear of Negative Evaluation, FNE: Watson & Friend, 1969). Furthermore, we examined whether interpretive bias causally modulates emotional vulnerability (the degree to which a stressor serves to aggravate a negative mood state). Therefore, participants had to perform a stress task after CBM-I to assess the degree to which participants differed in terms of their anxiety reactivity.

In sum, we designed the current study to examine whether reductions in negative interpretive bias in sub-clinically anxious individuals lead to congruent beneficial effects on mood. Pre-selected high trait anxious individuals with higher than average negative interpretations received either the eight-day experimental condition of CBM-I (positive CBM-I) or the eight-day control condition. The following hypotheses were formulated, all of which were directional. The first hypothesis predicted that CBM-I would effectively induce positive interpretations in the experimental group when compared to the control group. Assuming that the interpretive bias modification would be successful, the second hypothesis stated that the positively trained group would become less anxious than the control group. Finally, it was also predicted that the general psychopathology scores of the positively trained group would decrease. Concerning the effects on emotional vulnerability, a hypothesis was formulated predicting that the positively trained group would be less reactive to stressors in comparison to the control group.

Method

Participants

In order to obtain a group of high trait anxious participants with a negative interpretive style, we had to establish criteria for both high anxiety and negative interpretive bias. Following Yiend et al.'s example (2005), a score of 45 or higher on the trait version of the STAI (Spielberger et al., 1983) was set as a criterion for high anxiety. This represented the top 20% of a sample of 321 students who filled out the STAI trait questionnaire following a lecture (*M* trait anxiety = 37.4, *SD* = 8.7). To find a criterion for interpreting information negatively, we first assessed how students interpreted ambiguous information. A random sample of 40 students from the general student population completed the closed questions version of the Ambiguous Social Situation Interpretation Questionnaire (ASSIQ: Stopa & Clark, 2000) (see Materials section). The mean score for this sample of students was 1.56 (*SD* = 0.4), we therefore considered a score ≥ 1.57 higher than average for negative interpreting. This was the second criterion for inclusion. The combined criteria resulted in a sample of 36 highly trait anxious participants who had above average scores on the negative interpretation of ambiguous information. During the experiment, the data of two participants had to be removed because they skipped a training day, yielding a final sample of 34. Of this sample six were male and their mean age was 21.3 years (*SD* = 2.1). Before the start of CBM-I, participants in the positive and the control group did not differ significantly for scores on the ASSIQ, $t(32) = -1.58$, STAI state, $t(32) = -0.31$, STAI trait, $t(32) = -0.20$, and SCL-90, $t(32) = -1.51$. The groups differed on the FNE scores, $t(32) = -2.48$, $p < .05$, participants in the positive CBM-I group had higher scores than participants in the control condition (respectively, 36.4, $SD = 8.3$ vs. 28.3, $SD = 10.5$). As a next step, pre-CBM-I FNE scores were examined in relation to changes in crucial dependent mood variables. Pre-FNE scores were significantly related to change in FNE, $F(1, 31) = 5.44$, $p < .05$, $\eta_p^2 = .15$. Those statistical analyses are, therefore, performed with pre-FNE scores as a covariate. As pre-FNE scores were not significantly related to other dependent mood questionnaires, *F*'s < 1.1, those analyses were conducted without correction for pre-FNE scores. All participants received course credits and a financial reimbursement.

Materials

CBM-I stimuli. To modify interpretive bias, participants were trained for eight hours: one hour a day on eight consecutive days. Participants received 832 social stories in total, of which 104 were translated stories used by Mathews and Mackintosh (2000). The rest were designed exclusively for the present study. Every day, participants received 104 stories, presented in eight blocks with optional rests between each block. Each block contained (1) eight modification stories, (2) three filler stories, and (3) two probes, all presented in random order.

The ‘modification stories’ consisted of 3 lines that were ambiguous in terms of valence. The story’s meaning would be left ambiguous up to the final sentence, where a word fragment disambiguated the story. In the positive condition the stories would have a positive outcome. In the control condition half of the stories would have a positive and half a negative outcome. Every word fragment had only one meaningful solution and participants were asked to complete the fragments as quickly as possible. A comprehension question with relevant feedback appeared on the screen to reinforce the interpretation imposed by the word fragment. An example of a modification story with the completed word fragments for each condition (appearing in parentheses) is:

> *You asked a lot of questions during lecture because you didn’t understand the subject and tried to grasp it. The other students seemed to find it difficult too. They listened with … to all your questions.*
> *app-----tion (appreciation) / ir----tion (irritation)*

The story was immediately followed by a comprehension question:

> *Did the other students find you annoying?*

The ‘filler stories’ had no emotional content, nor did they contain ambiguity. They were inserted to make the CBM-I less obvious:

> *You arrange to meet a friend at your local pub*
> *one evening. As you arrive, you cannot help noticing*
> *that the sign in front has been …*
> *pa-n--d (painted)*
> *Has your pub changed its appearance?*

The ‘probes’ were similar to the modification stories, but they had a fixed positive and negative valence, irrespective of the modification condition. They were inserted to measure the speed of resolving word fragments of positive and negative valence across the training phase. Effective training was obtained when positively trained participants were faster at solving positive word fragments and slower at solving negative word fragments compared to the control group.

Recognition test stimuli: Test of CBM-I effects on interpretive bias. Upon completing the last block on the last day of training, participants received a recognition test to assess their interpretation style (translation of Mathews and Mackintosh’s (2000) recognition task). Participants had to resolve ten new ambiguous test items, much as they did for the CBM-I items. This time, however, every story had a title and was presented in a uniquely identifiable context, following Mathews and Mackintosh. To maximise the resemblance of these items to those presented in the modification phase, participants were required to solve a word fragment and to answer a comprehension question. Yet this time the valence of the story remained ambiguous. An example of these ambiguous test items is presented here (with the completed word fragment in parentheses):

> *The job interview*
> *You see a job advertised that you'd really like. You apply and are invited*
> *to an interview, where you answer the questions as well as you can.*
> *Reflecting later, you think that the quality of your answers decided the …*
> *ou--om- (outcome)*

The comprehension question immediately followed:

> *Did you think about your answers later?*

In the second part of the recognition test participants saw the title of the ambiguous story, together with four versions of the final sentence. These sentences represented a) a possible positive interpretation, b) a possible negative interpretation, c) a positive foil sentence, and d) a negative foil sentence. Participants rated each sentence for its similarity in meaning to the original story using a 4-point scale, ranging from 1 (*very different in meaning*) to 4 (*very similar in meaning*). The four corresponding sentences of the ambiguous test example above are presented here:

a) You think it must have been your clear answers that got you the job.
b) Reflecting later, you realise that your poor answers lost you the job.
c) Reflecting later, you think it was a good thing you did not take the job.
d) You think that your appearance must have made a bad impression.

It was predicted that positively trained participants would give more positive and less negative interpretations compared to the control trained participants.

ASSIQ. Participants had to fill in the closed-ended version of the ASSIQ (Stopa & Clark, 2000) before and after undergoing CBM-I. Participants received short descriptions of ambiguous social (14 items) and control situations (10 items), followed by three alternative, experimenter-provided explanations. One explanation was always negative, one was always neutral and the third was positive or neutral. Participants rank-ordered all three interpretations in terms of the extent to which "they would be most likely to come to your mind if you found yourself in a similar situation". When a negative social explanation was ranked first, second, or third, a score of 3, 2, or 1 was given respectively. Thus, higher scores reflected more negative bias in information processing.

Measurements of mood and psychopathology. The participants completed four questionnaires during pre- and post-test periods in the laboratory. We presented the participants with the state and trait scales of the State-Trait Anxiety Inventory (STAI-ST, Spielberger et al., 1983) to measure state and trait anxiety. Both scales contain 20 items. We used the 12-item Fear of Negative Evaluation questionnaire (FNE, Watson & Friend, 1969) to assess social anxiety and the Symptom CheckList (SCL-90, (SCL-90, Arrindell & Ettema, 1986; Derogatis, 1977) to assess general psychopathology.

To assess participants' daily mood and arousal state during CBM-I, each session started with a computerised pleasure and arousal subscale of the Self-Assessment Manikin (SAM). The SAM pleasure subscale ranges from a smiling, happy figure (score 1) to a frowning, unhappy figure (score 9). The arousal subscale ranges from a excited figure (score 1) to a relaxed figure (score 9) (Hodes, Cook, & Lang, 1985; Lang, 1980).

Stress task. During the post-test in the laboratory, the participants were exposed to an anagram stress task to elicit hypothesised variations in stress vulnerability affected by CBM-I. The task was adapted from the anagram stress task used by Macleod, Rutherford, Campbell, Ebsworthy, and Holker (2002) and is capable of inducing stress. Participants were told that the task would be difficult, but that intelligent participants like students usually perform well. They were also told that a meeting with other students would take place afterwards, to compare personal performance to the performance of others. Participants saw 15 anagrams on the computer screen, one at a time. The objective was to solve as many anagrams as possible by writing down the correct words on a response sheet and pressing the space bar to go to the next one. When no response was detected in 20 sec, the computer signalled that the participant should respond faster. Half of the anagrams were extremely difficult and consisted of at least 13 letters. The other half ranged from simple to quite difficult (4 to 9 letters).

Participants completed two computerized visual analogue mood scales (VAS) before and after the stress task to measure their emotional reactions to it. One scale assessed anxiety and was labelled at opposite ends with the words *relaxed* and *anxious*. The other scale assessed depression and was labelled at opposite ends with *happy* and *depressed* (Macleod et al., 2002). Both scales consisted of a 15-cm horizontal line. Participants scored their mood by selecting a location on the line with a mouse click. Each scale completion yielded a score ranging from 0 to 100, with a higher score indicating a higher level of negative mood.

At the very end of the experiment, participants were informed that there was, in fact, no meeting in which they could discuss their performance, and that the anagram task was extremely difficult.

Exit questionnaire. Participants completed an exit questionnaire to check whether they were aware of the object of the study. They were asked to indicate whether or not they had an idea about the purpose of the study and if so, to write their idea down.

Experimental software. The pre- and post-test measurements in the laboratory were programmed using E-prime version 1.1 (Schneider, Eschman, & Zuccolotto, 2002). The online CBM-I was programmed using HTML/PHP and reaction times were measured with a JavaScript timer. The data was saved in a MySQL database.

Procedure

The experiment started and ended with an assessment in the laboratory in groups of three participants. The eight-day CBM-I was performed individually at home. Participants were randomly assigned to the positive or control condition, so that each condition contained 17 participants.

During the pre-training baseline session, the experimenter explained the procedure of the 8-day experiment. Participants were told they had to imagine being in the situations described in a series of textual passages. CBM-I was not introduced as some sort of treatment and no mention was made of any beneficial effects that might occur. Participants received a login-name and password, as well as the experimenters' contact details, enabling the participants to contact the experimenters in the event of any difficulties. Participants were informed that payment would only be received if the series of sessions were completed without fail on eight consecutive days. The experimenter checked this every day in the online database. Participants gave written informed consent. They completed four computer-delivered questionnaires in separate cabins. The computer-program started with the state and trait versions of the STAI, followed by the FNE and the SCL-90. This session lasted for approximately 30 minutes.

Each home-session started with some instructions to try to ensure a quiet and undisturbed test environment. Then the mood and arousal subscales of the SAM were presented, after which CBM-I commenced. Reaction times and accuracy scores for solving word fragments in probe stories were assessed. Answers to the comprehension questions were also recorded. The duration of a session was approximately one hour. After the last block of training on the eighth day, participants received a recognition task to test for the predicted effects on interpretive bias (see Figure 1).

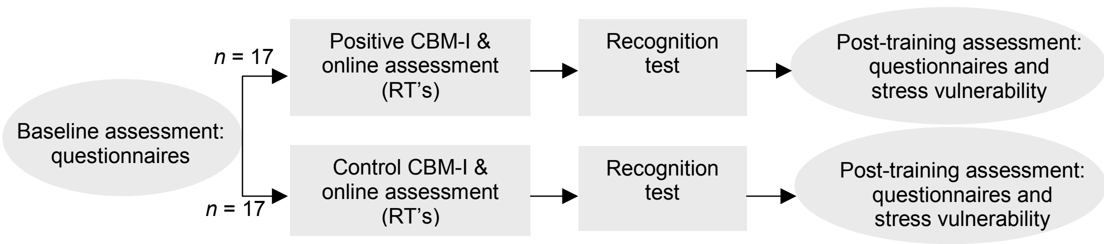

Figure 1.
The design of the study
Note. Circled text refers to assessments that took place in the laboratory and squared text refers to assessments that took place in the participant's home. CBM-I stands for Cognitive Bias Modification of Interpretations and RT's stands for reaction times.

During the one-hour post-test in the laboratory, participants were once again asked to fill-in the four questionnaires on a computer together with the ASSIQ. Then a stress task was administered with a pre- and post-test for mood (VAS). Finally, participants completed the exit questionnaire and were debriefed.

Results

Effectiveness of CBM-I in changing interpretations

Reaction times to probes. To test the effectiveness of CBM-I in changing interpretive style, reaction times were analysed with a three-way mixed model ANOVA with CBM-I group (positive vs. control) as the between-subjects factor and probe (positive vs. negative) and time (first vs. second half of CBM-I) as the within-subject factors. The factor time was added to examine the development of CBM-I effects on interpretations. Trials where an incorrect response was given were omitted from the analysis. There was a main effect of time, $F(1, 32) = 127.27$, $p < .001$, $\eta_p^2 = .80$, indicating that faster responses were given in the second half of CBM-I. There was also a main effect of probe, $F(1, 32) = 16.61$, $p < .001$, $\eta_p^2 = .34$, indicating that faster responses were given to positive probes. More importantly, the predicted Group x Probe interaction effect was significant, $F(1, 32) = 9.72$, $p < .01$, $\eta_p^2 = .23$, confirming the effectiveness of CBM-I. While the control group did not react differently to negative and positive probes (962 ms, *SD* = 325 and 945 ms, *SD* = 323), participants who had previously been exposed to the positive CBM-I displayed a marked slowing in reacting to negative (1071 ms, *SD* = 232) as compared to positive probes (943 ms, *SD* = 188, see Figure 2).

To examine the efficacy of the newly developed scenarios, a mixed model ANOVA was conducted with group as the between-subjects factor and probe and scenario type (original vs. new) as the within-subjects factors. The main effect of scenario type was not significant, $F(1, 32) = 0.02$ and no interaction effects were found involving group, *F*'s < 1.4.

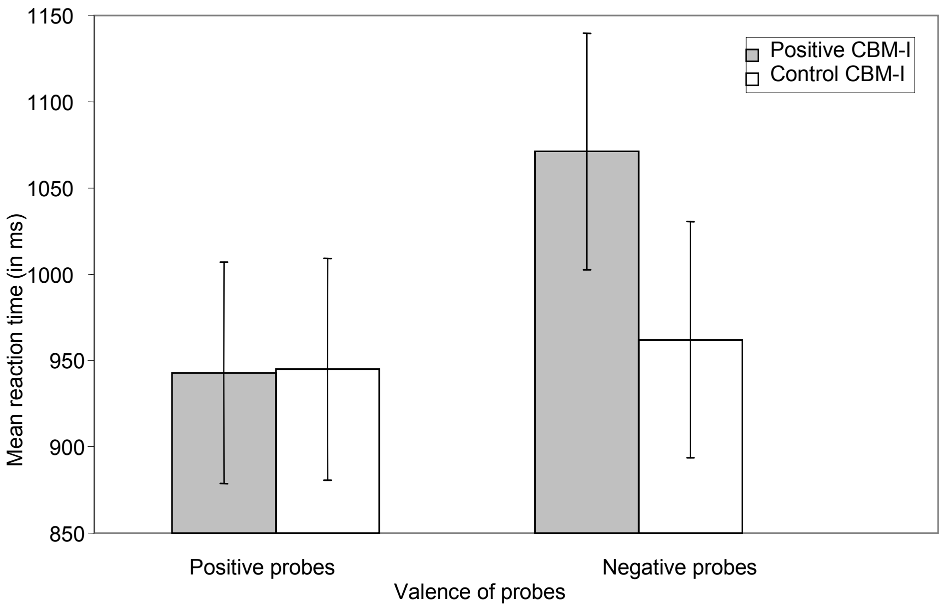

Figure 2.
Mean reaction times and *SE* (in ms) to solve probes during CBM-I

Recognition ratings. The second manipulation test of induced interpretations was the recognition test, which was to be completed at home after CBM-I. Due to technical problems, seven participants completed this recognition test the next day in the laboratory (four positively trained and three control trained participants). A mixed model ANOVA with group as the between-subjects factor and valence (positive vs. negative) and target (possible interpretation vs. foil sentence) as the within-subject factors was performed first with these seven participants and later without them. The first analysis revealed a main effect of valence, $F(1, 32) = 6.04$, $p < .05$, $\eta_p^2 = .16$, with positive sentences being endorsed more than negative sentences, and of target, $F(1, 32) = 112.94$, $p < .001$, $\eta_p^2 = .78$, indicating greater endorsement of probable interpretations than of foils. The most pertinent analysis with respect to our manipulation was the three-way interaction effect of Group x Valence x Target. This effect failed to reach significance, $F(1, 32) = 1.44$.

