Cogn Ther Res (2013) 37:173–182
DOI 10.1007/s10608-012-9445-8

ORIGINAL ARTICLE

Clinical Implications of Cognitive Bias Modification for Interpretative Biases in Social Anxiety: An Integrative Literature Review

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Published online: 14 March 2012

Abstract Cognitive theories of social anxiety indicate that negative cognitive biases play a key role in causing and maintaining social anxiety. On the basis of these cognitive theories, laboratory-based research has shown that individuals with social anxiety exhibit negative interpretation biases of ambiguous social situations. Cognitive Bias Modification for interpretative biases (CBM-I) has emerged from this basic science research to modify negative interpretative biases in social anxiety and reduce emotional vulnerability and social anxiety symptoms. However, it is not yet clear if modifying interpretation biases via CBM will have any enduring effect on social anxiety symptoms or improve social functioning. The aim of this paper is to review the relevant literature on interpretation biases in social anxiety and discuss important implications of CBM-I method for clinical practice and research.

Keywords Interpretative bias · Social anxiety · Social phobia · Cognitive bias modification (CBM) · Cognitive-behavioral therapy (CBT)

Introduction

Social anxiety disorder (social phobia) is one of the most prevalent anxiety disorders (Kessler et al. 2005) and has a very poor rate of recovery (see Sareen and Stein 2000 for a review). It is associated with a markedly lower quality of life, lower educational attainment, and a higher risk of unemployment (Fehma et al. 2005). Therefore, it is of great importance that we understand the underlying psychological mechanisms which are involved in the development and maintenance of this disorder. To facilitate this, several cognitive-behavioral models of social anxiety have been proposed and basic science research has focused on developing a better understanding of cognitive processes underpinning social anxiety. This research is based on the assumption that understanding the cognitive processes underlying the development and maintenance of anxiety disorders is a necessary prerequisite to the development of successful clinical interventions (e.g., Dalgleish and Watts 1990; Mathews and MacLeod 2002; Williams et al. 1997).

Cognitive-behavioural models of social anxiety (Beck et al. 1985; Clark and Wells 1995; Rapee and Heimberg 1997) propose that negative self-appraisals in social situations influence the development and maintenance of social anxiety. These negative appraisals may result from elaborative processing of negative information including biases in attention, interpretation, judgement, and memory (Clark and McManus 2002; Heinrichs and Hofman 2001; Hirsch and Clark 2004; Ledley and Heimberg 2006; Musa and Lépine 2000). In social anxiety it is suggested that this biased information processing is mainly focused on the self as being judged and evaluated negatively by others in social situations (see Stopa 2009 for a review). It has also been suggested that socially-anxious individuals often hold unrealistic expectations about their performance in social situations, and that their ideal selves are constructed based on these beliefs, whereas they perceive themselves as unable to fulfil these expectations. The discrepancy between their actual and ideal (hypothetical) selves leads to

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low levels of self-concept clarity and negative self-evaluations (Stopa 2009).

Beck et al. (1985) suggest that the main characteristic of social anxiety is the fear that one's deficiencies will be exposed in front of others and that one will be shamed. According to Clark and Wells's (1995) model, people with social anxiety interpret social situations based on dysfunctional assumptions which results in perceived social danger and anxiety. They selectively attend to negative information about themselves and use this information to make negative self-evaluations and negative predictions about their future social performance. The anxiety is maintained by heightened attention to internal cues which signal anxiety (self-focused attention), by negative self-processing and by safety behaviors.

Rapee and Heimberg's (1997) model of social anxiety emphasises formation of the negatively biased mental representations of the self and perceived negative self-evaluation in socially-anxious individuals. While Clark and Wells assert that socially-anxious individuals direct their attention towards internal cues, Rapee and Heimberg state that socially-anxious people simultaneously attend to the internal cues and to external stimuli which potentially indicate negative evaluation made by others. These stimuli include the facial expressions of other people in social situations. Thus, the latter model suggests that vigilance for negative, external social cues is also a significant component of social anxiety and serves as an input to negative self-focus, particularly during the formation of the mental representation of the self as seen by audience (Rapee and Heimberg 1997). An important implication of this model is that changes in the nature of the environment, such as audience behaviour, influence the socially-anxious person's mental representation of himself and the person shifts attention between this mental representation of self as seen by others and vigilant observation of external threats (e.g., audience behaviours). These two processes involved in attention to internal and external cues are interdependent and are likely to influence each other.

