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Enhanced effects of combined cognitive bias modification and computerised cognitive behaviour therapy on social anxiety

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Abstract: This study examines whether combined cognitive bias modification for interpretative biases (CBM-I) and computerised cognitive behaviour therapy (C-CBT) can produce enhanced positive effects on interpretation biases and social anxiety. Forty socially anxious students were randomly assigned into two conditions, an intervention group (positive CBM-I + C-CBT) or an active control (neutral CBM-I + C-CBT). At pre-test, participants completed measures of social anxiety, interpretative bias, cognitive distortions, and social and work adjustment. They were exposed to 6 × 30 min sessions of web-based interventions including three sessions of either positive or neutral CBM-I and three sessions of C-CBT, one session per day. At post-test and two-week follow-up, participants completed the baseline measures. A combined positive CBM-I + C-CBT produced less negative interpretations of ambiguous situations than neutral CBM-I + C-CBT. The results also showed that both positive CBM-I + C-CBT and neutral CBM-I + C-CBT reduced social anxiety and cognitive distortions as well as improving work and social adjustment. However, greater effect sizes were observed in the positive CBM-I + C-CBT condition than the control. This indicates that adding positive CBM-I to C-CBT enhanced the training effects on social anxiety, cognitive distortions, and social and work adjustment compared to the neutral CBM-I + C-CBT condition.

Subjects: Cognitive Science; Psychiatry & Clinical Psychology - Adult; Psychological Disorders - Adult

Keywords: social anxiety; cognitive bias modification; computerised cognitive behaviour therapy

ABOUT THE AUTHORS

Authors have been involved in developing the laboratory-based paradigms in modifying cognitive biases in anxiety over a decade. They have published extensively in the area of cognitive bias modification for anxiety disorders, both from a theoretical perspective and applied research.

PUBLIC INTEREST STATEMENT

People with social anxiety tend to interpret ambiguous situations in a negative manner. We developed a computerised treatment i.e. cognitive bias modification for interpretative biases (CBM-I) which aims to modify negative interpretations. We combined CBM-I with another treatment method, i.e. computerised cognitive behaviour therapy (C-CBT) and examined the effects of both CBM-I and C-CBT on social anxiety and negative interpretations. The results showed that combining both treatments produced better treatment outcomes.

1. Introduction

Social anxiety disorder (SAD) is one of the most common anxiety disorders (Kessler, Berglund, Demler, Jin, & Merikangas, 2005) and it is associated with negative outcomes in social functioning, family life, close relationships, occupational and educational domains (Fehm, Pelissolo, Furmark, & Wittchen, 2005; Stein & Kean, 2000). Cognitive models of social anxiety (Beck, Emery, & Greenberg, 1985; Clark & Wells, 1995; Rapee & Heimberg, 1997) place emphasis on the idea that dysfunctional social anxiety is initiated and sustained by particular types of negative thought content, usually involving the perception of social risks. This has led to the growth of the intervention approach known as cognitive behaviour therapy (CBT). CBT requires individuals to monitor their thought content, identify counterproductive patterns of negative thinking and employ logical appraisal and behavioural "experimentation" to challenge the veracity of their negative thoughts (Heimberg, 2002). CBT interventions have been found to produce modest to large effect sizes, in terms of clinical improvement (see Fedoroff & Taylor, 2001). However, despite its demonstrated efficacy, it is reported that less than 25% of people with SAD receive treatment due to their inability to cope with face-to-face interactions with clinicians (Gross et al., 2005). To overcome this barrier, there have been some attempts to develop computer-administered interventions which can be used without or with minimum therapist involvement. One of the earliest developments focused on computerised cognitive behaviour therapy (C-CBT) as an accessible alternative to face-to-face CBT treatment. Research suggests that C-CBT is effective in reducing social anxiety (e.g. Berger, Hohl, & Caspar, 2009; Carlbring, Nordgren, Furmark, & Andersson, 2009).