Performing the analysis with the smaller group of 27 participants yielded significant main effects of valence, $F(1, 25) = 14.46$, $p < .001$, $\eta_p^2 = .37$, and target, $F(1, 25) = 304.31$, $p < .001$, $\eta_p^2 = .92$. Interestingly, the predicted three-way interaction effect of Group x Valence x Target was significant, $F(1, 25) = 4.85$, $p < .05$, $\eta_p^2 = .16$. To decompose this interaction effect, we carried out separate analyses for probable interpretations and foil sentences. For the probable interpretations, a predicted Group x Valence interaction effect was significant when taking the directional nature of the hypothesis into account[8], $F(1, 25) = 3.24$, directional $p < .05$, $\eta_p^2 = .12$, which was absent for foils, $F(1, 25) = 0.00$. Positively trained participants gave more positive interpretations than the control trained participants (3.2, *SD* = 0.3 vs. 2.9, *SD* = 0.5, see Figure 3). Thus, when measured within a period of 24 hours, participants had the tendency to interpret new ambiguous information with the valence they had been trained in. The statistical analyses of the mood questionnaires were conducted with and without those seven people. Since a similar pattern of results was obtained for both groups, results are reported for the total sample.

[8] Directional testing in a 2 x 2 design is allowed, based on $F(1, df) = t^2(df)$ (Dobson, 2002).

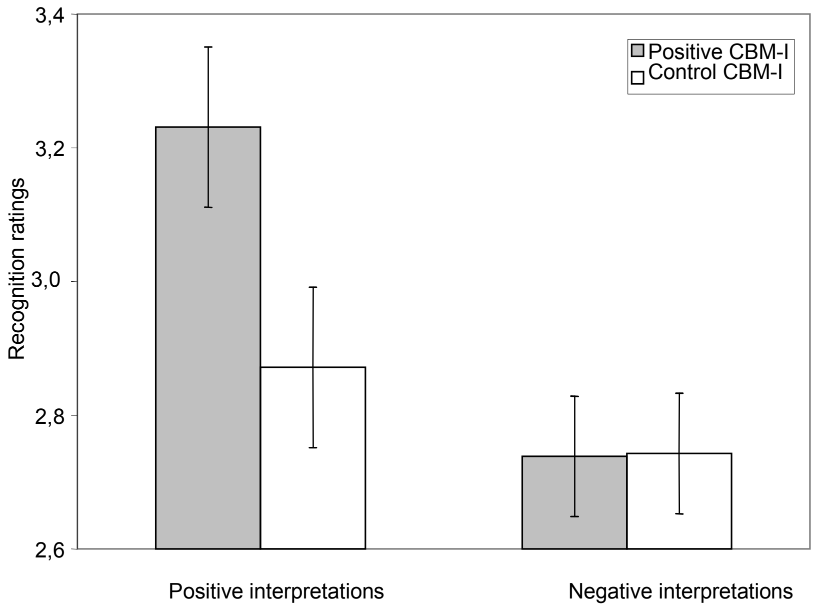

Figure 3.
Mean recognition ratings and *SE* for possible interpretations with negative and positive valence depicted for each CBM-I condition
Note. Recognition ratings ranged from 1 *(very different*) to 4 (*very similar)* and *n* = 27.

Ambiguous Social Situations Interpretations Questionnaire (ASSIQ). The presence and nature of the induced interpretive bias was also tested by analysing the social items of the ASSIQ. A two-way ANOVA with group as the between-subjects factor and time (before and after CBM-I) as the within-subject factor revealed a main effect of time, $F(1, 32) = 11.76$, $p < .01$, $\eta_p^2 = .27$, representing a reduction in negative interpretations in both groups. The positive group scored 2.2 (*SD* = 0.3) before CBM-I and 1.9 (*SD* = 0.4) afterwards and the control group scored 2.0 (*SD* = 0.3) and 1.9 (*SD* = 0.4) respectively. The predicted Group x Time interaction effect was not significant, $F(1, 32) = 1.77$.

Effects on mood and symptoms of psychopathology

Daily mood and arousal level. The effects of CBM-I on changes in mood and arousal during CBM-I (SAM) were examined with a two-way mixed model ANOVA with group as the between-subjects factor and time (first and second half of CBM-I) as the within-subject factor. Concerning mood, there was a main effect of time, $F(1, 32) = 4.61$, $p < .05$, $\eta_p^2 = .13$, indicating that both groups felt more negative during the second part of CBM-I. Concerning arousal, the predicted Group x Time interaction effect was significant, $F(1, 32) =$

2.94, directional $p < .05$, $\eta_p^2 = .08$. While the participants in the control group got more aroused (from 6.4, *SD* = 1.8 to 5.8, *SD* = 1.5), the positively trained participants remained relatively stable (from 5.4, *SD* = 1.7 to 5.6, *SD* = 1.7).

State and trait anxiety. A 2 x 2 ANOVA on state anxiety revealed the predicted Group x Time interaction effect, $F(1, 32) = 2.88$, directional $p \leq .05$, $\eta_p^2 = .08$. That is, state anxiety increased for the control group (from 39.4, *SD* = 8.9 to 43.0, *SD* = 8.6), but not for the positively trained group (from 40.5, *SD* = 11.2 to 39.4, *SD* = 6.6).

For trait anxiety, a significant main effect of time was found, $F(1, 32) = 5.93$, $p < .05$, $\eta_p^2 = .16$ reflecting a decrease in trait anxiety scores. This analysis also revealed the predicted Group x Time interaction effect, $F(1, 32) = 3.51$, directional $p < .05$, $\eta_p^2 = .10$. In line with our predictions there was a decrease of trait anxiety after positive CBM-I (from 50.0, *SD* = 9.0 to 47.3, *SD* = 9.6) compared to the control condition (from 49.5, *SD* = 6.0 to 49.1, *SD* = 7.1).

Fear of Negative Evaluations. A univariate analysis on the difference scores (post FNE – pre FNE), with pre-test FNE scores as a covariate, revealed a significant main effect for the covariate, $F(1, 31) = 5.44$, $p < .05$, $\eta_p^2 = .15$. The predicted main effect of group was not significant, $F(1, 31) = 0.01$.

Symptoms Check List. A two-way ANOVA revealed a significant Group x Time interaction effect in the expected direction, $F(1, 32) = 3.19$, directional $p < .05$, $\eta_p^2 = .09$. Compared to the control group (before 152.5, *SD* = 33 and after 153.9, *SD* = 36), the positively trained group tended to improve (from 175.9, *SD* = 55 to 159.8, *SD* = 23).

Stress vulnerability

On the stress task, a main effect of time was found for both anxiety and depression; anxiety: $F(1, 32) = 27.13$, $p < .001$, $\eta_p^2 = .46$, depression: $F(1, 32) = 8.41$, $p < .01$, $\eta_p^2 = .21$. No other effects were significant. While the stress task was capable of increasing both anxiety, from 30.3 (*SD* = 20.0) to 47.3 (*SD* = 22.7), and depression, from 40.2 (*SD* = 19.2) to 49.8 (*SD* = 20.6), it did not differentiate between both CBM-I groups.

Exit questionnaire

Results from the exit questionnaire revealed that only a small percentage of the participants (38%) indicated that they had an idea about the purpose of the study (positive CBM-I: *n* = 6, control condition: *n* = 7). Further inspection of their perceived study objectives showed that most of them (*n* = 11) thought it was an assessment study about ‘how you feel’, ‘self-confidence’, or ‘the perception of yourself and others’. Only two participants were conscious of the modification. One of them (control condition) wrote ‘gradually adjusting the negative attribution style’, while the other person (experimental condition) realised the association with mood: ‘improving self-confidence and attribution style’. Removal of these two participants from the statistical analyses did not change the results.

Discussion

We adapted an interpretive bias modification procedure used in earlier laboratory research so that it could serve as a clinical intervention. Students who scored high on trait anxiety and had the tendency to negatively interpret ambiguous information were allocated to either a positive CBM-I internet training or a neutral internet training for eight days. Consistent with earlier findings (Mathews et al., 2007), CBM-I proved successful in modifying interpretations. After the positive CBM-I, an increase in positive interpretations and a simultaneous decrease in negative interpretations was observed. This modification of interpretive style was evident from training congruent changes to solve word-fragments, as well as, training congruent effects on a post-training recognition test with new stimulus materials. The results from the latter task were somewhat mixed, since effects were only observed when interpretive bias was measured directly following CBM-I and within its same context. Mathews et al. found straightforward effects on this recognition test. It must be noted, however, that the recognition test was also presented immediately after CBM-I and in the same context. This might suggest that the temporal and contextual generalisability of the modified interpretive bias is small. Nevertheless, earlier findings revealed 24-hour effects on interpretation after undergoing CBM-I (Yiend et al., 2005), and Mackintosh et al. (2006) demonstrated that the interpretive bias effects survived changes in environmental context. However, the context switch here was rather subtle, thus context dependency may still be a viable explanation. Furthermore, the fact that Mathews et al. had a graded presentation of the CBM-I materials, might have influenced the results.

In the present study, no CBM-I effects were observed on the interpretive bias questionnaire. While the reaction time and recognition task have been used often to examine effects of CBM-I, the ASSIQ questionnaire has not. It might be that this questionnaire is not sensitive enough, or that self-reported interpretations are simply not affected by CBM-I. Moreover, the lack of interpretive bias effects on the ASSIQ is consistent with earlier failure to find transfer (Salemink et al., 2007b). Robust effects of modified interpretive bias have been found when assessed by reaction times and scores on a recognition task (Mackintosh et al., 2006; Mathews & Mackintosh, 2000; Mathews et al., 2007; Salemink, van den Hout, & Kindt, 2007ab; Yiend et al., 2005). The reaction time task assesses how fast one is at the very task that is being trained. The recognition task is procedurally rather similar to the training task. That is, in both tasks the participant reads a short vignette of a hedonically ambiguous situation. The finding that changes in interpretive style are mainly observed in tests that are very similar to the training itself, whilst tests of a different procedure show less clear-cut training effects (Salemink et al., 2007b), questions the validity of CBM-I. Clearly, the nature and generality of the induced changes in interpretative style warrant critical study.

The results regarding the effects of CBM-I on clinical measures were equivocal. While no differences between the CBM-I groups were found on a social anxiety measure (FNE), the positive CBM-I group had a medium effect on both state and trait anxiety and SCL-90 measured psychopathology. That is, SCL-90 measured levels of complaints remained the same in the control group and showed the predicted decline in the positively trained group. The same pattern was found in trait anxiety, which dropped 2.7 points in the positive CBM-I group (note that Mathews et al. (2007) observed a 4.2 decrease). A different pattern was found for state anxiety; it remained stable in the positive group, whilst showing an unexpected increase for the control group. Possibly, the control condition may have provoked anxiety, since almost half (38%) of their stories had a negative valence. The control condition might inadvertently have led to negative interpretations. Yet, based on both theoretical arguments as well as new empirical data this seems rather implausible. Theoretically, the argument that a negative bias was induced in combination with the present pattern of equal responses to positive and negative interpretations *after* control CBM-I, requires the assumption of a positive bias *before* CBM-I. This contradicts the substantial body of data showing that, when compared to healthy individuals, highly anxious individuals have a higher negative interpretive bias (e.g. Macleod & Cohen, 1993). Given that it is, theoretically, highly unlikely that our participants had a positive bias *before* CMB-I, the next step was to test whether the control condition could unexpectedly have led to more negative interpretations. An experiment was conducted to test whether baseline scores on the recognition task for a group of highly anxious individuals differed from the scores of participants *after* control CBM-I. Results showed[9] that the control CBM-I condition did not induce a negative interpretive style and that it functioned as a control condition, as intended.

A second explanation for increased scores for state anxiety in the control condition relates to the fact that CBM-I coincided with the period in which participants (all students) had to prepare for their final examinations. The increased scores on state anxiety and arousal in the control group may possibly reflect examination stress. The absence of such an increase in the positively trained group might be ascribed to a protective influence of the positive CBM-I. Thus, although the groups did not differ in reactions to laboratory stress (also see Salemink et al., 2007a, but see Mackintosh et al., 2006), they may have differed in

[9] A sample of 23 students with high anxiety levels (STAI trait > 45) from the same Faculty and academic year participated (mean age = 20.1, *SD* = 3.5). Their mean trait anxiety level was 50.7 (*SD* = 4.7) and did not differ significantly from full experiment participants, $F(2, 47) = .33$. As they only performed the recognition task (without any prior exposure to a CBM-I procedure), their scores could be considered the baseline interpretive bias scores of highly anxious individuals. The mean recognition rating for positive targets was 2.8 (*SD* = 0.5) and for negative targets, it was 2.5 (*SD* = 0.4). We compared these baseline ratings with those for the control CBM-I group, using an independent samples t-test. Results revealed no significant difference between the baseline scores and the control CBM-I group for both positive interpretations, $t(35) = 0.65$ and negative interpretations, $t(35) = 1.87$. This is inconsistent with the hypothesis that the control condition caused negative interpretations. It confirms that the control CBM-I did function as a control condition.

their response to naturally occurring stress, with the positively trained group being less affected than the control group.

For CBM-I to have clinical potential, it is crucial that the effects on clinical measures improve. The present training already tried to boost the impact of CBM-I by increasing the number of different trials, the frequency of training, and by having participants train in their own homes. In the present study, participants were trained for eight days instead of only one (in original CBM-I studies) or four days (in Mathews et al.'s (2007) study). Surprisingly, reaction time data shows no interaction effects with time. Even with a more fine-grained analysis (creating four blocks of two days instead of two blocks of four days), no effects emerged. A possible explanation is that effects of multiple training days will not be apparent due to ceiling effects, though they might appear in a challenge task where participants show no relapse into old interpretive bias habits. In the present study, mood and various symptoms were only assessed directly before and after the eight-session treatment. The exact time course of clinical change due to CBM-I is, therefore, an empirical issue that awaits further investigation.

There may be other ways to optimise CBM-I. Adapting it to individual needs may improve the effectiveness. In the present training all participants received the same CBM-I materials with regards to social situations. They might benefit from tailored materials as those used in standard CBT protocols. The stories could be designed to include names of people in the participant's social circle, or they could refer to the participant's job, home situation and leisure activities. Furthermore, the pace of the training might be adjusted to someone's performance. Mathews et al. (2007) previously used stories that became more positive along the course of the sessions, this could be made performance dependent. For instance, when non-negative situations are solved quickly and accurately the transition to a next level could take place. If situations are not solved fast and without errors then that level could be prolonged. The transition from easy to difficult situations could be created along the same lines. CBM-I would then become interactive and would consistently match a participant's learning curve. Also, in the present study participants were unaware of the fact that their interpretation style was being modified. Hirsch, Krebs, and Hayes (2007, November) showed that effects of attentional CBM were increased for those participants who were informed about the modification. This might, thus, be an interesting option for further research. Finally, CBT is designed to reduce anxiety vulnerability through the modification of biased cognition. If automatisation of the changed cognitions is a crucial aspect, then CBM-I seems promising because it directly intervenes with these processes. Targeting and optimizing automatisation might be a fruitful direction to improve the effects.

Though much additional research is needed, it is tempting to speculate about possible clinical applications of CBM-I. For instance, we can expect that clinical patients should have even higher anxiety scores before undergoing CBM-I, yielding more room for improvement. We must, of course, consider the possibility that CBM-I does not reduce anxiety in patients, due to deeply embedded mechanisms that may be present in patients and not in highly trait-anxious individuals. Also, our CBM-I concerns the interpretation of social situations. We can, therefore, expect that social phobic patients would benefit most from it. And still the present study and that by Mathews et al.'s selected its participants only on trait anxiety and they improved. A next question could be, would the effects of CBM-I differ across different types of emotional problems?