The central feature of cognitive-behavioural models of social anxiety is that socially-anxious individuals have cognitive vulnerability to social anxiety due to negative information processing biases (see Clark and McManus 2002; Heinrichs and Hofman 2001; Hirsch and Clark 2004 for reviews). An important prediction based on these models is that socially-anxious individuals will demonstrate negative cognitive biases when exposed to ambiguous social situations. Interpretative bias is thought to be particularly relevant for social anxiety because the information available to us in social situations is usually ambiguous and therefore open to a range of interpretations (Mathews and Mackintosh 2000). Individuals with social anxiety tend to perceive innocuous comments or behaviors by others as indicating criticism or rejection, and to interpret their own behaviors as poorer than the behaviors of other people. It is therefore important to investigate how socially-anxious individuals resolve this ambiguity in social situations. The present paper will review the literature on interpretative biases in social anxiety in adult populations and discuss an implicit computerised program, Cognitive Bias Modification for interpretative biases (CBM-I), which has been developed to modify these negative cognitive biases and reduce social anxiety. The paper will also discuss the therapeutic value of CBM-I for social anxiety in light of the theoretical rationale and emerging research evidence and will highlight potential directions for future research in this area.

A Review of Interpretation Bias Studies

As reviewed above, cognitive models propose a wide range of cognitive processes (attention and interpretation) underlying negative information processing biases in anxiety disorders. In addition to attentional bias, interpretation bias in social anxiety has been widely investigated by scientists in both cognitive and clinical areas. Researchers have focused on how people with social anxiety resolve ambiguity in social situations. To study interpretation bias in social anxiety, subjects are typically presented with a series of ambiguous social scenarios and are required to give an explanation for the event. Researchers have used a variety of measures (self-report questionnaires and computerised paradigms) to examine the interpretations of ambiguous situations. Amir et al. (1998) presented patients with social anxiety, patients with obsessive–compulsive disorder (OCD) and non-anxious controls with self- and other-relevant ambiguous scenarios of social events and asked them to explain each scenario. They used a self-report questionnaire as a measure of interpretative biases. As predicted, socially-anxious individuals interpreted self-relevant ambiguous social events more negatively than OCD patients and non-anxious controls even when a positive interpretation was available.

In another study, Constans et al. (1999) asked a non-clinical sample of students who were low and high in social fears to read an ambiguous social vignette depicting a 'blind date' between two students. The vignette included a number of ambiguous statements and behaviors about interpersonal evaluation (e.g., When meeting her date, Lisa said "You're certainly not what I expected") and evaluation of non-interpersonal information (e.g., Upon entering the restaurant, Lisa said "This is an unusual place"). After reading the vignette, participants completed a 19-item questionnaire that was designed to assess their interpretations of the ambiguous information. They also rated their level of agreement with interpretations of the ambiguous information (e.g., When Lisa said to Steve "You're

certainly not what I expected" she was impressed). In line with this content specificity in the interpretative bias, socially-anxious participants showed more threatening interpretations of ambiguous, interpersonal events compared to the low anxious participants.

Stopa and Clark (2000) replicated these findings with a clinical population of socially-anxious participants using self-report questionnaires designed to measure interpretations of ambiguous social and non-social scenarios and unambiguous mildly negative social scenarios. After reading each scenario, participants were required to write down the first explanation that came to their mind. They were also asked to rank the likelihood that different interpretations of mildly negative social events would come to their mind. An example of the mildly negative social events was 'You have been talking to someone for a while and it becomes clear that they're not really interested in what you're saying'. The interpretations which were suggested included, 'I am a boring person' (negative self-judgement), and 'Their mind was probably on something else' (neutral self judgement). Patients with social anxiety ranked negative interpretations (i.e., catastrophization) of the mildly negative social events as more likely to come into their mind than the control groups. Thus, in addition to interpreting ambiguous social events more negatively, patients with social anxiety were more likely to catastrophize about mildly negative social events than patients with other anxiety disorders, and non-clinical controls. In another study, using a sentence completion task and self-report measures, Huppert et al. (2007) reported that individuals with clinically significant social anxiety exhibited both the presence of a negative bias and a lack of positive bias at both generation and selection of responses in the face of ambiguity. Furthermore, Hertel et al. (2008) found that socially-anxious participants produced more socially negative continuations for ambiguous social scenarios and had a better memory for them.