A wealth of literature suggests that socially anxious individuals interpret ambiguous social information in a negative or less positive manner (e.g. Amir, Beard, & Bower, 2005; Hertel, Brozovich, Joormann, & Gotlib, 2008; Huppert, Pasupuleti, Foa, & Mathews, 2007; Stopa & Clark, 2000). One of the clinical implications of these research findings is to investigate whether these negative cognitive biases are amenable to any changes (Mobini & Grant, 2007; Mobini, Reynolds, & Mackintosh, 2013). In recent years, a computerised task, CBM-I, was developed from laboratory research to directly modify negative interpretative biases in socially anxious people (Mathews & Mackintosh, 2000). CBM-I is a text-based computerised programme in which individuals are repeatedly exposed to ambiguous social scenarios and trained to resolve them positively, through completion of a word fragment (Mathews & Mackintosh, 2000). CBM-I works through systematic and repeated computer-based training that gradually shifts negative interpretative biases towards a more positive direction (MacLeod & Mathews, 2012). CBM-I might be a suitable treatment option for individuals with SAD, particularly for those individuals who are not interested in face-to-face psychological therapy or those who are reluctant to take medication (Beard, 2011; Mobini et al., 2013). Therefore, CBM-I may be especially helpful in engaging this client group in some form of psychological interventions. Thus far, a few published studies using different methods of CBM-I have demonstrated positive effects of these computerised tasks on modifying interpretative biases and reducing anxiety in non-clinical or clinical social anxiety (e.g. Amir & Taylor, 2012; Beard & Amir, 2008; Beard, Weisberg, & Amir, 2011; Bowler et al., 2012; Khalili-Torghabeh, Salehi Fadardi, Mackintosh, Reynolds, & Mobini, 2014; Mobini et al., 2014; Murphy, Hirsch, Mathews, Smith, & Clark, 2007).

Unlike C-CBT which focuses on modifying conscious thoughts, CBM-I focuses directly on the automatic cognitive processes which underlie information processing (Beck & Clark, 1997; MacLeod & Mathews, 2012). In a recent study, Mobini et al. (2014) reported that a single session of CBM-I or C-CBT programme increased positive interpretations of ambiguous social scenarios and reduced anxiety symptoms in socially anxious participants. In the positive CBM-I training group, participants were trained during a number of trials to consistently resolve ambiguous social situations in favour of either positive or neutral outcomes via completion of word stems (Mathews & Mackintosh, 2000). In another study, Khalili-Torghabeh et al. (2014) used a multi-session CBM-I programme with an Iranian sample of socially anxious students and found that similar to Western samples, this sample of participants endorsed more positive interpretations of ambiguous scenarios and reported decreased social anxiety. In this study, these positive CBM-I induced results were maintained at a seven-week follow-up.

In a randomised controlled trial (RCT), Amir and Taylor (2012) used a word–sentence association task in which patients with social anxiety decided whether a word implying a threatening or benign meaning was related to an ambiguous social scenario. The results revealed that this interpretation modification program significantly decreased threat interpretations and clinician-rated social anxiety symptoms from pre- to post-assessment relative to the control group. However, no effects on self-rated social anxiety symptoms were reported. In another RCT study, Salemink and colleagues found that anxious patients who received eight online positive CBM-I training sessions developed more positive interpretations of ambiguous scenarios than the patients in the control condition (Salemink, Kindt, Rienties, & van den Hout, 2014). In this study, participants reported generally being less anxious but did not report changes in social anxiety (Salemink et al., 2014). To explain this lack of positive effect on social anxiety, the authors reported that patients were suffering from different anxiety disorders and the scenarios were not matched to the specific concerns of each anxiety state.

Thus, although studies have reported that both CBM-I and C-CBT can modify negative interpretative biases and reduce social anxiety, to our knowledge no study has yet investigated the effectiveness of combined CBM-I and C-CBT for social anxiety. The present study, therefore, aims to examine whether combining CBM-I and C-CBT would result in enhanced positive treatment effects on interpretation biases and social anxiety symptoms. An additional aim of the study was to investigate the effects of combined C-CBT and CBM-I on both cognitive distortions and social and work adjustment, as no study has yet examined this.