Research on biased information processing in emotional disorders started some 20 years ago. Yet evidence of a causal relationship between biased information processing and the presence or worsening of emotional problems has started to accumulate only recently. This study has touched upon some of the clinical potentials of positive interpretive bias modification in groups of highly anxious individuals. Results are suggestive rather than conclusive, leaving ample room for exciting new research.

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6

Cognitive bias modification of interpretations: Effects in patients with anxiety disorders

Salemink, E., van den Hout, M. A., Kindt, M., & Rienties, H. Cognitive bias modification of interpretations: Effects in patients with anxiety disorders.

Abstract

Previous research has shown that interpretive bias plays a causal role in anxiety. As patients with an anxiety disorder have the tendency to interpret ambiguous information in a negative way, it was hypothesised that training more positive interpretations would lead to a reduction of anxiety. Patients with anxiety disorders were trained over eight days to generate positive interpretations of ambiguous social scenarios (*n* = 18) and patients in the control condition generated 50% positive and 50% negative interpretations (*n* = 18). Results showed that positively trained participants made more positive interpretations and less negative ones than participants in the control condition. A decrease in trait anxiety, depressive symptoms, and general psychological distress was observed in both the positive and control group. This was maintained at three months follow-up. Several explanations for the observed general decrease in negative mood are discussed. More research with clinical samples is needed to determine the exact therapeutic value of cognitive bias modification of interpretations.

Introduction

Cognitive Behaviour Therapy (CBT) is highly effective in treating anxiety disorders like generalised anxiety disorder (GAD), panic disorder with and without agoraphobia (PD), social phobia (SP), posttraumatic stress disorder (PTSD), and childhood anxiety disorders (Butler, Chapman, Forman, & Beck, 2006; Chambless & Ollendick, 2001). It is in fact one of the treatments of choice for PD and PTSD in the United Kingdom (National Institute for Clinical Excellence, 2004, 2005), USA (American Psychiatric Association, 2004ab), and in the Netherlands (Dutch National Steering Committee Guidelines Mental Health and Care, 2003).

The core assumption of CBT is that patients with an anxiety disorder interpret potential threatening information as much more threatening than they are and this biased interpretation is held to be the pathogenic nucleus of the disorder (Beck, Emery, & Greenberg, 1985). For example, in a cognitive formulation of panic disorder, panic attacks result from the catastrophic misinterpretation of bodily sensations (Clark, 1986). Consequently, CBT is aimed at altering those biased interpretations. Evidence supporting this idea is accumulating. In PTSD, it was shown that good treatment outcome is related to greater changes in dysfunctional post-traumatic appraisals (Ehlers, Clark, Hackmann, McManus, & Fennell, 2005). It was also shown that changes in negative social interpretations during treatment are associated with later changes in social anxiety symptoms at six month follow-up (Hofmann, 2004). To the degree that altered interpretations are the mechanism of therapeutic change, modification of those biases is important when striving for long-term clinical improvement.

CBT addresses the biased interpretations in an effortful and elaborative way. The patient is invited to critically think about the validity of the threatening interpretation and formulate less negative interpretations. It is assumed that this effortful evaluation of threat will, after practice, result in a less threatening interpretation becoming the automatic cognitive style. Automatisation of the new interpretation is held to be associated with reductions of anxiety complaints. Furthermore, stress utilises cognitive resources (Muraven & Baumeister, 2000) and individuals will more easily revert to old, dysfunctional habits. Also in this light the automatisation of the new cognitive habit is important. Thus, changes in automatic interpretations seem to be the final common pathway to therapeutic change, by implication it may be predicted that direct modification of such interpretations should be helpful.

One of the most promising new avenues in this regard, is Cognitive Bias Modification (CBM). Techniques have been developed that directly modify specific information processing biases and interestingly, those procedures affect anxiety and anxiety vulnerability (Mathews & MacLeod, 2002). Mathews and Mackintosh (2000) examined the modification of interpretive bias and its effects on anxiety. A sample of mid range anxious individuals were trained to interpret ambiguous information either in a positive or in a negative way. This modification of interpretive bias was effectuated by having them read ambiguous social scenarios that ended with a word fragment. Solution of the fragment disambiguated the story in a positive or negative direction, depending on the assigned condition. Results showed that Cognitive Bias Modification of Interpretations (CBM-I) was successful in modifying interpretations. Subsequent mood assessment revealed that participants trained to make positive interpretations were less anxious, while negatively trained participants were more anxious (Mathews & Mackintosh). The main findings observed in this study were replicated various times (Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Salemink, van den Hout, & Kindt, 2007b; Yiend, Mackintosh, & Mathews, 2005).

The capacity to successfully modify interpretations with effects on anxiety holds the clinical promise of treating anxiety by directly targeting biased interpretations. As a potential treatment, CBM differs from CBT in that it directly modifies the biased automatic processing style. CBM's potential therapeutic value might be to serve as a specialised treatment for specific cognitive biases that might be an adjunct to more traditional CBT interventions. But, of course it might also serve as a follow-up treatment to automise the new more positive interpretations acquired during CBT.

As a first step to examine the potential clinical effects of CBM-I, Mathews, Ridgeway, Cook, and Yiend (2007) selected an analogue sample of 39 highly anxious individuals. Half of the participants received the social scenarios paradigm to interpret ambiguous information in a more positive way, while the other half was assigned to a test-retest control condition. Positive CBM-I consisted of four sessions spaced over a two-week period and appeared to be successful. Those participants made more positive interpretations and simultaneously made less negative interpretations. A promising finding is that trait anxiety scores were reduced more in this group than in the test-retest control group, when baseline levels were statistically controlled. No effects were observed on state anxiety. Hence, in a sample of participants who are prone to relatively high levels of anxiety, CBM-I was not only effective in reducing negative interpretations, but also in reducing trait anxiety. Interestingly, comparable findings were reported from a different lab (Salemink, van den Hout, & Kindt, 2007a). The authors increased the number of CBM-I sessions from four to eight and developed a control training condition with half of the stories ending positively and half ending negatively. They successfully modified interpretive bias in a sample of highly anxious students and replicated the effects on trait anxiety. Furthermore, a broader range of effects was observed: state anxiety and levels of general distress were also affected by CBM-I. Murphy, Hirsch, Mathews, Smith, and Clark (2007) also replicated the findings in a sample of high socially anxious students. Students who practiced accessing benign interpretations showed a positive bias after single session training and these trained students predicted that they would be less anxious in future social situations compared to a control group.

The important next step would be to examine the effects of positive CBM-I in a clinically anxious sample. It is not entirely clear what to expect in such samples. On the one hand, patients are more anxious before undergoing CBM-I than non-clinical participants, yielding more room for improvement in anxiety and one might expect stronger anxiolytic effects of CBM-I in patients. On the other hand, maintaining mechanisms may be present in patients and not in highly trait anxious individuals, therefore one might also predict that the treatment is less effective or not effective at all in a clinical sample. Amir and Beard (2007, July) already performed an attentional and interpretive CBM using participants who sought treatment for their social anxiety symptoms. They showed that both attentional as well as interpretive CBM was efficacious in reducing social anxiety symptoms. These results are very encouraging, though hard to evaluate since details are lacking in the Congress abstract and no formal paper is available.

The aim of the present study is to examine the efficacy of positive CBM-I in a clinical sample of patients with an anxiety disorder. Half of the patients received an intensive eight-day positive CBM-I program that was offered online. It consisted of the social scenario paradigm designed to modify interpretive bias in a more positive direction. This positive CBM-I condition was compared with a control condition that was followed by the other half of the participants. This control condition also consisted of an eight-day online program, but in this condition only half of the scenarios ended positively while the other half ended negatively to control for the effects of repeated exposure to emotional social material. It was predicted that positive CBM-I was effective in modifying interpretive bias. Furthermore, it was predicted that positive CBM-I treatment would produce improvement in anxiety, depressive mood, general psychological distress, and positive mood over and above a control condition and that those treatment gains would be maintained at follow-up. Therefore, various measures of mood were obtained before and directly after CBM-I as well as three months after CBM-I cessation.

Method

Participants

The first inclusion criterion was a main diagnosis of an anxiety disorder (PD with or without agoraphobia, SP, PTSD, or GAD). Comorbid Axis I and Axis II disorders were allowed. Other inclusion criteria were age above 18, access to internet, and Dutch literacy. General exclusion criteria were current psychosis, addiction, and receiving psychological treatment. Patients using psychotropic medication were allowed to participate. Patients were recruited at two institutes in Utrecht, the Netherlands (Altrecht Centre for Mental Health and Mesos

Medical Centre). Patients who were on a waiting list for treatment and who seemed eligible for participation received an extensive invitation letter informing them about the study. Within one week, the experimenter contacted them by telephone. If the inclusion criteria were met and the exclusion criteria were not met, and if the patient was willing to participate, an appointment was made to determine the main Axis 1 diagnosis and co-morbid Axis 1 diagnoses. A trained clinician (ES) performed the Structured Clinical Interviews for the DSM-IV, version I (First, Spitzer, Gibbon, & Williams, 1996; van Groenestijn, Akkerhuis, Kupka, Schneider, & Nolen, 1999). A medical ethics committee approved the study. Participants did not receive compensation for screening, assessments nor participating in the study; they only received a small financial reimbursement for their internet costs.

Materials and apparatus

Cognitive Bias Modification. To modify interpretive bias, patients were trained for eight hours online: one hour a day on eight consecutive days. Participants received 832 social scenarios, of which 104 were translated scenarios used by Mathews and Mackintosh (2000) The rest were designed exclusively for the present study and involved situations that could be part of the daily life of patients. Every day, participants received 104 scenarios presented in eight blocks with optional rests between each block. Each block contained eight modification stories, three filler stories, and two probes, all presented in random order.

The 'modification stories' consisted of 3 lines that were ambiguous in terms of valence. The story's meaning would be left ambiguous up to the final sentence, where a word fragment disambiguated the story. In the positive condition, the stories would have a positive outcome. In the control condition half of the stories would have a positive and half a negative outcome. Every word fragment had only one meaningful solution and participants were asked to complete the fragments as quickly as possible. A comprehension question with relevant feedback appeared on the screen to consolidate the interpretation imposed by the word fragment. An example of a modification story with possible word fragments for each condition (and solutions appearing in parentheses) is:

> *Since your move to a new house you have spent an increasing amount of time with your new neighbours. You see less of your old neighbours. When one of them calls, you explain that it's because of the move. Your old neighbour sounds …*
> *unde----nding (understanding) / a--oyed (annoyed)*

The story was immediately followed by a comprehension question:

> *Does your neighbour forgive you for not keeping in touch?*

The ‘filler stories’ had no emotional content, nor did they contain ambiguity. They were inserted to make CBM-I less obvious:

You arrange to meet a friend in your local pub
one evening. As you arrive, you cannot help noticing
that the sign in front has been …
pa-n--d (painted)
Has your pub changed its appearance?

Manipulation check I: Reaction times to probes. To check whether CBM-I was successful in modifying interpretive bias, the time taken to solve ‘probe stories’ was recorded. Probe stories were similar to the modification stories, but they had a fixed positive and negative valence, irrespective of modification condition. They were inserted to measure the speed of resolving word fragments of different valences across the modification phase.

Manipulation check II: Recognition task. Upon completing the last block on the last day of training, participants received a recognition test as a second manipulation check (translation of Mathews and Mackintosh’s (2000) recognition task). Participants had to resolve ten new ambiguous test items, much as they did for the CBM-I items. This time, however, every story had a title and was presented in a uniquely identifiable context, following Mathews and Mackintosh. To maximise the resemblance of these items to those presented in the modification phase, participants were required to solve a word fragment and to answer a comprehension question. Yet this time the valence of the story remained ambiguous. An example of these ambiguous test items is presented here (with the completed word fragment in parentheses):

The evening class
You’ve just started going to an evening class. The instructor asks a question
and no one in the group volunteers an answer, so he looks directly at you.
You answer the question, aware of how your voice must sound to the …
oth--s (others)

The comprehension question immediately followed:

Have you been going to the evening class for a long time?

In the second part of the recognition test, participants saw the title of the ambiguous story, together with four versions of the final sentence presented in a random order. These sentences represented a) a possible positive interpretation, b) a possible negative interpretation, c) a positive foil sentence, and d) a negative foil sentence. The four corresponding sentences of the ambiguous test example are presented here:

a) You answer the question, aware of the others listening attentively.
b) You answer the question, aware of how unsteady your voice sounds.
c) You answer the question and then realise what a good answer it is.
d) You answer the question, but realise that you have made a mistake.

Participants rated each sentence for its similarity in meaning to the original story using a 4-point scale ranging from 1 (*very different in meaning*) to 4 (*very similar in meaning*).

Outcome measurements. Four self-report measures were administered three times: Assessment 1 (before the first CBM-I session), Assessment 2 (after completing all eight CBM-I sessions), and Assessment 3 (at three months follow-up). The Dutch version of the State-Trait Anxiety Inventory (STAI-ST, Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983; Van der Ploeg, Defares, & Spielberger, 2000) was administered to measure state and trait anxiety. To measure level of depressive symptoms, the widely used and psychometrically sound Beck Depression Inventory (BDI, Beck, Rush, Shaw, & Emery, 1979) was used. A third measure was the Dutch translation of the Symptom CheckList-90 (SCL-90; Derogatis, 1977; Arrindell & Ettema, 2003), which is a psychometrically robust self-report questionnaire to measure general psychological distress. Fourth, positive and negative affect was measured with the Positive and Negative Affect Schedule (PANAS, Watson, Clark, & Tellegen, 1988).

To assess participants' daily positive and negative mood state during CBM-I, each day started with 6 items from the PANAS; three positive ones (strong, enthusiastic, and active) and three negative ones (anxious, tense, and nervous) were presented in random order.

Exit interview. An exit interview was conducted to obtain the participants' ideas about their allocated condition (experimental vs. control). They were asked to indicate which condition they thought they had followed. If they had no idea, they were invited to guess.

Experimental software. The online CBM-I was programmed using HTML/PHP and reaction times were measured with a JavaScript timer. Data was saved in a MySQL database. The outcome measures obtained during Assessments 1 - 3 were paper and pencil tasks.

Procedure

Participants were randomly assigned to the positive or control CBM-I condition, so that each condition contained 18 participants. Study researchers and patients were masked to condition allocation during the complete study, including the follow-up assessment.

The experiment started with the first assessment at the patient's home. The experimenter explained the procedure of the experiment. Participants were told that they had to imagine themselves being in the situations described in the series of textual passages. Participants received a login-name and password as well as the experimenters' contact details, enabling the participants to contact the experimenters in the event of any difficulties. Signed informed consent was obtained after full explanation of the procedures. Participants then completed the four self-report questionnaires. As a next step, participants filled out ten practice CBM-I trials on their personal computer in the presence of the experimenter. After finishing the practice trials, the experimenter left and the participant started the first CBM-I session individually.

Each session started with some instructions on creating a quiet and undisturbed test environment. Then six items of the PANAS were presented, after which CBM-I commenced. Reaction times and accuracy scores for solving word fragments in probe stories were assessed. Accuracy for answering the comprehension question was also recorded. The duration of a session was approximately one hour. Participants had to complete eight sessions in a period of 11 days and were allowed to include three training free days. After the last block of training on the eighth day, participants received a recognition task to test for the predicted effects on interpretive bias.

Assessment II was planned within three days following the cessation of the CBM-I program. Again the experimenter visited the patient at home and they were again asked to fill-in the four questionnaires. Afterwards, an exit interview took place.

Assessment III was at three months follow-up. Participants received the questionnaires by mail and were asked to complete and return them within one week.