Beard and Amir (2008) used the Word Sentence Association Paradigm (WSAP) to examine interpretation bias in socially-anxious individuals. In the WSAP, participants decide whether or not a word (implying a threat or benign interpretation) is related to an ambiguous sentence. Threat or benign meanings precede the ambiguity in order to examine the influence of positive and negative beliefs on interpretation of ambiguous information. The WSAP results in two types of interpretation indices: (1) response latency to make relatedness decisions for threat and benign interpretations, and (2) endorsement rates of the relatedness of threat and benign interpretations to ambiguous sentences. Using these indices as a measure of interpretation bias, Beard and Amir (2008) found a threat interpretation bias and a lack of a benign interpretation bias in both reaction time and self-report data from socially-anxious participants.

Other studies have investigated how socially-anxious individuals interpret social events with different valence. Voncken et al. (2003) assessed participants' interpretations of four types of social scenario: positive (e.g., 'someone makes a compliment about your looks'), ambiguous (e.g., 'someone you know looks in your direction'), mildly negative (e.g., 'the newly introduced person doesn't say anything to you'), and strongly negative (e.g., 'a friend tells you a colleague dislikes you'). Socially-anxious individuals were asked to rank order four interpretations of each scenario in terms of likelihood that it was the explanation for the situation. They made more negative interpretations of all four types of scenario compared to control individuals. Moreover, it was found that the interpretation bias was specific to social information rather than non-social information. Voncken et al. (2003) argued that interpretation bias in social anxiety can be seen as a negative interpretation of all social events, irrespective of valence. Similarly, Vassilopoulos (2006) reported that high socially-anxious individuals were more likely to interpret positive social events in a negative fashion and to catastrophize in response to unambiguous, mildly negative social events than low socially-anxious controls. The fact that interpretation bias in social anxiety was limited to social situations rather than involving non-social situations implies that socially-anxious individuals process social information differently from other information. This is consistent with content-specificity hypothesis as outlined in cognitive-behavioural models of social anxiety.

A plausible explanation for negative interpretation bias in social anxiety is that it might be caused by general negative affect or low mood rather than be specifically related to social anxiety. Using a computerised paradigm of 'on-line' processing to measure interpretative biases, Huppert et al. (2003) examined whether negative interpretative biases in socially-anxious participants was related to social anxiety or general negative affect (depression, state and trait anxiety). They reported that a negative interpretation bias for social situations was positively related to social anxiety, but not to general negative affect. Furthermore, Amir et al. (2005) conducted a study with undergraduate students which included a sample of socially-anxious individuals, generally anxious individuals, and non-anxious and dysphoric controls. Participants were presented with video clips involving a female and male actor who approached the camera and commented on some aspect of the individual's belongings or actions. One-third (24) of the video clips were ambiguous (e.g., *That is an interesting shirt you have on*), one-third (24) were positive (e.g., *I really like your shoes*), and the other one-third (24) were negative (e.g., *That is a horrible hair cut*). Participants were required to rate the emotional valance of each video as if they heard the comment in a real situation. Socially-anxious students

rated the valence of ambiguous social interactions as more negative than did non-anxious, high trait anxious and dysphoric control groups. Consistently, Alden et al. (2008) reported that a negative interpretation bias in patients with social anxiety was not due to the presence of depression as measured by Beck Depression Inventory.

A potential methodological problem with the studies reviewed so far is that they either used laboratory-based paradigms or self-report questionnaires to assess interpretation biases. Taylor and Alden (2005) used a more ecologically valid paradigm, in which patients with social anxiety and non-anxious controls engaged in a social interaction with an experimenter who behaved in either a positive or an ambiguous social way. Participants then rated their own performance (self-judgement) and their partner's behavior (social interpretation). Consistent with the literature, socially-anxious patients displayed negatively biased self-judgements but failed to display biased interpretations of their partner's behaviour.

In addition to the perceived threat of social cues, the interpretation process also involves estimates of the *probability and cost* of certain types of negative events (i.e., the perceived impact of the social events on the individual). According to cognitive models, people with social anxiety overestimate perceived social danger (Clark and Wells 1995) and have distorted probabilistic reasoning related to social events (Rapee and Heimberg 1997) which maintain their social anxiety. Recent research has focused on socially-anxious individuals' overestimation of the probability and cost of negative social events. This line of research is often described as *judgemental bias* studies. In line with the interpretation bias literature, a number of studies have reported that socially-anxious individuals estimate that the probability and cost of negative social events is higher compared to non-anxious controls (Foa et al. 1996; McManus et al. 2000; Voncken et al. 2003). Furthermore, Vassilopoulos (2006) reported that individuals with high social anxiety estimated the emotional cost of negative social events as higher and the probabilities of positive social events as lower compared to individuals with low social anxiety. Similarly, Schofield et al. (2007) reported that high socially-anxious individuals estimated the perceived cost of interacting with someone showing disgust facial expression to be greater than low socially-anxious individuals.