2. Methods

2.1. Participants

Forty volunteers ($N = 40$) with high scores on the Social Phobia Inventory (SPIN) were recruited from a student population at the University of Newcastle in Australia. Participants were undergraduate or postgraduate students and all identified that they spoke fluent English prior to commencing the study. Potential participants who reported a current history of mental health problems including depression and anxiety disorders, other than social anxiety, were excluded from the study. However, those participants with depression and anxiety disorders who were receiving a stable medication treatment for the past two months were included in the study. Participants' demographic information and mean scores of the SPIN for each condition in the study are depicted in Table 1.

2.2. Measures

2.2.1. Social Phobia Inventory (Connor et al., 2000)

The SPIN was used as a screening measure to ensure people who went on to complete the main component of the study demonstrated some symptoms or features of social anxiety. The SPIN consisted of 17 items that aimed to evaluate clinically important aspects of social anxiety such as fear in/of social situations, avoidance and physiological symptoms. Potential participants were only invited to take part in the study if they scored 19 or above. A cut-off point of 19 discriminates well between subjects with and without social phobia (Davidson et al., 1997). It is reported that the SPIN has good psychometric properties for both screening and treatment response assessment (Connor et al., 2000).

Table 1. Demographic information for each group

	Positive CBM-I + C-CBT	Neutral CBM-I + C-CBT
Age M (SD)	23.85 (6.58)	24.4 (7.21)
Gender (female %)	14 (70%)	14 (70%)
Ethnicity	Caucasian = 17Asian = 3	Caucasian = 19Asian = 1
Psychiatric history	Anxiety = 2Depression = 1	Anxiety = 4

2.2.2. Cognitive Distortions Scale (Mobini, Pearce, Grant, Mills, & Yeomans, 2006)

The Cognitive Distortions Scale (CDS) was used as a measure of cognitive distortions (negative thinking). The CDS is a 20 item scale that addresses 20 cognitive distortions that are relevant to cognitive models of psychopathology. Participants were asked to read each definition and the example(s) and rate the occurrence of each thought with a number on a scale from 0 to 100. Mobini et al. (2006) reported a Cronbach's α of .92 for the CDS, indicating a high level of internal consistency and a high internal reliability (Guttman coefficient = .90).

2.2.3. Work and Social Adjustment Scale (Mundt, Marks, Shear, & Greist, 2002)

The Work and Social Adjustment Scale (WSAS) is a simple five item scale that aims to measure the amount of disability associated with a certain condition. For this study, the scale was modified to be specifically related to social anxiety. Participants rated their level of impairment on an 8-point Likert scale from 0 (not at all) to 8 (very severely) in five areas including work, home management, social leisure activities, private leisure activities and in close relationships. The WSAS has demonstrated good internal consistency and test–retest reliability with Cronbach's α ranging from .80 to .90 (Mataix-Cols et al., 2005; Mundt et al., 2002). In the current study, internal consistency for the WSAS total score was high (α = .92).

2.2.4. Interpretation bias assessment (Mathews & Mackintosh, 2000)

Interpretation biases were tested individually using a text-based encoding task that has been widely used in a number of previous studies investigating interpretation biases in anxiety (e.g. Hertel et al., 2008; Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Mathews & Mackintosh, 2000; Mobini et al., 2014). In a recent study, Salemink and van den Hout (2010) reported that this assessment is a valid measure of trained interpretation biases following CBM-I training. Participants were presented with 10 ambiguous social scenarios and 5 fillers, one at a time, and instructed to imagine themselves in the situation while reading each description as if they were actually there. Each scenario ended ambiguously to allow participants to apply their own spontaneous interpretation to the meaning of the passage. Following each scenario, a comprehension question was then asked to ensure participants understood what the passage was about. After participants read all 15 scenarios, they were presented with the titles of each ambiguous scenario again, along with four interpretations in an individually randomized order. The four different interpretations for each previously presented ambiguous scenario were presented one at a time. Two of the four sentences were target sentences, which matched the preceding ambiguous scenario in meaning but were of either a positive or negative valence. The remaining two sentences were foils, which did not directly correspond to the preceding ambiguity but were positively or negatively valenced. Foils were included to assess any wider priming effects of training. They were used to indicate any potential response bias for endorsing any information of a certain emotional valence. Participants were asked to rate each sentence according to how closely it corresponded in meaning to what was described in the preceding scenario. They made this rating using a 4-point Likert scale ranging from 1 ("very different in meaning") to 4 ("very similar in meaning"). Altogether, each participant made 60 recognition ratings using this scale. Three versions of this task, each 15 scenarios, were used across pre-test, post-test and follow-up sessions in a counterbalanced order.