Results

Patient flow

In total 192 patients received an invitation letter and 59 (30.7%) declined participation (all during initial contact by phone, except one after having the SCID interview). Another 85 patients (44.3%) were not eligible for participation: 43 were untraceable; 21 did not meet inclusion criteria (14 had no computer or internet access and seven had insufficient Dutch literacy); and 21 met the exclusion criterion of being in treatment. Forty-eight patients (25%) were randomised. In this sample, six patients were lost in the positive CBM-I condition (five skipped more than three days, one stopped due to a death in the family) and six were lost in the control CBM-I condition (all skipped more than three days). In total, 18 patients in the positive CBM-I condition successfully followed the eight-day procedure and 18 in the control CBM-I condition. Due to technical difficulties, five participants did not receive the recognition test (one in positive CBM-I and four in control condition). Six participants did not return the follow-up questionnaires. The patient flow is presented in Figure 1.

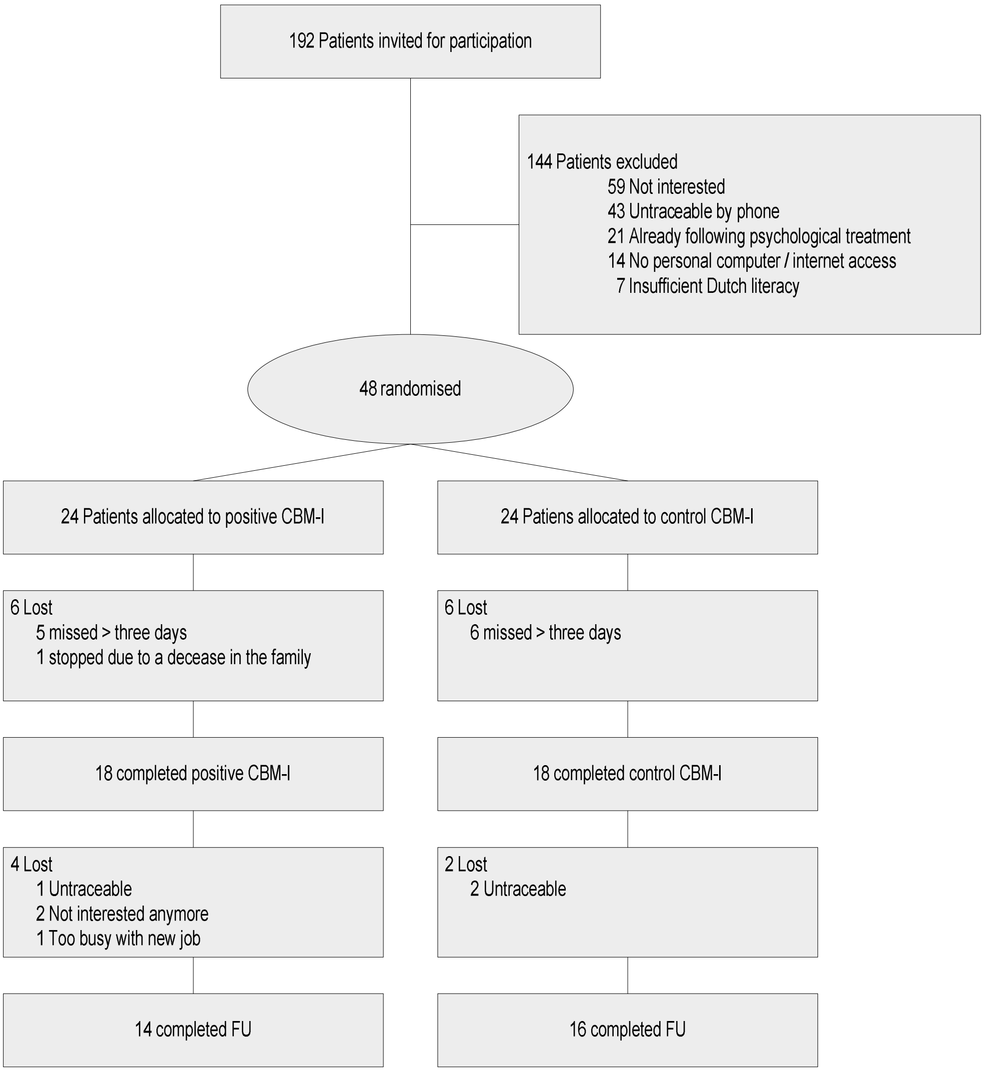

Figure 1.
Patient flow

Treatment groups at baseline

In total, 36 patients participated (26 women and 10 men) and their ages ranged between 24 and 59 years. Table 1 gives an overview of patients' characteristics in both conditions at baseline. Age, sex, marital status, children, and educational level did not differ significantly between the groups.

Table 1.
Sociodemographic and clinical characteristics of 36 study participants

	Positive CBM-I group (n = 18)	Control CBM-I group (n = 18)	*p*-value
Age, mean (*SD*)	41.9 (9.5)	38.6 (10.8)	.34
Women	15	11	.14
Marital status			
Single	2	2	
Relationship, not cohabitating	0	3	
Cohabitating	6	5	.24
Married	4	6	
Divorced	6	2	
Children	11	10	.74
Education: exams passed			
University – graduate level	2	2	
University – undergraduate level	3	5	
High school	1	0	.88
Middle school	10	8	
Elementary school	2	3	
Psychotropic medication use at baseline	8	14	.04
Years of treatment before baseline, mean (*SD*)	1.7 (2.4)	1.3 (1.6)	.49
No. of Axis I diagnoses, mean (*SD*)	1.9 (1.0)	1.9 (1.2)	.88
Duration of diagnoses, mean (*SD*), in years	14.9 (12.7)	15.7 (10.8)	.84

Note. Data is given as number and the *p*-value is based on the Pearson χ^2 test, except where is indicated that data is given as means with standard deviation in parentheses, then the *p*-value is based on an independent samples *t*-test.

As a main diagnosis, fourteen patients met diagnostic criteria for PD with or without agoraphobia, eight patients met GAD criteria, six SP, six others PTSD, and two agoraphobia without a history of panic disorder. As a co-morbid Axis I disorder, nineteen patients met diagnostic criteria of another anxiety disorder, one met criteria for hypochondriasis, one for body dysmorphic disorder, and one reported a binge-eating disorder. Numbers of Axis I disorders were equally distributed across CBM-I groups as well as years of treatment. Psychotropic medication use differed significantly between groups, $\chi^2(1, N = 36) = 4.21$, $p < .05$. Eight participants in the experimental condition used psychotropic medication and 14 in the control condition. The majority used SSRI's and/or benzodiazepines. Two patients used antipsychotic drugs. The difference in medication use was added as a covariate to the subsequent analyses. Since the analysis showed no effect of medication for the interpretive bias variables, nor for the dependent mood variables, the covariate was not included in the further analyses.

Before the start of CBM-I, participants in the positive and the control group did not differ significantly for scores on the STAI trait, $t(34) = 0.97$, BDI, $t(34) = 0.83$, SCL-90, $t(34) = 0.89$, PANAS positive scale, $t(34) = -1.53$, and PANAS negative scale, $t(34) = 1.27$ (see Table 2 for these means and standard deviations). The groups differed on the STAI state scores, $t(34) = 2.11$, $p < .05$, that is, before staring CBM-I participants in the control group had higher scores than participants in the positive CBM-I condition (respectively, 48.8, *SD* = 9.6 vs. 40.6, *SD* = 13.5). Analyses of PANAS negative scale were corrected for pre-CBM-I state anxiety scores. Since analyses showed that pre-CBM-I STAI state scores were not related to the reaction time data, recognition task, trait anxiety, SCL-90, BDI, and PANAS positive scale, the pre-training state anxiety scores were not added as a covariate in those analyses.

Interpretive bias outcomes

Manipulation check I: Reaction times to probes. Reaction time trials where an incorrect response was given when completing the word fragment or answering the comprehension question were omitted from the analysis. A three-way mixed model ANOVA with CMB-I group (positive vs. control) as the between-subjects factor and probe (positive vs. negative) and time (first vs. second half of CBM-I) as the within-subject factors was conducted to test the effectiveness of CBM-I in changing interpretations. The factor time was added to examine the development of CBM-I effects on interpretations. There was a main effect of time, $F(1, 34) = 95.13$, $p < .001$, $\eta_p^2 = .74$, indicating that faster responses were given in the second half of CBM-I. There was also a main effect of probe, $F(1, 34) = 32.63$, $p < .001$, $\eta_p^2 = .49$, indicating that faster responses were given to positive probes. The Group x Probe interaction effect was significant, $F(1, 34) = 21.53$, $p < .001$, $\eta_p^2 = .39$, confirming the effectiveness of CBM-I. While the control group did not react differently to negative and positive probes (1470 ms, *SD* = 557 and 1447 ms, *SD* = 539), participants who had previously been exposed to the positive CBM-I displayed a marked slowing in reacting to negative (1852 ms, *SD* = 507) as compared to positive probes (1635 ms, *SD* = 433, see Figure 2). The Group x Time x Probe interaction effect was not significant, $F(1, 34) = 0.20$.

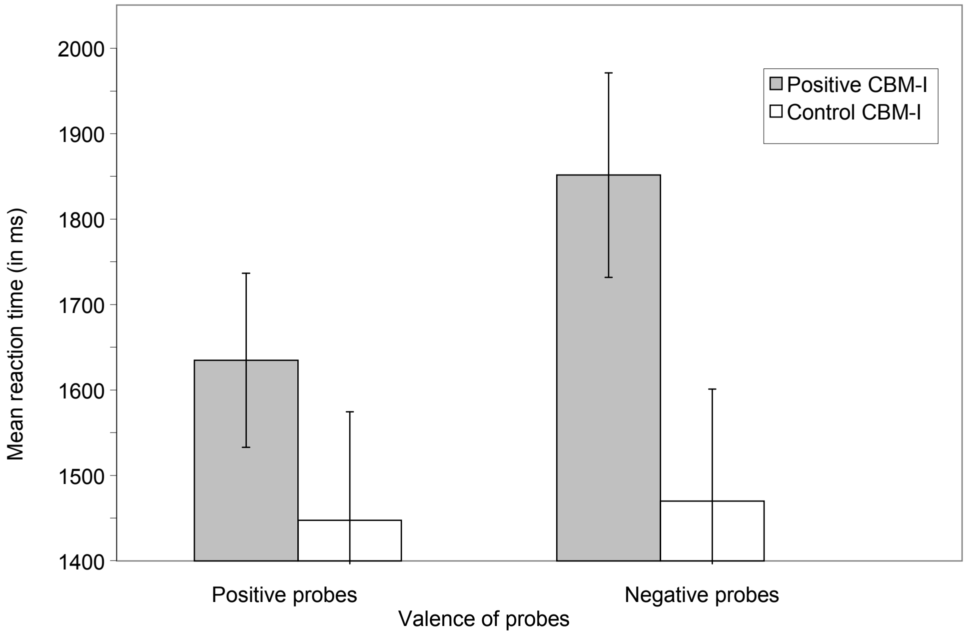

Figure 2.
Mean reaction times and *SE* (in ms) to solve positive and negative probes during CBM-I depicted for both groups

Manipulation check II: Recognition task. The second check of modified interpretations was the recognition test. A mixed model ANOVA with group as the between-subjects factor and valence (positive vs. negative) and target (possible interpretation vs. foil sentence) as the within-subject factors was performed. The analysis revealed a main effect of valence, $F(1, 29) = 50.40$, $p < .001$, $\eta_p^2 = .64$, with positive sentences being endorsed more than negative sentences, and of target, $F(1, 29) = 55.47$, $p < .001$, $\eta_p^2 = .66$, indicating greater endorsement of probable interpretations than of foils. The analysis also revealed a Group x Valence interaction effect, $F(1, 29) = 6.58$, $p < .05$, $\eta_p^2 = .19$. As can be seen in Figure 3, both the positively trained and control trained participants made more positive than negative interpretations, but this was more marked in the positive CBM-I group (2.58, *SD* = 0.42 vs. 1.71, *SD* = 0.50) than in the control group (2.42, *SD* = 0.42 vs. 2.01, *SD* = 0.33).

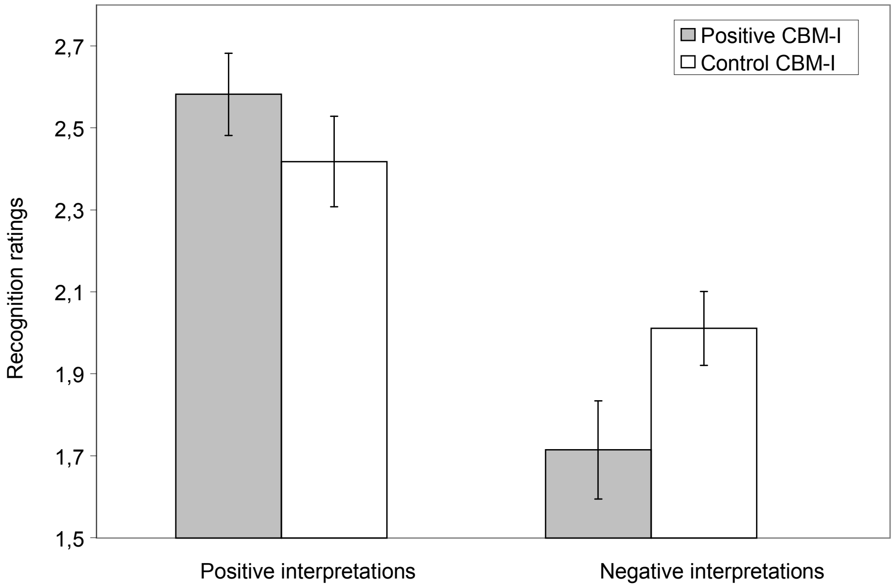

Figure 3.
Mean recognition ratings and *SE* for positive and negative interpretations depicted for each group
Note. Recognition ratings ranged from 1 (*very different*) to 4 (*very similar*).

Clinical outcomes I: Group averages

Table 2 gives means and standard deviations of the clinical assessments for the positive and control CBM-I group. A two-way mixed model ANOVA with group (positive CBM-I vs. control condition) as the between-subjects factor and time (before vs. directly after CBM-I) as the within-subject factor was performed on the clinical outcome measures, except for PANAS negative scale where pre-CBM-I state anxiety scores were added as a covariate. To examine the stability of the effects on the clinical measures, a two-way ANOVA with group as the between-subjects factor and time (post-CBM-I vs. three-months follow-up) as the within-subject factor was conducted.

Anxiety. Analyses of the effects of CBM-I on trait anxiety, revealed a significant main effect of time, $F(1, 34) = 6.08$, $p < .05$, $\eta_p^2 = .15$. Trait anxiety decreased in both the positive CBM-I group and in the control condition. The predicted Group x Time interaction effect was not significant, $F(1, 34) = 0.63$. Analysis of the stability of the reduction of trait anxiety revealed no significant effects, indicating that there was no change in treatment gain in trait anxiety from post-CBM-I to follow-up.

Analyses regarding effects on state anxiety did not reveal the predicted interaction effect of group by time, $F(1, 34) = 0.01$. That is, the positive and control CBM-I groups did not differ in change in state anxiety. A significant main effect of group was observed, $F(1, 34) = 6.38$, $p < .05$, $\eta_p^2 = .16$ with the control group being more state anxious than the positive CBM-I group. No changes were observed from post-CBM-I assessment to follow-up.

Table 2.
Mean scores of the outcome measures (*SD* in parentheses) for the positive and control CBM-I group

	Positive CBM-I group (*n* = 18)			Control CBM-I group (*n* = 18)		
	Pre-CBM-I	Post-CBM-I	FU (*n* = 14)	Pre-CBM-I	Post-CBM-I	FU (*n* = 16)
STAI state	40.6 (13.5)	41.1 (10.1)	44.6 (12.2)	48.8 (9.6)	49.7 (12.3)	51.8 (12.3)
STAI trait	50.7 (12.5)	46.7 (10.1)	46.0 (10.1)	54.3 (10.1)	52.3 (9.9)	51.7 (12.1)
BDI	17.2 (9.4)	12.9 (8.3)	13.4 (10.6)	20.0 (10.6)	17.4 (12.2)	14.9 (12.6)
SCL-90	190.6 (61.4)	177.8 (62.5)	179.7 (70.9)	207.5 (53.1)	187.3 (56.9)	187.3 (61.3)
PANAS PA	29.2 (9.3)	28.4 (8.1)	32.2 (8.5)	24.8 (7.9)	25.1 (9.1)	23.3 (8.6)
PANAS NA[a]	18.3 (8.1)	17.1 (6.7)	18.9 (8.0)	21.7 (7.9)	20.9 (6.7)	20.3 (8.2)
	21.2 adj. *M*	19.0 adj. *M*	20.7 adj. *M*	20.1 adj. *M*	18.8 adj. *M*	18.6 adj. *M*

Note. FU = follow up. PA = positive affect and NA = negative affect.
[a] As the difference in state anxiety before CBM-I was related to change in PANAS negative scale, we also report adjusted means (adj. *M*).