Taken together, the studies reviewed above collectively suggest that both clinical and non-clinical socially-anxious individuals demonstrate biased interpretations of ambiguous social situations. These negative interpretation biases are mainly unrecognised by socially-anxious individuals when exposed to social situations and may underlie anxiety symptoms in social anxiety disorder. The studies reviewed above indicate that the negative interpretative biases have the following characteristics: (1) when presented with social events (social scenarios, video clips and social interactions), particularly ambiguous social information, socially-anxious individuals tend to interpret it in a more negative or less positive manner, (2) socially-anxious individuals have a tendency to catastrophize about mildly negative social events and overestimate the probability and cost of potentially negative social events, (3) negative interpretation biases in socially-anxious individual are specific to social anxiety rather than other negative affect or depression, and (4) interpretative biases in social anxiety are limited to self-referent social events (content-specific) rather elicited by social and non-social events.

These findings are consistent with the cognitive theories of social anxiety which suggest negative self-processing as a central feature of social anxiety (Beck et al. 1985; Clark and Wells 1995; Rapee and Heimberg 1997). Given that social anxiety is associated with negative interpretation biases a next phase of research is to establish whether such a bias is amenable to modifications or treatment (Mobini and Grant 2007). Considering the theoretical and research background, it is reasonable to hypothesize that reducing a negative interpretation bias should lead to reductions in social anxiety. Thus, it is important to move beyond description of interpretation biases and design studies that examine the effectiveness of interventions in modifying negative interpretative biases and improving social functioning.

Cognitive Bias Modification

Mathews and Mackintosh (2000) developed a CBM paradigm in which participants were trained during a number of trials (anything up to 100 trials) to consistently resolve ambiguous word stems (e.g., in favor of either positive or negative outcomes, depending on training condition). Subsequently, clinical and cognitive psychology researchers have developed a number of CBM interventions to directly modify cognitive biases associated with anxiety via repeated practice on computerized cognitive tasks (see Beard 2011 for a recent review).

This line of research suggests that it is possible to experimentally manipulate (or 'train') interpretation bias in healthy volunteers. For instance, Grey and Mathews (2000) showed that normal volunteers with high scores on trait anxiety could be trained to generate negative interpretations of ambiguous stimuli. Similarly, Mathews and Mackintosh (2000) used short passages of text describing ambiguous social situations relevant to social anxiety to manipulate positive and negative interpretation biases in a volunteer sample. These biases were associated with congruent changes in state anxiety. Yiend et al. (2005)

reported that experimental training produced interpretation biases which were maintained over 24 h. Mackintosh et al. (2006) replicated this enduring induced interpretation bias despite a change of context (modality, place, and experimenter) between training and test conditions over 24 h and over stress manipulation (video) too.

In a review of data on the experimental induction of interpretative and attentional biases, Mathews and MacLeod (2002) concluded that these cognitive biases have causal effects on vulnerability to anxiety via their influence of how significant events are processed. Wilson et al. (2006) found that participants who were exposed to training in a benign interpretation bias experienced less anxiety in response to a video stressor as compared to participants who were exposed to training designed to induce threat congruent interpretations. Similarly, Mathews et al. (2007) reported that inducing a benign interpretation bias reduced trait anxiety in high trait anxious volunteers. In another study, Salemink et al. (2009) found that high trait-anxious participants who completed positive CBM-I program online for eight consecutive days were less state and trait-anxious compared to the control group. More recently, Tran et al. (2011) adopted the scenarios developed by Mathews and Mackintosh (2000) to train participants to interpret ambiguous scenarios in either a negative, self-relevant way or a positive, self-relevant way. Following the training, the researchers examined changes in participants' self-reported affect and self-esteem in an emotional vulnerability task. Participants exhibited a tendency to interpret novel ambiguous scenarios in accordance with their training condition. Furthermore, participants in the positive training condition did not exhibit a decrease in self esteem after a subsequent stress task, whereas participants in the negative condition did.