2.3. Web-based computerised interventions

The interventions included CBM-I and C-CBT. They were carried out in six sessions over a six-day period (one session per day) in an alternating order. The positive CBM-I + C-CBT condition received three sessions of positive CBM-I training and three sessions of C-CBT. The active control group received three sessions of neutral CBM-I training and similarly three sessions of C-CBT. Thus, the only difference between the intervention group and the active control group was that in the former participants were exposed to the positive CBM-I training rather than the neutral CBM-I training. Both CBM-I and C-CBT programs were carried out online through a web-based programme.

2.3.1. Positive cognitive bias modification for interpretative biases

CBM-I is a text-based computerised task which aims to train participants during a number of trials to consistently resolve ambiguous social situations in favour of positive outcomes via the completion of

word stems (Mathews & Mackintosh, 2000). Participants in the positive CBM-I group received three 30-min online sessions of CBM-I positive training. In total, 120 passages were used in the training sessions, with each session containing 40 ambiguous scenarios relating to either social interactions or social performance. The passages were presented in four lines individually and participants were instructed to imagine themselves in the situation as if they were actually there. This imagery task is consistent with findings that mental imagery is more effective than verbal training in inducing positive mood (Holmes, Mathews, Dalgleish, & Mackintosh, 2006). The social scenarios were designed to stay emotionally ambiguous until the last word, which was presented as a fragment (e.g. *fri--d-y*). In the positive CBM-I training, this fragmented word would always disambiguate the passage in a positive way (*friendly*). A simple comprehension question was then asked to ensure participants understood the scenarios.

2.3.2. Active control condition (neutral CBM-I)

In this control condition, the passages were identical to those used in the positive CBM-I condition, with the critical exception that the last sentences of these passages did not communicate ambiguous scenarios amenable to positive or negative interpretation. Instead, the social scenarios were all emotionally neutral in tone and ended with a neutral fragmented word followed by a comprehension question (Mobini et al., 2014). Similar to the positive CBM-I condition, participants in this condition completed the C-CBT program.

2.3.3. Computerised cognitive behaviour therapy

Participants in both conditions completed three sessions of C-CBT as part of their online training. This programme was an online extended version of C-CBT used by Mobini et al. (2014). It was originally developed based on self-help CBT guidebooks for social anxiety (Antony & Swinson, 2008; Butler, 2008). The C-CBT for social anxiety was comprised of three main parts presented over three sessions: (1) Psychoeducation about CBT and SAD; (2) Socialising participants to the CBT model of social anxiety and the role of anxiety provoking thoughts, assumptions and core beliefs in causing and maintaining social anxiety; and (3) Overcoming social anxiety using behavioural and cognitive strategies. Each session was designed to be self-directed and interactive. Participants were required to actively interact with the training materials through identifying their negative thinking (e.g. negative automatic thoughts or assumptions) and reflect on how these thoughts or beliefs affect their feelings in social situations. They were taught to link their thoughts, emotions and behaviour using imagery instructions. Participants were instructed to read cognitive distortions with an example for each and asked to identify their own thinking errors. Additionally, some cognitive restructuring strategies to help modify these thoughts were provided. They were taught about maintenance cycle and how avoidant behaviours can reinforce social anxiety. This was followed by discussions about some behavioural strategies and imagery exposure to the social situations. In the final session, participants practised some behavioural strategies (*in vivo* exposure) and cognitive restructuring strategies (e.g. evidence for and against, cost-benefit analysis, alternative explanations) in the session.

In line with face-to-face CBT for social anxiety (Hofmann & Otto, 2008), throughout the sessions participants were encouraged to personalise the materials and complete CBT-based homework (e.g. thought diary, anxiety-provoking hierarchy). Each part ended with a quiz consisting of seven relevant questions for participants to answer. The aim of these quizzes was to encourage participants to concentrate on the training materials and consolidate their learning; in answering these quizzes they were told that it was not an exam. Each training session took approximately 30–40 min to complete.