Depression. Analyses of the CBM-I effects on depression revealed a main effect of time, $F(1, 34) = 15.05$, $p < .001$, $\eta_p^2 = .31$, indicating that both groups had less depressive symptoms during the second part of the CBM-I training. This was not qualified by a significant Group x Time interaction effect, $F(1, 34) = 0.93$. The decrease in depressive symptoms was maintained at follow-up; an ANOVA comparing post-CBM-I scores with follow-up scores revealed no significant effects.

SCL-90. For the general level of distress, the two-way ANOVA revealed a main effect of time, $F(1, 34) = 10.35$, $p < .01$, $\eta_p^2 = .23$, reflecting a general decrease in psychopathological symptoms in both the positive and the control group. No other effects were significant, including the predicted Group x Time interaction effect, $F(1, 34) = 0.53$. There were no changes in SCL-90 scores between post-CBM-I and follow-up assessment.

PANAS. The data from the PANAS positive subscale were analysed with a two-way ANOVA and there were no significant effects. Examination of change in positive mood from post-CBM-I to follow-up revealed a main effect of group; participants who followed the positive CBM-I condition felt more positive than participants who followed the control condition. The scores on PANAS negative subscale were entered into an ANCOVA with pre-state anxiety as a covariate. The assumption of homogeneity of regression slopes was met and results revealed a significant main effect for the covariate, $F(1, 33) = 11.88$, $p < .01$, $\eta_p^2 = .27$, reflecting a positive relationship between pre-state anxiety and negative mood state. No other results were significant, thus showing that the positive and control CBM-I groups did not differ in change in negative mood state. No changes were observed from post-CBM-I assessment to follow-up.

Clinical outcomes II: Number of participants clinically improved

In addition to examining statistically significant improvement, we also examined clinically meaningful change. Two approaches were used; 1) clinically significant change, this reflects the number of participants that no longer belong to the patient population subsequent to therapy and 2) reliable change, this reflects how much change has occurred during the course of treatment (Jacobson & Truax, 1991).

First of all, it was tested what number of patients from both groups improved clinically significant. Given that data from a normative sample is available and that the patient and non-patient distributions overlap, the following criterion is preferred: clinically significant change occurs when a post-treatment score is closer to the mean of the non-patient population than to the mean of the patient population (Jacobson & Truax, 1991). The formula taking unequal variances into account has been used. Results showed that 39% of the participating patients improved clinically significant on state anxiety, 36% on trait anxiety, 42% on depressive mood, 39% on SCL-90 measured general psychopathology, 50% on PANAS positive scale, and 47,2% of the patients on PANAS negative scale. No differences were observed between the CBM-I conditions, except a trend was observed on trait anxiety, $\chi^2(1, N = 36) = 3.01$, $p < .10$, indicating that slightly more patients who followed positive CBM-I fell within the non-patient range ($n = 9$) compared to patients who followed the control condition ($n = 4$).

Secondly, the number of patients that showed a ‘reliable change’ was calculated by dividing the difference between an individuals pre-test and post-test score by the standard error of difference between two test scores (which is computed from the standard error of measurement) (Jacobsen & Truax, 1991). Regarding anxiety, only 3% showed a reliable change in state anxiety (one in positive CBM-I and one in control condition) and 6% changed regarding trait anxiety (one in positive CBM-I and two in control condition). Fourteen percent improved reliably regarding depressive mood (three in positive CBM-I and two in control condition) and 8% regarding general distress (one in positive CBM-I and two in control condition). Finally regarding the PANAS; 6% improved in positive mood (one patient from each condition) and 8% changed regarding negative mood (one in positive CBM-I and two in control condition).

Daily assessments of mood

The effects of CBM-I on changes in mood during CBM-I were examined with two 2 x 8 mixed model ANOVA's for the positive and negative mood separately, with group as the between-subjects factor and time (eight CBM-I days) as the within-subject factor. For positive emotions, there was a main effect of group, $F(1, 34) = 5.07$, $p < .05$, $\eta_p^2 = .13$. The positive CBM-I group experienced more positive emotions than the control group (2.58, *SD* = 0.82 vs. 2.03, *SD* = 0.65). No significant effects were observed for negative emotions (*M*positive group 2.03, *SD* = 0.94 vs. *M*control group 2.37, *SD* = 0.70).

Exit interview

Analysis of the results from the exit interview revealed that there was no difference between the CBM-I groups in their ideas about the treatment they had received, $\chi^2(1, N = 35) = 0.24$. Five participants in the positive CBM-I and four in the control CBM-I thought they had followed the positive CBM-I condition. As a next step, it was examined whether their belief about the experimental condition was related to the dependent variables by adding this variable as a covariate to the analyses. Results showed that belief about what condition patients had been in, was neither related to the interpretive bias measures (reaction time, $F(1, 32) = 0.02$ and recognition task, $F(1, 27) = 0.10$), nor to the dependent mood variables, *F*'s (1, 32) < 1.72, and daily assessments of mood, $F(1, 32) = 0.52$.

Discussion

A first finding of the present study was that interpretation of emotional ambiguity can be influenced in patients with anxiety disorders. That is, after following an eight-day training program to interpret ambiguous information in a more positive manner, patients were slow in responding to negative word fragments compared to a group of patients that received a control training. In order to inspect the development of change in interpretive bias, reaction time data was obtained on all CBM-I training days. Notably, the difference in interpretive bias between the groups did not interact with time. This finding is consistent with earlier findings (Mathews & Mackintosh, 2000; Salemink et al., 2007a; Yiend et al., 2005). A second measure of interpretive bias was obtained with a recognition task after completing CBM-I and these findings confirmed the reaction time findings. Positively trained patients interpreted new ambiguous information more positively and less negatively than the control group.

A remarkable finding is that the post-CBM-I interpretive bias task revealed a general positive bias. This recognition task showed that both the positively trained group as well as the control group made more positive then negative interpretations (though this was more marked in the positive group). While this positive bias is predicted to occur after positive CBM-I, it is not after control CBM-I. It seems unlikely that this finding of a positive interpretive bias in the control condition is due to chance, since it is consistent with results from previous CBM-I studies. Both Murphy et al. (2007) and Salemink et al. (2007a) observed a general positive bias (in addition to differential group effects) following positive and control CBM-I in high anxious volunteers. These previous findings of a positive bias in the control condition were obtained in a high anxious *non-clinical* sample. Note that it has been shown that these non-clinical anxious individuals are characterised by biased information processing towards threat at a more automatic level, but not at a strategic level (MacLeod & Rutherford, 1992). It was suggested that strategic processes eliminate the automatic negative bias and thus reduce the associated impact in high anxious non-clinical individuals. Thus, the observed positive bias following control CBM-I in high anxious *non-clinical* volunteers could be explained by those protective processes at a strategic level that are already present before CBM-I. However, the present experiment concerned *clinically* anxious individuals. It has been suggested that these individuals lack such a protective strategic process and are characterised by negative processing biases, both at an automatic and strategic level. Thus, since we observed a positive bias following control CBM-I in a *clinical* sample, the findings cannot readily be explained by the presence of such a strategic process.

The occurrence of a positive interpretive bias in the control condition might be due to the possibility that not only positive CBM-I, but also control CBM-I has inadvertently led to more positive interpretations. Suppose that patients have a tendency to spontaneously interpret the ambiguous scenarios used in the training in a negative way and suppose that they are inclined to do so for 90% of the scenarios. The "control" condition consisted of 50% negative and 50% positive interpretations and might thus have served to disconfirm spontaneous negative interpretations. It may have taught individuals that, at least in the present context, positive outcomes of ambiguous scenarios are much more common than assumed. We will return to this point when discussing the effects on the clinical measures.

The other important finding of the present study was a decrease in trait anxiety, depressive mood, and psychological distress observed in both the positive and the control CBM-I group that was maintained at follow-up. The finding of improvement in the positive CBM-I group mirrors earlier findings in sub-clinical individuals (Mathews et al., 2007; Murphy et al., 2007; Salemink et al., 2007a). The predicted *superior* improvement in the positive condition was however absent and this finding contradicts findings in sub-clinical individuals and findings in anxious patients (Amir & Beard, 2007, July). In general, Amir and Beard observed larger effects and this might be due to the fact that our CBM-I procedure was directed at social interpretations that failed to match the specific concerns of our heterogeneous sample of different anxiety disorders. Amir and Beard had a match between their social CBM and the current social concerns of their patients with social phobia. It might be important to 'tailor' the content of CBM to the specific current concerns of the participating patients. Nevertheless, there is no obvious reason why CBM-I materials should match the clinical concerns of the patients to have positive effects, while in sub-clinical individuals no such match is necessary for the occurrence of superior improvement in positively trained individuals.

The observed general decrease in negative mood and distress in both the positive and control group might reflect general processes unrelated to effects of interpretive bias. Firstly, it might reflect regression to the mean. Higher levels of complaints might be reported the moment help is sought and later, when patients are accepted for treatment they have returned to their general level of (dys)functioning. However, our pre-test measures were carried out well after patients had been accepted for treatment, thus rendering this explanation of regression to the mean unlikely. Secondly, the observed general decrease could have resulted from a placebo effect. Non-specific effects such as participating in an academic clinical research project might have affected the results. This could be examined by performing a study consisting of an eight-day computer program in the same organisational context without modifying interpretations at all. Thirdly, the observed general decrease in anxiety, depressive mood, and distress might be due to the repetition of the measurements. We are unaware of theoretical or empirical arguments to believe that repetition, over a 12 days period, of the measures we took, is likely to yield less severe scores at the second test. A new experiment including a test-retest condition could shed light on this possibility. A fourth explanation might be that participation in the experiment activated a more distant type of reflection upon the complaints. As patients are normally overwhelmed by their anxious feelings, CBM-I motivates them to focus on cognitive processes and, due to the included positive scenarios, to take a different perspective. Both positive and control CBM-I might have resulted in more distance from their complaints and a related reduction of negative mood (cf. mindfulness-based cognitive therapy; Segal, Williams, and Teasdale (2002)). Fifthly, all patients have invested much time and effort and the reported general decrease in negative mood might reflect cognitive dissonance reduction.

Finally, besides general processes explaining the comparable improvement in both groups, it could also be due to specific effects of interpretations. We already suggested that both groups of patients might have obtained a more positive interpretive style (although to a greater extent in the positive condition). The 'control' condition containing 50% positive and 50% negative interpretations might not have functioned as a control condition and might have promoted more positive interpretations. The improvement in negative mood seen in the positive and control group may, thus, have both been caused by the acquired tendency to interpret ambiguous information in a more positive way. The validity of this account could have been tested on our data set if we had obtained pre-training measures of interpretive bias. Like in other studies (Mathews & Mackintosh, 2000; Mathews et al., 2007; Mackintosh et al., 2006; Murphy et al., 2007; Salemink et al., 2007ab; Yiend et al., 2005) the ‘recognition task’ was only administered after CBM-I and the systematic difference between CBM-I groups over studies yields evidence for the supposed causal relationship between a cognitive bias and emotion. Until now, neither we, nor other researchers have obtained a pre-training assessment of interpretive bias. In the light of the present data however, it seems important to have a valid indication of the pre-training nature of individual’s interpretive style. Future research could include a baseline measurement of interpretive bias to enable inspection of the *change* in interpretive bias.

It seems premature to dismiss the clinical potential of CBM-I. To determine the precise nature of the effects of CBM-I, future research is necessary that either includes a pre-CBM-I measurement of interpretive bias, or a control condition consisting of a test-retest measurement, or consisting of a program that does not modify interpretations. Note, that although statistically and clinically significant improvements were found for both CBM-I conditions on anxiety, depression, and scl-90 measured psychopathology that were maintained at three month follow-up, only very few patients were reliably changed. Both behavioural and cognitive theories argue (although differing in the exact emphasis) that changing safety seeking (avoidance) behaviour is a crucial factor in the treatment of anxiety disorders (Salkovskis, 1991; but see Rachman, Radomsky, & Shafran, 2008). A combination of CBM-I with behavioural techniques might be a fruitful new direction.

In sum, the present study revealed that positive CBM-I is effective in modifying interpretations in patients with anxiety disorders. Patients who had received the positive training showed a more positive interpretive style than the control group. Note that after training, the control group also made more positive than negative interpretations (though to a lesser extent than the positively trained patients). Observed reductions of negative mood were not specific for the positive CBM-I group, but were observed following both positive and control CBM-I. The absence of such differential mood effects is in sharp contrast to the results obtained by Amir and Beard (2007, July) and future CBM-I experiments in clinical samples are needed to draw conclusions about the potential utilisation of CBM-I in the treatment of patients.

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Part III

General discussion

Introduction

In this final part of the thesis, the main results of the empirical studies will be summarized and discussed with respect to the four themes described in the General introduction: replication; generalisability; underlying mechanisms; and clinical application of Cognitive Bias Modification of Interpretations (CBM-I). Limitations and suggestions for future research will be given. Finally, remaining issues and theoretical implications regarding the relationship between cognitions and emotions will be provided.

Four themes

Theme 1. Replication

Beck, Emery, and Greenberg's cognitive theory of anxiety disorders (1985) postulates that the cognitive vulnerability of developing an anxiety disorder is biased information processing towards threat (i.e. attentional bias, interpretive bias, and memory bias). In 2000, Mathews and Mackintosh were the first to show that interpretive bias causally contributes to anxiety. They did so by modifying interpretive bias and examining the effects on anxiety. The first aim of this thesis was to test the robustness of this finding.

Modifying interpretive bias. We conducted three CBM-I studies in mid range anxious individuals and in each study congruent changes in interpretive bias were observed (Chapter 1, 2, and 3). A remarkable finding was that in two studies (Chapter 2 and 3) it proved easier to induce a bias towards positive interpretations than towards negative interpretations. The same was true for a highly anxious group of individuals. Following positive CBM-I, high anxious (non-clinical) individuals (Chapter 5) and patients with an anxiety disorder (Chapter 6) made less negative interpretations and simultaneously interpreted new ambiguous information in a more positive way. This is an encouraging finding when pursuing clinical application of positive CBM-I.

Our confirming findings on the successful modification of interpretive bias are accompanied by similar findings from others (Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Mathews, Ridgeway, Cook, & Yiend, 2007; Yiend, Mackintosh, & Mathews, 2005). It may, therefore, be concluded that modification of interpretive bias is robust and clearly replicable.

Effects on anxiety. Effects of CBM-I on anxiety appear to be less consistent, though across studies most evidence seems to indicate that CBM-I affects anxiety. Our first study (Chapter 1) showed a trend in the predicted direction and a subsequent study revealed the predicted congruent effects on anxiety (Chapter 2). State anxiety increased in the negatively trained group and it decreased in the positively trained group. In addition, both studies training positive interpretations in highly anxious individuals revealed effects on anxiety (Chapter 5 and 6).

Conclusions and future research. Both the modification of interpretive bias, as well as subsequent effects on anxiety, are replicable findings that are consistent with predictions from Beck's cognitive theory regarding a causal relationship between biased interpretations and anxiety. Studies modifying interpretive bias have been well-designed and well-controlled. The systematic difference between positively versus negatively trained groups over the studies yields evidence for the supposed causal relationship between this cognitive bias and emotion. A future study might include a control condition such as a test-retest condition or a neutral training condition to examine the absolute impact of each CBM-I condition. A pre-CBM-I measurement of interpretive bias would also be informative as to the direction of change of each condition. Until now, no researcher group has obtained a pre-CBM-I assessment of interpretive bias, because the recognition task is not suitable as a pre- and post-test. Ambiguity is a crucial component of a task assessing interpretive bias, as this bias is the tendency to selectively disambiguate ambiguity. Since ambiguity is already resolved during the first administration of the recognition task, the crucial ambiguity is absent during the second presentation.

Theme 2. Generalisability

Overall, mixed findings were obtained regarding the generalisability of CBM-I.