Studies reviewed above mainly employed a method in which participants were encouraged to actively generate positive interpretations of ambiguous scenarios. Hoppitt et al. (2010) compared two methods of training in a CBM task (active vs. passive). In the active training condition, non-clinical volunteers were trained to generate and select threatening or non-threatening meanings of ambiguous event descriptions, whereas in a passive method participants were provided with identical valenced information with no need to generate or select emotional meanings. The authors reported that this active method of interpretive training increased subsequent self-rated emotionality of images of new emotionally ambiguous descriptions in a training-congruent direction. In contrast, when a passive method of training was used change in the emotional valence of ambiguous descriptions was not observed. The authors suggested that this difference may be due to the induction of an implicit production rule, in which participants in the active training method continue to actively generate threatening meanings of ambiguous events, even in the absence of any requirement to do so in a new task.

So far, a few published studies (Beard and Amir 2008; Murphy et al. 2007; Turner et al. 2011) have used CBM procedures to modify interpretation biases in participants who have social anxiety. Murphy et al. (2007) trained socially-anxious students to make benign interpretations in a single training session. The benign training group listened to 95 short descriptions of ambiguous social situations which were resolved in a positive manner. Participants in the control condition listened to the same descriptions of social situations but the outcome of the situation was not specified. After training, participants read a series of new ambiguous social situations. Their interpretations of these situations were tested using subsequent recognition ratings of possible interpretations. Socially-anxious participants who received a benign (positive or non-negative) interpretation induction generated more benign, less negative interpretations of new ambiguous social situations than the control group and predicted that they would be significantly less anxious in a future social situation.

Using a different procedure of changing interpretations, the word sentence association paradigm (WSAP), Beard and Amir (2008) trained benign interpretations in socially-anxious individuals. In the WSAP, participants decide whether or not a word (implying a threat or benign interpretation) is related to an ambiguous sentence. Participants completed 8 training sessions over 4 weeks. Those in the experimental group showed decreased threat interpretations, increased benign interpretations and decreased social anxiety symptoms. Mobini et al. (2012) found that socially-anxious participants who were trained to access benign interpretations in a single-session CBM-I program made fewer negative interpretations and more positive interpretations of ambiguous 'social performance' scenarios than a control group. Two methods of modifying interpretation biases were used—implicit training and explicit training. Training materials were identical in both CBM programs, except that in the explicit CBM condition participants were given information about the intention of the (positive) training. A larger effect size ($d = .74$) was observed for the explicit CBM-I condition which suggests that providing explicit instructions to the participants about the CBM-I enhanced the emotional transfer of training. Turner et al. (2011) used cognitive bias modification (CBM-I) training developed by Mathews and Mackintosh (2000) with eight socially-anxious patients who had a diagnosis of psychosis. They reported that all participants showed improvements in positive mood and three of the six participants who completed the test of interpretative bias displayed an improvement in positive interpretative bias.

In another recent study, Khalili-Torghabeh et al. (2012) adopted the CBM-I scenarios developed by Mathews and

Mackintosh (2000) to train a sample of Iranian socially-anxious students for 4 sessions over 2 weeks. The results showed that the CBM-I group significantly endorsed fewer threat interpretations and more benign interpretations of ambiguous social scenarios at post-test than the control group. Participants in the CBM-I condition also reported a significant decrease in social anxiety symptoms measured by the fear of negative evaluation (FNE) and social avoidance and distress scale (SADS). Moreover, the CBM-I group showed a significant reduction in negative interpretation biases and social anxiety symptoms at a 1-month follow-up. To our knowledge, this is the first cross-cultural CBM study which demonstrates such CBM effects using a non-English speaking sample of socially-anxious individuals.

A method which may enhance the clinical impact of CBM treatment is to combine training of interpretative and attentional biases. As discussed by Beard (2011), both attention and interpretation biases are important targets for treatment of anxiety disorders. Like CBM-I, cognitive bias modification for attention (CBM-A) is a newly emerging intervention for anxiety that is rooted in cognitive models of anxiety disorders (see Bar-Haim 2010 for a recent review). In a randomized double-blind placebo-controlled trial, Beard and colleagues (Beard et al. 2011) examined the efficacy of combined CBM for interpretation (CBM-I) and attention (CBM-A) in the treatment of social anxiety disorder in a community sample. Participants in the CBM-I condition completed a word-sentence association task in which they received positive feedback for making benign interpretations of word–sentence pairs and negative feedback for making negative interpretations, whereas participants in the CBM-A condition completed a dot probe task in which probes always followed neutral faces when paired with a disgust face, thereby directing attention away from threat. Participants in the combined CBM-I and CBM-A condition reported significantly reduced self-reported social anxiety symptoms relative to the placebo condition. These gains were also evident on a behavioral measure of social anxiety (i.e., performance on an impromptu speech). Beard and colleagues (Beard et al. 2011) also assessed participants' perceived credibility of and satisfaction with the two CBM programs. Participants rated the CBM-I and CBM-A treatments as moderately credible and found both CBM protocols acceptable and reported high satisfaction. Participants also reported that CBM-I was more helpful than CBM-A. Finally, credibility and expectancy ratings at baseline correlated with change in social anxiety symptoms. In another qualitative study, Beard et al. (2011) examined 10 socially-anxious patients' attitudes toward and initial impressions of CBM. The patients were asked to report both positive and negative aspects of CBM-I and CBM-A tasks. They found CBM-I to be more 'fun and engaging' than CBM-A. Overall, most participants reacted more negatively to the CBM-A task than the CBM-I task and preferred the latter because it was more 'intuitive and engaging'. Some participants thought that both CBM programs were 'weird', and repetitive and boring'. Despite the fact that most participants were able to make sense of the need for repetition in CBM, many still did not think they would complete such a repetitive treatment. Similar findings are reported in a previous study where anxious participants described both the CBM-A and CBM-I tasks as acceptable, with the attentional task experienced as boring and the interpretative task as helpful (Brosan et al. 2011). Brosan et al. (2011) also used a combined approach of CBM-A and CBM-I with a sample of 13 anxious patients and found significant reductions in threat related attentional and interpretative biases, as well as decreased state and trail anxiety. Given these emerging qualitative data, it is important to work towards developing more appealing and engaging CBM programs for social anxiety and other anxiety disorders.

In sum, a growing body of literature indicates that cognitive bias modification is an effective intervention in modifying negative interpretation biases and reducing emotional vulnerability to anxiety. Although mainly developed from basic science laboratory research, CBM is a possible new treatment, based on cognitive theories and research about anxiety. Given this promising prospect of using CBM as a treatment method for anxiety disorders in general and social anxiety in particular, we will discuss some important clinical and research implications of CBM findings in the next part.

Clinical and Research Implications

The findings that cognitive bias modification training can modify negative interpretative biases in people who have social anxiety have both theoretical and clinical implications. The research evidence reviewed above supports cognitive-behavioral theories of social anxiety that emphasize a biased allocation of information processing resources to negative evaluation (Clark and Wells 1995; Rapee and Heimberg 1997). The common theme of these cognitive models is that perceived negative self-processing is associated with biased information processing which makes certain individuals vulnerable to developing social anxiety (Spokas et al. 2007).

Despite very promising results from laboratory-based CBM studies using analogue samples (see Beard 2011), the therapeutic values of CBM largely remain to be investigated. There are limited data on whether the CBM programs can be used clinically with patients who have social anxiety. Apart from Beard et al.'s (2011) recent study,

there have been no other clinical trials of CBM with participants who have social anxiety. The development of a method to reduce negative cognitive biases could provide an important supplement to existing clinical practice (see Beard 2011 for a review). As a stand-alone treatment or an adjunct to cogntive-behavioral therapy (CBT), CBM has the potential to be delivered flexibly by computer without or with less clinician involvement. In addition, as an adjunctive treatment, CBM may complement other psychological therapies in its mode of delivery (i.e., as a home-based task conducted in-between sessions of CBT). It may be a particularly suitable treatment for patients with social anxiety who do not wish to engage in a face-to-face treatment with a therapist such as CBT or who are not suitable for or do not wish to take medication. Computerised delivery of therapeutic interventions for social anxiety may also enhance the efficacy of face-to-face CBT for social anxiety. Moreover, given that social anxiety is one of the most common anxiety disorders with a poor rate of recovery (Sareen and Stein 2000), the availability of a treatment method such as CBM which is easy to deliver via the internet or on CD-ROM either at the clinic or in the patient's own environment could result in significant reductions in economic and social costs of this debilitating disorder.