Generalisability across tasks. Two manipulation checks (reaction time and recognition measure) have generally been used to check whether CBM-I is successful in modifying interpretations. Considering that both manipulation checks resemble the modification procedure in content and format, generalisability of the modified bias, beyond the tasks in which it was initially practiced, was tested. Four other interpretive bias tasks, which are less similar to the modification procedure than the standard tasks were added as post-tests following CBM-I. An implicit measure of interpretive bias, an open-ended questionnaire to measure self-generated interpretations (Chapter 2), a vignette questionnaire, and video fragments (Chapter 3) were added to the two standard manipulation checks. We consistently found that while interpretive bias effects were observed on the standard manipulation checks, no effects were observed on the four other measures that differ (in varying degree) from the CBM-I procedure. Based on these findings, it could easily be concluded that generalisability to other experimental tasks is limited and that CBM-I is rather task-dependent. And yet the finding mentioned earlier of CBM-I effects on anxiety seems to contradict this conclusion. The finding that CBM-I affects anxiety, which is measured with a questionnaire, is indicative of *task generalisability* (as well as *domain generalisability*).

The inconsistency of these findings might be related to the important role of imagery in information processing and emotions. Holmes and Mathews (2005) argued that having to imagine the described social scenarios during CBM-I is an active ingredient in producing the observed effects. It was shown that there is a special relationship between mental imagery and anxiety; self-generated imagery led to greater changes in anxiety than focussing on the verbal meaning of a story. Additionally, imagery resulted in more positive encoding of new ambiguous descriptions than verbal processing (Holmes & Mathews; Holmes, Mathews, Dalgleish, & Mackintosh, 2006). Thus, the use of imagery during the training phase of CBM-I plays an important role in obtaining effects on emotions and interpretations. The observed inconsistency of interpretive bias effects using different tasks (limited task generalisability) might be related to a (mis)match between training and assessment regarding imagery. Tasks that demonstrated CBM-I effects all share the feature of imagination. In the reaction time and recognition task, participants are explicitly instructed to imagine themselves as the central character in the scenarios. Likewise, answering items on a mood questionnaire requires self-representational strategies as one tries to reconstruct past mood states. However, the use of imagery is absent in tasks failing to observe CBM-I effects. Future research is warranted to precisely examine the role of imagery when assessing interpretive bias effects following CBM-I.

Generalisability across domains. Chapter 3 states that modification of social interpretations generalised to another domain, namely that of academic performance. In addition, the more clinically oriented studies (Chapter 5 and 6) showed that CBM-I affected depressive mood and general complaints, corroborating effects of CBM-I on depressive reactivity (Wilson, MacLeod, Mathews, & Rutherford, 2006). Overly enthusiastic conclusions about domain generalisability need to be tempered as we failed to observe effects on physical symptoms in an open-ended questionnaire (Chapter 2). However, the particular assessment style differed from the modification procedure. This finding might, therefore, reflect lack of task generalisability instead. Alternatively, lack of effects on physical sensations could also indicate that CBM-I only generalises to potential domains of concern. Malfunctioning at school is a relevant issue for students, while fearing that a tight feeling in the chest represents a heart attack seems to be less relevant. Other research has provided some evidence for the generalisation of CBM-I across (self-relevant) domains (Chapter 3, 5, 6; Wilson et al., but see Chapter 2).

At a more theoretical level the finding of domain generalisability contradicts predictions from Beck et al.'s cognitive theory (1985). The theory predicts that processing biases are domain specific; patients with social phobia are expected to specifically process information regarding social concerns in a biased manner as compared to, for example, panic related information. However, the present findings indicate that effects of the modified social bias cut across different fear domains and emotions. A better fit for the data might then be a hierarchical model containing higher order processes (such as interpretive bias) that encompass different more specific emotional disorders. Lilienfeld (1996) formulated a hierarchical model regarding higher-order personality traits (e.g. negative emotionality) and lower-order constructs (e.g. social evaluation sensitivity) that are nested hierarchically within the higher-order trait. Similarly, interpretive bias might be a higher-order process with lower-levels representing specific domains. Modification of such a general processing style would result in modified processing of all new ambiguous situations encountered (i.e. generalisability across domains).

Generalisability to emotional reactivity. Changes in experienced emotions following CBM-I are said to occur because of the influence the modified interpretive bias has on the processing of new ambiguous events. Direct effects on state anxiety following CBM-I are believed to be due to the differential processing of ambiguous text in the recognition task. However, the observed changes may also be due to direct effects of the modification procedure (such as exposure to positive or negative information; see Underlying mechanisms later in this section). The effect of differential processing of information on mood effects was studies using an ambiguous stress task, which could be interpreted in a positive or negative way. Differences in interpretations should be related to differences in emotional responding to the stressor. Results from two experiments (Chapter 1 and 5) revealed that despite a general increase in negative mood following an ambiguous stress task, no differences were observed between the CBM-I groups. Note, however, that one experiment coincided with students' exams. Under these circumstances the control group got more anxious towards their examinations, whilst no such increase was observed in the positively trained group (Chapter 5). This finding confirms recent work of Mackintosh et al. (2006) and Wilson et al. (2006), who also performed a CBM-I experiment and observed differential responding to a stressor. In sum, there is some evidence in favour of interpretive bias effects on anxiety reactivity.

Conclusions and future research. The limited generalisability across tasks found for CBM-I might be due to the role of imagery in training and assessment. Future studies could contrive different assessment tasks in which the degree of imagery is manipulated. Likewise, limited generalisability across assessment modalities could be due to the fact that modification is currently effectuated with only one task. To specifically train generalisability across tasks future studies could develop CBM-I procedures consisting of several tasks differing in, for example, stimulus material (single words, text, pictures, faces, video fragments), presentation modality (visual, auditory), and implicitness/explicitness. The present empirical evidence of generalisability of CBM-I across *domains* is matched by recent new theorising regarding cognitive processes covering different disorders (Harvey, Watkins, Mansell, & Shafran, 2004). This transdiagnostic processing will be discussed in more detail later.

A next step regarding generalisability is to examine whether the modification of one bias generalises to another bias. The hypothesis is that attentional and interpretive bias might be concurrent expressions of a single underlying biased selectivity mechanism. Attentional bias in anxious individuals expresses the tendency to focus attention on threatening information, while interpretive bias expresses the tendency of having the threatening meaning of an ambiguous event capture attentional resources. If both processing biases are the product of biased selectivity, then modifying attentional bias should be evident on interpretive bias tasks and vice versa. Some encouraging work regarding cross-bias transfer has been performed in Perth, Australia (Jeffery & Macleod, 2007, July).

Anxiety is represented in a triad of different response systems: cognitive/subjective, physiological, and behavioural responding (Marks, 1987). Since there is little concordance between these three response systems, it is important to consider all three when investigating anxiety. Examination of CBM-I effects on cognitive/emotional responding has flourished, but research on physiological responses and behavioural responding is surprisingly scarce. Future research could fill this gap by examining effects on, for example, the eye blink reflex. The magnitude of the human blink reflex is augmented when elicited during negative rather than neutral imagery. In other words, the blink reflex is sensitive to valence. As interpretation of ambiguous information results in perceived positive or negative valence, the blink reflex could be used as a *psychophysiological* measure that is sensitive to interpretations (Lawson, MacLeod, & Hammond, 2002). In addition, actual social *behaviour* could be tested following CBM-I with unobtrusive tests like, for example, the waiting-room task developed by Macrae, Bodenhausen, Milne, and Jetten (1994).

Theme 3. Underlying mechanisms

CBM-I is designed to modify interpretive bias and appears to be successful in doing so: effects have been consistently observed on interpretive bias measures, following CBM-I. The assumption is that these effects reflect the modified interpretive bias. However, effects on these measures could also have occurred due to other processes such as demand characteristics or mood effects whilst leaving interpretations unchanged. Another assumption is that the effects on anxiety observed after CBM-I are due to the modified interpretations. In other words, it is assumed that the CBM-I procedure affects interpretations, and that those modified interpretations, in turn, affect anxiety. Yet, this hypothetical cascade is not the only possible explanation for the observed effects on anxiety. The CBM-I procedure could, for example, have a direct effect on anxiety by changing mood through repeated exposure to either positive or negative information. The underlying mechanisms in CBM-I had not been explicitly tested and were, therefore, examined in the present thesis.

Modified interpretive bias. Mathews and Mackintosh (2000) argued that an emotional interpretation rule is acquired implicitly during CBM-I and is unintentionally applied to later ambiguous information. While participants might have been unaware of the intended function of the stories, they might have been aware of the emotional valence and could have applied a positivity or negativity rule throughout the entire experiment. Chapter 1 shows that participants were fully aware of the emotional valence of their CBM-I stories. Each participant could clearly indicate whether they had followed the positive or negative CBM-I condition.

As a next step a mediational analysis was performed to examine the influence of this explicit knowledge on interpretive bias. Results showed that CBM-I effects on interpretations were due to both the direct effect of CBM-I and the indirect effect via explicit awareness of the emotional outcome. Firstly, CBM-I is performed with previous assessment tasks that were adapted to modify interpretations. An advantage of using an adapted assessment task is that CBM-I results can be compared with 'naturally occurring' effects found in patients with anxiety disorders. It could be suggested that the present finding of explicit knowledge undermines the comparison between the modified processes and those seen in patients. However, anxious patients are also aware (to varying extent) of their thoughts and are able to explicitly verbalise the rules they use ('If I blush, I look completely inept', 'People will judge and reject me'). The explicitness of such rules does not prevent the rules from being applied. Also, the finding that interpretive bias effects are not only explained by awareness of the valence of the induced interpretations, but are also due to the modification of the interpretive bias itself, underscores the validity of CBM-I.

Causal role of interpretive bias in anxiety. In CBM-I experiments, interpretive bias is modified to examine its causal contribution to anxiety. It is assumed that the modified bias affects anxiety, as opposed to the procedure itself having direct effects on anxiety. Structural equation modelling was used to examine the underlying pathway. Results confirmed that CBM-I affected interpretive bias, which in turn affected trait anxiety (Chapter 4). A different picture emerged when effects on state anxiety were tested; changes in state anxiety were due the direct effects of the CBM-I procedure. They were not related to changed interpretive bias. A subsequent experiment, designed to examine which element of CBM-I could be responsible for the effects, showed that the mere exposure to valenced information is capable of affecting state anxiety. Thus, the modification procedure itself seems to function as a mood induction procedure. As a consequence, the effects on state anxiety observed after CBM-I may not be a valid indicator of a causal relationship between the processing bias and anxiety.

Contrary to state anxiety, the relationship between CBM-I and changes in trait anxiety was mediated by changed interpretive bias. A limitation of the study is that trait anxiety (the tendency to react anxiously) was measured using a questionnaire. While the questionnaire explicitly asks participants to state what their *ideas* are about their anxiety reactivity, *actual* behavioural reactivity could also be assessed, thereby revealing the process under study. In 2006, two experiments were published that examined the effects of CBM-I on actual anxious reactivity (Mackintosh et al.; Wilson et al.). Their empirical results supported our results from the mediational analysis. Due to the differential processing of ambiguous information in the stress task, negatively trained participants responded with larger increases in anxiety than positively trained participants (but see Chapter 1).

Conclusions and future research. Interpretive bias effects following CBM-I have been assessed with test items in a recognition task. Following the presentation of ambiguous scenarios, participants received items that included target interpretations and foil sentences. Targets were possible positive and negative interpretations of the ambiguous scenarios. Conversely, foils were valenced sentences whose content differed factually from that of the ambiguous scenarios. Foil items did not represent genuine interpretations of the original scenarios. Results showed that CBM-I directly influences target interpretations, but also exerts some of its influence via explicit knowledge about the stories. In addition, CBM-I effects have also been slightly evident in the foil sentences. These effects on the foil sentences could be due to a general affective priming effect. Results from our mediational analysis confirms this suggestion; the observed effects on the foil sentences were not due to direct effects of interpretive bias modification, but due to a more general rule regarding the positive or negative tone of the scenarios.

In general, the mechanism underlying the process of change in CBM-I is not entirely clear. A possibility is that semantic priming is responsible for the changes in interpretations (this would also explain the effects on foil sentences). Repetitive generation of either positive or negative meanings for ambiguous information during CBM-I could prime a whole domain of positive or negative meanings. Subsequently, when encountering new ambiguous information, those positive or negative meanings are more easily activated due to shared associative links (cf. Bower, 1987). As a consequence the chances that ambiguity is encoded as positive (or negative) is increased. Alternatively, the effects on interpretive bias might (also) be attributed to a learned selection rule. The practice in selecting either positive or negative meanings during CBM-I might result in a selection rule: *if ambiguity is encountered, select the positive (or negative) meaning*. Operant conditioning could also be an explanation of the interpretive bias effects. In CBM-I, responses to ambiguous information are followed by specific consequences. Take the positive CBM-I condition; responding in a positive way to ambiguity is reinforced ('Correct Answer' appears in blue ink), while endorsement of a negative meaning is 'punished' ('Wrong answer' appears in red ink). In sum, while there are several candidate explanations for the mechanism of change in CBM-I, more research is warranted to fully conceptualise CBM-I data.

Theme 4. Clinical application

In an attempt to unravel the causal nature of interpretive bias in anxiety experiments have been conducted in non-anxious individuals where CBM-I was followed by change in anxiety. The finding that training more positive interpretations resulted in reduced anxiety suggests that appropriately adapted CBM-I methods may contribute to developing therapeutic techniques within a clinical setting.

Highly anxious individuals. As a first step, the clinical application of CBM-I was examined in a population of high anxious students (Chapter 5). CBM-I was optimised; participants were trained for eight days instead of the original single day training and they were presented with 832 different stories instead of the original 104. Additionally, training was performed online in participants' home environments. Half of the participants received positive CBM-I, while the other half received a control CBM-I (half of the stories ending positively and the other half ending negatively). Compared to the control group, participants who had received the positive CBM-I training program reacted slower to negative word fragments and made more positive interpretations in the recognition task. The finding that positively trained participants were less state and trait anxious following CBM-I than the control group is clinically interesting. Furthermore, they also scored lower on a measure of general psychopathology (SCL-90). However, no effects were observed on social anxiety and anxious reactivity. Our results regarding change in state and trait anxiety following positive CBM-I in highly anxious (non-clinical) individuals corroborate results from two other experiments. Positive CBM-I decreased trait anxiety in highly anxious individuals (Mathews et al., 2007) and positively trained participants predicted that they would feel less anxious in future social interactions compared to a control group (Murphy, Hirsch, Mathews, Smith, & Clark, 2007). Taken together, results indicate that CBM-I could have potential value as a therapeutic tool.

Patients with anxiety disorders. To examine the effects of CBM-I in a clinical population, patients with a main diagnosis of panic disorder, social phobia, posttraumatic stress-disorder, or generalised anxiety disorder were randomly allocated to either positive CBM-I or the control CBM-I condition (Chapter 6). CBM-I was successful in modifying interpretive bias in this clinical sample. The positively trained group was slower in responding to negative word fragments and made more positive than negative interpretations compared to the control group. Regarding clinical outcome measures: both groups showed a statistically and clinically significant improvement for trait anxiety, depressive mood, and general psychopathological complaints. While the improvement was predicted for the positively trained group, recovery in the control group was unexpected. Explanations for this include a placebo effect, a more distant type of reflection upon complaints, or regression to the mean. Another possibility is that the control condition inadvertently led to a more positive interpretive style, which in turn led to a reduction of negative mood. In the control condition 50% of the stories ended negatively and 50% positively. Theoretically, it could be argued that whereas patients normally interpret the vast majority of ambiguous situations in a negative way, now they are motivated to interpret half of them positively. The 'control condition' might thus also have served as a training condition through which patients shifted to a more positive information processing style. This suggestion is supported by empirical data showing that a general positive interpretive bias was found for both groups on both manipulation checks.

Conclusions and future research. A limitation is that our findings for the clinical population are subject to various interpretations. Based on these findings it is, therefore, premature to acknowledge a possible clinical application of CBM-I. Moreover, while the decrease in negative mood was clinically significant (post-treatment scores fell within the range of the non-patient population), pre-treatment scores were neglected in those analyses. Some patients already had scores falling in the non-patient population range before starting CBM-I. When examining *how much* change occurred during the course of CBM-I (Jacobson & Truax, 1991), only a few patients showed reliable change. This further tempers the optimism regarding clinical utilisation. Note though that the present findings are in sharp contrast with unpublished findings (Amir & Beard, 2007, July) which show that attentional and interpretive CBM was highly effective in reducing symptoms of social anxiety. The exact therapeutic potential of CBM-I is still an empirical issue that awaits further investigation.