It is important to examine methods of enhancing the effects of CBM-I training on modifying cognitive biases and symptomatic presentation of the disorder as well as transferring the impact into the real world. It would be helpful to demonstrate that reductions in symptom severity are associated with improvements in social functioning. CBM studies have examined the effect of training over a single session or multiple (eight) sessions and there is still uncertainty about what may constitute an optimal 'dose' of CBM. Despite some promising effects of CBM-I, it seems improbable that direct modification of interpretative biases through a single session will yield enduring therapeutic benefits. MacLeod et al. (2009) suggested that future researchers should investigate how to optimize the transfer of CBM-induced cognitive change from the laboratory into the naturalistic setting and to maintain any changes over time. One would expect that multiple training sessions are more likely to induce long-term changes in interpretation bias, consequently resulting in decreased social anxiety symptoms. Multiple practices outside the clinical (or laboratory) setting, for example, using home computers or using training materials in naturally occurring social situations may result in more enduring positive effects of CBM practice on social anxiety symptoms.

Holmes et al. (2006) reported that positive interpretation training enhanced positive mood through mental imagery as opposed to verbal processing. Furthermore, Holmes and colleagues (Holmes et al. 2009) demonstrated that CBM gave greater protection against subsequent negative mood induction when imagery rather than verbal processing of the ambiguous scenarios was used. These findings suggest that images, rather than verbal representations contribute to negative or positive affectivity and may play a key role in the efficacy of CBM-I. In line with these research findings, it is important to explore variants of CBM which have a greater impact on producing mental imagery of the social scenarios, for example, by employing visual prompts or video images of the events. This is particularly important when using CBM with a clinical sample. Patients with social anxiety might find it difficult to imagine themselves in social situations because they naturally tend to avoid those situations. Thus, this heightened arousal provoked by imagery exposure to social situations may interfere with their ability to imagine themselves in social scenarios. There seems to be a need for continued research in the laboratory-based development of more imaginative ways of activating mental imagery in patients while engaging in the CBM task. It is also important to bear in mind that not all people are able to produce mental imagery, therefore verbal processing might work better for some people than others.

Thus far, CBM training materials for social anxiety have been mainly limited to some passages related to social interactions and social performance. Future research on interpretation bias training needs to take into account the clinical presentations and the phenomenology of social anxiety disorder. Social anxiety can result from negative interpretations of various social situations. Mobini et al. (2012) suggested that the content of CBM training materials should be tailored to different features of social anxiety such as fears specifically related to 'social interactions' (e.g., meeting strangers) as opposed to 'social performance' (e.g., public speaking). This content-specificity of the interpretative training materials may be particularly important when studying clinical populations. Some individuals with social anxiety disorder experience great distress in a wide range of social situations, whereas others experience anxiety only in specific social situations (American Psychiatric Association 2004). Therefore, CBM and training programs should distinguish between more general and specific features of clinical presentation of social anxiety disorder. More specific CBM-I training programs may prove to have more robust effects on cognitive biases and anxiety symptoms.

The relationship between different aspects of cognitive biases needs to be investigated. CBM research has mainly focused on modification of either attentional bias or interpretation bias. There is consistent evidence that people with social anxiety have both attentional and interpretation biases (e.g., Asmundson and Stein 1994; Pineles and Mineka 2005; Pishyar et al. 2004). Preliminary data

(Mobini et al. 2012) indicated that reducing a negative interpretation bias resulted in decreased attentional bias towards social threat words. This suggests that a change in one aspect of information processing (e.g., interpretative bias) may mediate changes in other more salient aspect of information processing. Taking into account the very nature of information processing and involvement of automatic (attentional bias) and more conscious (interpretative bias) processing systems (Beck and Clark 1997), further CBM research needs to examine the interactional nature of different cognitive biases using different (attentional and interpretative) variants of CBM. It is important to investigate whether CBM training targeting one aspect of cognitive biases influences other aspects within information processing. This line of research can shed light on the complicated cognitive systems and mechanism of action by which different cognitive processes interact with each other and influence emotion.

One of the ways of investigating this interactional nature of cognitive processes is to combine CBM tasks for different cognitive biases and investigate the effects of this combined CBM treatment on each bias. A similar combined CBM approach was used in Beard et al.'s (2011) study but the authors did not report any effects of combined CBM-I and CBM-A treatment on interpretative or attentional biases. In this regard, meditational analysis may help the researchers specify the cognitive mechanisms underlying symptom reductions following repeated practice of the CBM task.

As discussed previously, research suggests that individuals with social anxiety demonstrate negative judgemental biases, i.e., they overestimate the probability of negative outcomes in social situations and exaggerate the costs of negative social events (Foa et al. 1996; McManus et al. 2000; Schofield et al. 2007; Vassilopoulos 2006). So far, CBM research has focused on interpretations of ambiguous social scenarios rather than modification of cognitive processing involved in overestimation of the probability and costs of negative social events. Thus, future studies could also develop CBM materials which directly modify of judgmental biases in social anxiety.

Studies reviewed above indicate that the existence of a negative interpretation bias is a robust phenomenon associated with social anxiety. However, cognitive theories of social anxiety (Beck et al. 1985; Clark and Wells 1995) describe several levels of information processing (e.g., dysfunctional assumptions and negative core beliefs) as underlying cognitive explanations for this disorder. It is not yet clear that a strategy that has been learned in a more implicit and automatic fashion via CBM task can modify more conscious cognitive processing such as dysfunctional assumptions underlying social anxiety (Clark and Wells 1995). Future CBM research should go beyond of this 'tip of the iceberg' and determine whether the CBM-induced modifications can affect deeper levels of thinking patterns seen in social anxiety. It is not yet clear that a strategy that has been learned in a more implicit and automatic fashion via the CBM task can modify more conscious cognitive processing such as dysfunctional assumptions underlying social anxiety (Clark and Wells 1995).

Beck and Clark (1997) introduced a three-stage model of information processing of anxiety consisting of (a) *initial registration,* (b) *immediate preparation,* and (c) *secondary elaboration*. The first stage of processing involves an automatic recognition of threat information by the activation of the *orienting mode*. The recognition of a negative stimulus leads to the immediate preparation stage involving the activation of the *primal mode*. The primal-mode processing involves a mixture of both automatic and more elaborative processing (e.g., activation of negative automatic thoughts). The activation of the primal mode leads to secondary elaboration stage, that is, elaborative and strategic processing based on the activation of the *metacognitive mode*. At this stage information processing is characteristically slow, effortful, and schema driven. Beck and Clark (1997) suggested that automatic anxious thoughts and cognitive biases result from the activation of the orienting and primal threat modes at the earlier stages of information processing. Therefore, according to this model of information processing, the main task in treating anxiety disorders should focus on the deactivation of the primal threat mode and the strengthening of more reflective and elaborative processing. Taking into account Beck and Clarks' model and the fact that cognitive biases operate outside of awareness and are relatively habitual, studies that combine automatic and elaborative processing outcomes can build on our understanding of how automatic and conscious processes are affected by CBM interventions.

Understanding the relation between automatic and conscious processing is particularly important because these implicit cognitive biases are relatively difficult to modify using traditional CBT, where the focus is more on helping patients to consciously and explicitly engage in attempts to explore positive/rational alternatives to negative thinking and to learn explicit cognitive and behavioural strategies to target such cognitions in the future. Mobini et al.'s (2012) study provides preliminary evidence that making socially-anxious participants aware of the intention of the (positive) training in CBM-I enhances its effectiveness in reducing negative interpretation biases. However, it remains to be seen whether this explicit CBM-I training influences underlying thought processes involved in social anxiety.

One of the interesting questions is whether processing self-relevant information through CBM training would lead to constructing more positive mental representation of the self in socially-anxious individuals (see Stopa et al. 2010).

As Stopa (2009) suggested, lack of clarity about the self is associated with elevated social anxiety, and it is possible that activating positive self-relevant information through CBM-I training might help socially-anxious individuals develop a stable sense of self within social situations. It is not clear whether processing positive self-relevant information through imagined social scenarios would change a negative representation of the self which is assumed to maintain social anxiety (Rapee and Heimberg 1997).

Finally, more work needs to be done to assess the impact of CBM on participants including issues around safety and potential adverse effects of CBM tasks on patients with social anxiety. Despite the fact that CBM-I appears to be a benign treatment with low drop outs from treatment, ranging from 0 to 8% (see Beard 2011), the feasibility and acceptability of delivering CBM to various clinical populations with less therapist involvement largely remain to be seen.

Conclusions

CBM-I has been developed from basic science laboratory research to modify negative interpretative biases in social anxiety and reduce emotional vulnerability and social anxiety symptoms. Although existing treatment approaches such as cognitive-behavioural therapy explicitly target cognitive biases, CBM-I offers an alternative approach that may be less time-consuming and require significantly less therapist involvement. However, the clinical efficacy of this treatment method for social anxiety disorder has yet to be established. Although, several studies suggest that CBM- I is a promising treatment for social anxiety this approach requires systematic evaluation through high quality clinical trials.

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