Safety behaviours serve to prevent disconfirmation of irrational threat beliefs (Salkovskis, 1991, but see Rachman, Radomsky, & Shafran, 2008) and both behavioural and cognitive theories argue (although differing in the exact emphasis) that changing safety seeking behaviour is a crucial factor in the treatment of anxiety disorders. In fact, Cognitive Behaviour Therapy (CBT), which is the treatment of choice for a range of anxiety disorders (American Psychiatric Association, 2004ab; Dutch National Steering Committee Guidelines Mental Health and Care, 2003; National Institute for Clinical Excellence, 2004, 2005), is a combination of pure cognitive therapy and behavioural interventions. It appears that directly targeting (safety) behaviours is a crucial ingredient for anti-anxiety treatments. The combination of the present CBM-I procedure with behavioural techniques might be a fruitful new direction.

While more clinical research is needed, it is tempting to speculate about possible clinical applications. The present CBM-I program has several advantages: 1. it is cost-efficient, seeing as therapy can be followed without a therapist; 2. rooms in mental health institutes are no longer needed seeing as participants perform the training online in their own homes, and; 3. time and date of therapy are flexible. If future experiments yield promising results, CBM-I could potentially be used as a self-help program.

General discussion

CBM with modified assessment tasks

Remarkably, modification of processing biases is typically effectuated with modified versions of assessment tasks. Attentional CBM is performed with a dot probe task that was originally designed as an attentional bias measurement. Due to an introduced contingency between the location of an emotional word and the occurrence of a dot, the assessment task was turned into a modification task. Similarly, interpretive bias modification is effectuated by a modified recognition task, which is originally a measure of interpretive bias. A potential disadvantage of using modified assessment tasks is that participants might become extremely good in performing that specific task, whilst the underlying process remains unchanged. However, as some generalisability has been observed, it seems that the underlying process is changed to some extent. Furthermore, much effort has been invested in the development of those tasks to ensure that they are capable of specifically measuring a certain process. Therefore, when the goal is to modify that specific process, it can be sensible to use the well-established assessment tasks.

Yet, the modified assessment tasks could be optimised to obtain better effects. Up to now, participants all received exactly identical stimulus materials, while idiosyncratic materials might increase the effectiveness. Social stories in CBM-I could include names of people in the participant's social circle, or could refer to a participant's job, home situation, and leisure activities. In a similar manner, words used in attentional CBM could be tailored to each participant. While this approach might seem advantageous, it has large methodological disadvantages. Another way to optimise CBM might be to make the pace and level of difficulty of the training dependent on performance. An example of how this might work is if easy situations are solved accurately, transition to a next level, containing more difficult situations, could take place. Similarly, if too many errors occur the current level may be prolonged. Furthermore, the variety of tasks and stimulus materials could be increased to reduce the training of specific task performances and increase the modification of the underlying process. Another possibility is to directly instruct participants on what they should learn by, for example, telling them that each positive word in the dot probe training task is followed by a dot, or telling them to interpret ambiguous information in a positive way. Such explicit instruction could enlarge effects on the processing bias, but it could also have counterproductive effects. Some encouraging findings of the effects of explicit instruction on attentional bias have been obtained (Hirsch, Krebs, & Hayes, 2007, November).

Automaticity

A distinction between automatic and controlled processes has been made (Shiffrin & Schneider, 1977). In general, automatic processes have been characterised as not requiring cognitive capacity (i.e. resources, effort), not requiring awareness, and not involving volition. These three attributes do not always covary and in anxiety disorders, biases are often automatic in the sense of being involuntary and unconscious, but at the same time the 'automatic' responding does require cognitive capacity (McNally, 1995). Current therapies, such as CBT, tackle negative automatic thoughts in an elaborative and strategic manner. The patient is invited to critically think about the validity of the threatening interpretation and formulate new, more positive, interpretations. This deliberate and effortful process of change is likely to fail when the patient experiences stress. As stress overwhelms cognitive resources, individuals will more easily revert to old habits. One of the goals of CBT is that an effortful evaluation of threat will, after practice, result in a less threatening interpretation, and that this will become the automatic cognitive response. Automatisation of the new interpretational style seems to be the final pathway to change. In present treatments of anxiety disorders automatic processes are not directly targeted. Since CB*M* is developed to directly modify the automatic process, it has potential advantages and could be a promising avenue.

At this moment, little is known on whether CBM procedures result in new automatic habits. In Chapter 2, no effects of CBM-I on more automatic interpretations were observed. While this could be due to a low validity of the newly-developed task, it could also be that far more training trials are needed for developing an interpretive bias at an automatic level (Shiffrin & Schneider, 1977). To clarify whether the modified bias is automatic in nature, future research is needed using tasks effective in assessing automatic processes. Automaticity of the modified bias could also be tested under different (visual, cognitive, auditory, etc.) loads to assess whether or not participants regress to their old information processing habits.

Finally, as it is important to automate the new processing style, current CBM procedures might be adapted in such a way that automaticity is increased. Different strategies may be used for this. To augment the development of automatic biases, 1) the number of training trials may be increased; 2) stimulus materials could be presented in increasingly degraded fashions; 3) time pressure during training could be increased; 4) the new processing style may be practiced under an increasing external load, or 5) the task could be performed under increasing feelings of anxiety. These suggestions are open to empirical investigation.

Theoretical implications concerning cognition and emotion

CBM-I effects are observed across different emotions and problems; anxiety, depressive mood, and general complaints, such as sleeping problems and somatic complaints (SCL-90) (Chapter 5 and 6; Wilson et al., 2006). Earlier theorising and research has focussed on specific disorders characterised by specific sets of cognitive distortions and behaviour. The Diagnostic and Statistical Manual of Mental Disorders (DSM, American Psychiatric Association, 1994) defines over 350 psychological syndromes as discrete entities and this classification system functions as the organising principle in research and theory. This approach has several advantages: it enables professional communication and facilitates important developments in understanding and treating psychological disorders. Finally, having a specific diagnosis can be a relief for patients. However, being diagnosed could also be associated with feeling stigmatised and experiencing discrimination. Other disadvantages to classification have been identified (Beutler & Malik, 2002). Classification is associated with potential minimalisation of the complexity of a clinical case. Furthermore, each disorder is considered as a discrete entity that is distinct from other disorders and from normal behaviour. For several disorders this categorical conceptualisation does not reflect the clinical reality; a more dimensional view fits better (Harvey et al., 2004). The use of a new approach to define the relationship between cognitions and emotions has been suggested (Harvey et al.). Instead of categorising psychopathological phenomena in discrete disorders, it is suggested to order phenomena on the basis of biased processes. While it has already been suggested that certain *emotion* constructs could cover different disorders (Lilienfeld, 1996), now *processes* are suggested to cut across different disorders and to be transdiagnostic. This new framework of psychopathology may provide an explanation for the high rates of comorbidity observed in clinical practice. Moreover, it could lead to greater transfer of theoretical and treatment advances between different disorders. The fact that differences exist between psychological disorders could, for example, be explained by different current concerns (Harvey et al.).

The proposed transdiagnostic perspective is supported by empirical data. After examining five broad cognitive behavioural processes (attention, memory, reasoning, thought, and behaviour), it was concluded that 13 specific processes could be identified as *definite* transdiagnostic processes and nine were *possible* transdiagnostic processes (Harvey et al., 2004). The process examined in this thesis, interpretive bias, was classified as a definite transdiagnostic process. Interpretive bias is present in anxiety and depression (e.g. Butler & Mathews, 1983). Three other categories of disorders are also associated with biased interpretations; somatoform disorders, eating disorders, and substance-related disorders. It has been shown that individuals with hypochondriacal concerns make catastrophic misinterpretations of common harmless bodily sensations (Haenen, Schmidt, Schoenmakers, & van den Hout, 1997; Hitchcock & Mathews, 1992). Similarly, patients with anorexia nervosa and bulimia nervosa responded to ambiguous self-referent scenarios with more weight- and shape-related interpretations than controls (Cooper, 1997). Also, Stacy (1995) showed that the tendency to disambiguate ambiguous homographs as alcohol-related was associated with greater alcohol use.

The new transdiagnostic approach has direct implications for the treatment of psychological disorders. Harvey et al. (2004) argued that a more process-focused approach to treatment would be beneficial when added to the standard content-focused CBT. Such therapy should explicitly target cognitive and behavioural processes that maintain the disorder. Furthermore, as some processes function as barriers to change, it is important to address different processes in therapy. Another implication of using a transdiagnostic approach is designing a transdiagnostic treatment that is suitable for different disorders (within a category of disorders, that is within anxiety, somatoform disorders, or sleep disorders, or across such categories). Within the field of eating disorders, a transdiagnostic treatment has already been developed that can be applied across different eating disorders. Patient’s specific diagnosis is not relevant for treatment, and results have been encouraging

(Fairburn, Cooper, & Shafran, 2003). A transdiagnostic group treatment for anxiety has been designed and provided to a group of patients with generalised anxiety disorder, social phobia, and panic disorder (Hayes & Norton, 2007, November). Preliminary results indicated that working alliance and cohesion were comparable to standard group CBT. Finally, assuming that interpretive bias is a transdiagnostic process, a final clinical implication of this new model is adapting the CBM-I paradigm to serve as a transdiagnostic treatment.

The proposal of a transdiagnostic theory and different transdiagnostic treatments is still in its infancy and remains to be directly investigated. There seems room for exciting new experimenting.

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Summary

Over the past 20 years evidence has accumulated stating that anxiety is associated with a negative interpretive bias. That is, high anxious individuals have the tendency to interpret ambiguous information in a more threatening way than low anxious individuals. Cognitive theories argue that this biased information processing is not an incidental epiphenomenon of anxiety, but that it plays a critical role in the aetiology and maintenance of pathological anxiety. Thus, a causal relationship is predicted in which interpretive bias affects anxiety. Studies using a cross-sectional design revealed a relationship between interpretive bias and anxiety, yet, in such studies, the direction of that relationship remains unclear. To examine whether interpretive bias *causes* anxiety, experiments with a pure experimental design are indispensable. Therefore, the aim of the present thesis is to examine the prediction that interpretive bias contributes to anxiety. Examination of the causal nature is not only of theoretical relevance, but also of clinical importance. Together with depression, anxiety disorders are the most common psychiatric disorders. Also, anxiety disorders result in the second greatest reduction in quality of life (immediately following coronary heart disease). A better understanding of the development and maintenance of such anxiety disorders is important and research on the causal relationship between interpretive bias and anxiety could shed light on this issue. Different experimental studies were conducted to elucidate the causal relationship between interpretive bias and anxiety; they are reflected in six empirical chapters.

Chapter 1 describes an experimental study designed to examine the hypothesised causal relationship between interpretations and anxiety by modifying interpretive bias and examining effects on anxiety. In total, 118 students were trained to interpret ambiguous information in either a positive or a negative way. During training, short social stories were presented that were ambiguous in terms of valence. The final sentence contained a word fragment (word with several letters missing) and solution of that fragment disambiguated the story in a positive or negative way, depending on the assigned condition. It proved possible to modify interpretive bias with this paradigm. That is, when confronted with new ambiguous information after training, this information was interpreted in the same valence as the training condition. Unfortunately, the effects on anxiety were marginal; a trend was observed for a difference in state anxiety between the positively and negatively trained groups after training.

In *Chapter 2*, an experimental study is presented that, again, modified interpretive bias to examine the predicted causal role of interpretive bias in anxiety. Furthermore, effects of interpretive bias modification have typically been shown on two specific tasks that resemble the training in format (and content). Therefore, generalisation of the modified interpretive bias to other interpretive bias measures that are less closely related to the training itself, was examined. Results from the two original dependent measures indicated that the training was, again, successful in changing interpretations. Moreover, modification

of interpretive bias had significant effects on state and trait anxiety. State anxiety decreased after positive interpretive bias training and increased after negative training. Surprisingly, also trait anxiety decreased in both groups, but this was more marked after positive training. When taking results from other studies into account, the weight of evidence seems to suggest that modified interpretations affect anxiety. These findings are consistent with the hypothesised causal relationship between interpretive bias and anxiety. With respect to generalisability, there was no evidence for training congruent changes in interpretations on the two additional measures. This seems to suggest that the generalisability of the interpretive bias modification procedure is limited.

To examine generalisability in more detail, another experiment was designed that specifically focussed on task- and domain-generalisability. In this experiment, which is described in *Chapter 3*, interpretive bias is modified with the social story paradigm. Generalisability to other tasks within the social domain was assessed with a post-training vignette and video task. To test generalisability to another domain, the content of an original interpretive bias task was changed to reflect academic performance instead of social evaluations. A total of 82 participants completed the experiment. The original interpretive bias tasks revealed that the story paradigm was again successful in altering interpretations. This finding underscores the robustness of the interpretive bias effects following training. Regarding task generalisability, it was found that modified interpretive bias did not generalise to other tasks within the social domain, which replicates our earlier findings presented in Chapter 2. The particular measurement of interpretive bias seems important and imagery might be a crucial component of measurement. Comparison of the different interpretive bias tasks revealed that the tasks that successfully demonstrated interpretive bias effects, share a self-generated imagery feature. That is, in both original interpretive bias tasks, participants are specifically instructed to imagine themselves. In contrast, the tasks that have failed to reveal generalisation effects have minimised any need to image one-self. Regarding domain generalisability, the effects of training transferred from the social training domain to another domain (academic performance). As interpretive bias is linked with neuroticism, a higher order trait, this finding of domain generalisability is encouraging.

Chapter 4 is devoted to examining the underlying mechanism. The above mentioned experimental studies were designed to examine the causal relationship between interpretive bias and anxiety. A crucial assumption in those studies is that the modified interpretive bias affects anxiety, instead of the procedure itself affecting anxiety. Structural equation modelling was used to test this assumption and results indicated that changes in trait anxiety observed after performing such an interpretive bias training were, as assumed, caused by an altered interpretive bias. However, a different picture emerged when effects on state anxiety were examined. It was shown that changes in state anxiety, following interpretation training, were not related to altered interpretations, but were caused by direct effects of the modification procedure. Given that these findings were only based on statistical analyses, an experiment was designed to directly test which element of the modification procedure could be responsible for the observed changes in state anxiety. Ninety-one students participated in this study and it appeared that mere exposure to materials with an emotional valence is sufficient to affect anxiety. Thus, the present interpretive bias modification procedure directly influences state anxiety and seems to serve as a mood induction procedure. On the other hand, however, effects on trait anxiety following the modification procedure *are* mediated by altered interpretations. This latter finding supports the assumption that observed effects on trait anxiety following an interpretation training are a valid indicator of a causal relationship between interpretive bias and anxiety.

The capacity to successfully modify interpretations with effects on anxiety holds the clinical promise of treating anxiety by directly targeting biased interpretations. *Chapter 5* concerns an experiment that is designed to examine, as a first step, the potential clinical effects of interpretation retraining in high trait anxious individuals. An intensive online training was developed consisting of eight consecutive days of training. Each day, participants solved word fragments in social stories for approximately one hour. Participants were randomly assigned to one of two conditions. Half of the participants (n = 17) followed the positive interpretation training; they solved social stories with a positive outcome. Half of the participants were assigned to the control condition (n = 17); they also received an eight-day program, but now half of the stories ended positively, while the other half ended negatively. It was hypothesised that positively trained participants would interpret information more positively than negatively compared to the control condition. Results from the two standard manipulation checks confirmed this (however no effects were evident on an interpretive bias questionnaire). Regarding the effects on clinical outcome measures, it was predicted that developing a more benign interpretive style would lead to a reduction in anxiety and general distress. The results supported the hypothesis; positively trained participants were less state and trait anxious after training than participants in the control condition. In addition, effects were observed on general psychological distress. Levels of distress remained unaltered in the control condition and showed the predicted decline in the positively trained group. No effects were observed on social anxiety.

In *Chapter 6* a study is described that is similar to the one described in Chapter 5. This time, however, patients with an anxiety disorder participated in the interpretive bias retraining program. The study was performed in collaboration with Altrecht Centre for Mental Health and Mesos Medical Centre. In total, 36 patients completed either the positive or the control condition and their main diagnoses were panic disorder (with or without agoraphobia), generalised anxiety disorder, social phobia, or posttraumatic stress disorder. It was hypothesised that the training would be successful in altering interpretations and that reduction in negative interpretive bias would lead to congruent beneficial effects on mood in clinically anxious individuals. In line with the prediction, patients who had followed the positive training made more positive interpretations and less negative ones than patients in the control condition. Surprisingly, a general decrease in negative mood was observed. Trait anxiety, depressive symptoms, and general psychological distress decreased both in the positive and in the control condition, and these effects were maintained at three months follow-up. Several explanations for this general decrease in symptoms are suggested in Chapter 6, including non-specific effects such as participating in an academic clinical research project. Another explanation for the comparable improvement in both groups could be that participants in the control condition (consisting of 50% positive and 50% negative interpretations) also obtained a more positive interpretive style. Based on the present findings it is premature to acknowledge a possible clinical application of this interpretation retraining-program. More research with clinical samples is needed to determine the exact therapeutic value of the program.

Taken together, the main conclusion that can be drawn from the studies presented in this thesis is that the results support the hypothesis that interpretive bias can play a causal role in anxiety. First of all, it proved possible to reliably modify interpretations. Secondly, while it seems that the effects on anxiety are more fragile, across different studies in different laboratories the weight of evidence suggests that interpretive bias affects anxiety. Thus, results are consistent with a causal relationship between interpretive bias and anxiety. Note that the results regarding the clinical potential of interpretive bias retraining are suggestive rather than conclusive, leaving interpretations of the potential therapeutic merits of the training method open for future research.
Modification of interpretive bias is effectuated with adapted versions of assessment tasks. A potential disadvantage is that participants might become extremely good in performing that specific task. To obtain better training effects, the present training method might be optimised and suggestions for improvement are given in Part III of the thesis (General discussion). Furthermore, suggestions are provided to adapt the training method in such a way that automaticity of the trained interpretive bias is increased since automatisation of a new interpretational style is an important goal in therapy. Finally, in Part III it is argued that the present evidence of generalisability of trained interpretations across domains is matched by recent hypotheses regarding cognitive dysfunctional processes that cut across different disorders. Instead of categorising psychopathological phenomena in discrete disorders, this approach suggests that psychopathology should be ordered on the basis of transdiagnostic processes, such as interpretive bias. By implication, the present interpretive bias training procedure might serve as a form of transdiagnostic treatment. Obviously, the suggestions put forward in the General discussion section remain to be investigated and there is plenty of room for exciting new research.

Samenvatting

In de afgelopen 20 jaar is gebleken dat angst samenhangt met een negatieve interpretatie bias. Angstige mensen hebben, meer dan niet-angstige mensen, de neiging om ambigue informatie op een dreigende manier te interpreteren. Cognitieve theorieën beargumenteren dat vertekende negatieve informatieverwerking geen toevallig epi-fenomeen van angst is, maar dat deze een cruciale rol speelt in de aetiologie en instandhouding van pathologische angst. Met andere woorden, er wordt een causale relatie voorspeld waarin interpretatie bias invloed uitoefent op angst. Onderzoeken met een cross-sectioneel design hebben aangetoond dat er een relatie is tussen interpretatie bias en angst; echter de richting van deze relatie kan uit dergelijke onderzoeken niet afgeleid worden. Om vast te stellen of interpretatie bias ook de veroorzaker van angst kan zijn, zijn onderzoeken met een puur experimenteel design noodzakelijk. Het doel van de studies beschreven in dit proefschrift is om deze theoretische voorspelling te onderzoeken. Naast het theoretische belang, is dit doel tevens van klinisch belang. Angststoornissen zijn, samen met depressie, de meest voorkomende psychiatrische aandoeningen. Bovendien gaan angststoornissen gepaard met een grote reductie in kwaliteit van leven; angststoornissen staan op de tweede plaats wat betreft ziektelast (direct na coronaire hartziekten). Een beter begrip van de ontwikkeling en instandhouding van angststoornissen is belangrijk voor de behandeling en onderzoek naar de causale relatie tussen interpretatie bias en angst draagt hieraan bij. Verschillende experimentele studies naar deze gehypothetiseerde causale relatie zijn uitgevoerd en worden beschreven in zes empirische hoofdstukken.

Hoofdstuk 1 beschrijft een experimentele studie die ontworpen is om de causale relatie tussen interpretaties en angst te onderzoeken door interpretatie bias te veranderen en de effecten op angst vast te stellen. Proefpersonen (n = 118) werden willekeurig ingedeeld in twee groepen, waarbij de ene groep werd getraind om informatie systematisch positief te interpreteren en de andere groep om deze juist negatief te interpreteren. Het trainen van meer positieve of meer negatieve interpretaties gebeurde als volgt. Deelnemers lazen korte verhalen die een sociale situatie beschreven. De verhalen waren ambigue van aard en konden zowel positief als negatief aflopen. Elk verhaal eindigde met een woordfragment (een woord waarbij een aantal letters ontbreekt) en voltooiing van dit fragment plaatste het verhaal in een positief of negatief licht (afhankelijk van de groepsindeling). Resultaten lieten zien dat het mogelijk is om interpretaties te veranderen met dit paradigma. Na afloop van de training gaven deelnemers in de positief getrainde groep meer positieve interpretaties van nieuwe informatie dan deelnemers die de negatieve training gevolgd hadden. Dit maakte de weg vrij voor de vraag of, als gevolg van de training, het angstniveau veranderd was. Er was een klein verschil tussen de positief en negatief getrainde groep op de mate van ervaren angst na afloop van de training.

Hoofdstuk 2 betreft een experimentele studie waarin opnieuw interpretatie bias is veranderd om de voorspelde causale rol van interpretatie bias in angst te onderzoeken.

Daarnaast is onderzocht of de gewijzigde interpretatie bias generaliseert naar twee andere interpretatietaken die minder overeenkomst met de training vertoonden. Dit is gedaan omdat de effecten van interpretatietraining steeds zijn aangetoond met twee specifieke interpretatietaken die qua vorm (en inhoud) sterk lijken op de training. Opnieuw werden twee groepen deelnemers gecreëerd; de ene groep (n = 40) volgde de positieve interpretatie-training en de andere groep de negatieve training (n = 41). De twee originele interpretatie-taken toonden aan dat de training opnieuw succesvol was in het wijzigen van interpretaties. De cruciale causale vraag was vervolgens of de gewijzigde interpretaties angst beïnvloed hadden. Dit bleek het geval te zijn; er waren significante effecten op angst. De mate van toestandsangst daalde na positieve interpretatietraining en nam toe na negatieve training. Als gekeken werd naar angstdispositie, dan bleek dat dit in beide groepen was afgenomen, maar sterker in de positief getrainde groep. De huidige bevindingen lijken, tezamen met resultaten uit andere studies, te suggereren dat interpretaties invloed uitoefenen op angst. Deze bevindingen zijn consistent met een mogelijke causale relatie tussen interpretaties en angst. Daarnaast bleken er geen trainingscongruente effecten op interpretatie bias te zijn, gemeten met de twee andere taken. Dit lijkt te suggereren dat de taakgeneraliseerbaarheid van de interpretatietraining beperkt is.

Om de generaliseerbaarheid gedetailleerder te onderzoeken, is een ander experiment ontworpen dat specifiek taak- en domeingeneralisatie test. In dit experiment, dat beschreven is in *Hoofdstuk 3*, werd interpretatie bias opnieuw veranderd met het verhalenparadigma. Generalisatie naar andere taken binnen het sociale domein werd gemeten met een vignetten- en een videotaak. Om generalisatie naar een ander domein te meten, was de inhoud van een originele interpretatietaak veranderd van sociale evaluatie naar academische prestatie. In totaal hebben 82 proefpersonen deelgenomen aan het onderzoek. De originele interpretatietaken lieten zien dat het verhalenparadigma opnieuw succesvol was in het wijzigen van interpretaties. Deze bevinding onderstreept de robuustheid van de interpretatie-effecten geobserveerd na training. Er waren geen effecten van training op de andere interpretatietaken binnen het sociale domein, hetgeen wijst op beperkte taakgeneraliseerbaarheid. Dit repliceert onze eerdere bevinding beschreven in Hoofdstuk 2. De precieze meting van interpretatie bias lijkt belangrijk te zijn waarbij inbeelding mogelijk een cruciale rol speelt. Vergelijking van de verschillende interpretatietaken liet zien dat in alle taken die succesvol een interpretatie bias effect toonden, proefpersonen zelf een voorstelling van zaken moesten maken. In de originele taken wordt de proefpersoon bijvoorbeeld expliciet geïnstrueerd om zich de verhalen voor te stellen. Daarentegen, in de taken die geen effect van interpretatietraining lieten zien, is de noodzaak tot inbeelding geminimaliseerd. De training lijkt in staat om interpretaties te veranderen, echter bij het meten van de effecten lijkt inbeelding een belangrijke rol te spelen. Tot slot, analyse liet zien dat de effecten van de sociale interpretatietraining generaliseerden naar een ander domein (academische prestatie).

Hoofdstuk 4 van dit proefschrift gaat nader in op de onderliggende mechanismen. Bovengenoemde experimentele studies zijn ontworpen om de causale relatie tussen interpretaties en angst te onderzoeken. Een cruciale aanname in dergelijke studies is dat de interpretaties angst beïnvloeden en niet dat de trainingsprocedure zelf invloed op angst heeft. Om deze aanname te onderzoeken zijn statistische pad modellen gebruikt. Resultaten lieten zien dat veranderingen in angstdispositie na een interpretatietraining, zoals verwacht, het gevolg waren van veranderde interpretaties. Echter uit de analyse van toestandsangst kwam een ander patroon naar voren. Er bleek dat veranderingen in toestandsangst, na het volgen van interpretatietraining, niet samenhingen met gewijzigde interpretaties, maar het directe gevolg waren van de training. Gezien het feit dat deze bevindingen gebaseerd zijn op puur statistische analyses, is er een experiment ontworpen om direct te testen welk element van de trainingsprocedure verantwoordelijk kon zijn voor de geobserveerde veranderingen in toestandsangst. In totaal hebben 91 studenten deelgenomen aan dit onderzoek en hierbij bleek blootstelling aan positieve en negatieve informatie voldoende te zijn om verandering in toestandsangst teweeg te brengen. De trainingsprocedure blijkt dus direct de stemming te beïnvloeden. Aan de andere kant was gebleken dat de effecten op angstdispositie wel het gevolg zijn van veranderde interpretaties. Deze laatste bevinding ondersteunt dus de aanname dat effecten op angstdispositie, geobserveerd na interpretatietraining, een valide indicatie zijn voor een causale relatie tussen interpretaties en angst.

De bovengenoemde bevindingen, waarin interpretaties succesvol veranderd kunnen worden en effecten op angst hebben, bevatten mogelijk klinische implicaties. Pathologische angst zou mogelijk behandeld kunnen worden door direct vertekende interpretaties te wijzigen. De beschreven training kan wellicht ingezet worden om nieuwe, positieve interpretaties te bewerkstelligen bij angstige personen. *Hoofdstuk 5* betreft een experiment ontworpen om als eerste stap de mogelijke klinische effecten van interpretatie-training te onderzoeken bij een groep angstige studenten. Een intensieve online training werd ontwikkeld welke bestond uit acht achtereenvolgende trainingsdagen. De deelnemers voerden elke dag gedurende een uur de training uit. Deelnemers werden willekeurig ingedeeld in een positieve interpretatietrainingsgroep of in een controle groep. Proefpersonen in de positieve groep (n = 17) losten verhalen met een positieve uitkomst op. De proefpersonen in de controle conditie (n = 17) volgden ook een acht-dagen programma, maar nu eindigde de helft van de verhalen positief, terwijl de andere helft negatief eindigde. De verwachting was dat ook in deze groep angstige studenten de positief getrainde deelnemers informatie positiever zouden interpreteren dan de controle groep. De resultaten van de twee originele interpretatietaken bevestigden dit. Daarnaast was voorspeld dat het ontwikkelen van een positievere interpretatiestijl zou leiden tot een reductie in angst en stress. De resultaten ondersteunden ook deze hypothese; positief getrainde deelnemers waren minder angstig na training dan deelnemers uit de controle groep. Bovendien bleek, conform de verwachting, dat de mate van stress onveranderd bleef in de controle groep, terwijl die afnam in de positief getrainde groep.

In *Hoofdstuk 6* wordt een onderzoek beschreven waarin patiënten met een angststoornis deelnamen aan het trainingsprogramma waarbij de positieve interpretatie-training werd vergeleken met een controle conditie. Het onderzoek is uitgevoerd in samenwerking met GGZ instelling Altrecht en Mesos Medisch Centrum. Zesendertig patiënten met een diagnose paniek met of zonder agorafobie, generaliseerde angststoornis, sociale fobie of posttraumatische stress stoornis hebben het onderzoek afgerond. De hypothesen waren dat de training in staat zou zijn om interpretaties bij patiënten te veranderen en dat een reductie van negatieve interpretaties tot gunstige effecten op de stemming zou leiden. In overeenstemming met de eerste hypothese bleek dat patiënten die de positieve training hadden gevolgd meer positieve en minder negatieve interpretaties gaven dan patiënten uit de controle groep. Wat betreft de bevindingen op het gebied van stemming was het opvallend dat er een algemene daling in negatieve stemming werd geobserveerd. Zowel in de positieve als in de controle groep daalde de mate van angst, depressieve symptomen en stress. Deze afname bleef gehandhaafd bij drie maanden follow-up. Verschillende verklaringen voor deze algemene afname in klachten worden gegeven in dit hoofdstuk, waaronder de rol van non-specifieke effecten zoals deelname aan een academisch onderzoeksproject. Een andere verklaring voor de vergelijkbare verbetering in beide groepen kan zijn dat deelnemers in de controle conditie (bestaande uit 50% positieve en 50% negatieve interpretaties) ook een meer positieve stijl van interpreteren hebben ontwikkeld. Wanneer patiënten normaliter de neiging hebben om 90% van de ambigue informatie die ze zien negatief te interpreteren, dan zou de controle conditie met maar 50% negatieve interpretaties geleid kunnen hebben tot een weerlegging van de vele negatieve interpretaties. Deze patiënten zouden geleerd kunnen hebben dat positieve uitkomsten waarschijnlijker zijn dan ze dachten. De 'controle' conditie zou dus onbedoeld tot meer positieve interpretaties geleid kunnen hebben en daardoor een verbetering van de stemming tot gevolg hebben gehad. Op dit moment loopt er een vervolgonderzoek om dit te testen.

In het algemeen kan geconcludeerd worden dat de studies in dit proefschrift de gehypothetiseerde causale rol van interpretatie bias in angst ondersteunen. Ten eerste blijkt het mogelijk te zijn om interpretaties in positieve en negatieve richting te wijzigen. Ten tweede blijkt uit de studies in dit proefschrift en uit andere onderzoeken dat interpretatie bias angst kan beïnvloeden. De resultaten zijn consistent met een causale relatie tussen interpretaties en angst. Op basis van de huidige bevindingen is het niet mogelijk om conclusies te trekken betreffende de mogelijke klinische toepassing van deze interpretatietraining. Meer onderzoek met klinische populaties is nodig om de precieze therapeutische waarde van dit programma vast te stellen.

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Curriculum vitae

Elske Salemink was born on January 28, 1979, in Doetinchem. After completing secondary education (VWO, Isala College in Silvolde) in 1997, she studied Health Sciences (Mental Health Science) at Maastricht University and graduated cum laude in 2002. For almost two years, she worked as an academic research assistant and junior lecturer at the Department of Medical, Clinical, and Experimental Psychology of Maastricht University. From 2004 until 2008, she was a PhD student at the Department of Clinical and Health Psychology at Utrecht University. During this period, she also performed a study at the University of Western Australia, Perth for three months in collaboration with Professor Colin Macleod. In 2006 she began with her training as a behavioural and cognitive therapist for the registration as a member of the Association of Behavioral and Cognitive Therapy (VGCt). Since 2007 she has been working as a psychologist at Ambulatorium, Utrecht University. Since March 2008 Elske has been working as a post-doc at Utrecht University.

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National presentations

Salemink, E., van den Hout, M. A., & Kindt, M. (2007, November). *Trainen van positieve interpretaties bij mensen met een angststoornis: Therapeutische mogelijkheden.* Paper presented at the meeting of the Vereniging voor Gedragstherapie en Cognitieve Therapie, Veldhoven, The Netherlands.

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