3. Design

The design of the study was a mixed within and between subjects experimental design. The type of training (positive CBM-I + C-CBT versus neutral CBM-I + C-CBT) was the between-subject factor and measures of interpretative biases, social anxiety, cognitive distortions, and work and social adjustment at three time intervals (pre-test, post-test and two-week follow-up) were within-subject factors.

4. Procedure

The study protocol was approved by the Human Research Ethics Committee at the University of Newcastle, Australia. Potential participants were recruited via posters and through the University's research participation database. We recruited 40 participants out of 59 volunteer students. As the study was advertised for social anxiety, a high proportion of students with social anxiety volunteered for the study. Following the initial contact via e-mail, they were required to read the information sheet and consent form and if they agreed with this information they then completed the SPIN online. They also provided demographic information (age and ethnicity) and whether they were being treated for mental illnesses. Each participant was given a code to log into the online SPIN questionnaire so the researcher could match the participant to relevant information. Eligible participants were then invited to the psychology laboratory where they completed a computerised task (interpretation bias assessment) and self-report questionnaires (CDS and WSAS). Using a computer generated randomisation procedure, participants were assigned into one of the two conditions: the intervention (positive CBM-I + C-CBT) group or the active control (neutral CBM-I and C-CBT) group.

At the end of the first laboratory session participants in both conditions were provided with an information sheet that instructed them to complete six 30-min online intervention sessions over a six-day period (one a day) in an alternating order between CBM-I and C-CBT sessions. The instruction sheets included links to the host websites and recommended dates of online completion for each intervention session. Participants were also provided a unique code to access the online training programme.

After completion of all training sessions, participants returned to the laboratory to complete post-training measures which involved repeating the baseline scales. These measures were also repeated again at a two-week follow-up session in the laboratory. At the follow-up meeting, participants were asked to evaluate the intervention programs and then they were debriefed about the purpose of the study.

5. Apparatus

In the laboratory sessions the interpretation bias assessment was presented using E-prime software on a PC and participants used the keyboard to respond. The first SPIN screening questionnaire was completed and recorded online using the LIMESURVEY programme. The online intervention sessions (both C-CBT and CBM-I) were presented on internet-based web links so participants could access the sessions in their own time. The websites automatically recorded when each session was completed by each participant.

6. Results

Demographic information for each group is depicted in Table 1. The two groups did not differ significantly from each other in terms of age, $F(2, 38) = .19$, $p = .89$ and as shown in Table 1 gender and ethnicity of the participants were evenly distributed across the two groups.

7. Interpretation bias

Participants' recognition ratings of disambiguated versions of the final sentences of the test scenarios were the main measure of interest to show the persistence of any training effects. The mean ratings for each participant were calculated across the four different sentence types: negative target, positive target, negative foil and positive foil. Three bias scores for each participant (pre-test, post-test, two-week follow-up) were calculated by subtracting the mean recognition rating for the negative targets from the mean recognition ratings for the positive targets. This gave each participant three bias scores that could range from −3 to +3, with a negative score indicating less positive and a positive score representing more positive interpretations. Similar bias scores were calculated by subtracting the mean recognition ratings for the negative foils from the mean recognition ratings for the positive foils.

Table 2 summarises the bias scores for target and foil sentences (positive and negative) for both groups at each of the three phases of the study. The means of bias scores were entered into a 2 × 3 × 2 repeated measures ANOVA with Group (intervention, active control) as the between-subject factor and time (pre-test, post-test and two-week follow-up) and sentence type (targets versus foils) as the within-subject factors. The results indicated a significant Group effect, $F(1, 38) = 5.78$, $p = .02$, $\eta^2 = .13$ and a significant three-way (Group × Time × Type) interaction effect, $F(2, 76) = 3.73$, $p < .03$, $\eta^2 = .09$. To follow up this interaction and investigate group differences, the bias change scores were subjected to *post hoc* comparisons using the Fisher's least significant difference. The results showed significant differences for target sentences between the two groups at post-test, $t(2, 76) = 4.12$, $p < .01$, $d = .96$, and at two-week follow-up $t(2, 76) = 3.26$, $p < .01$, $d = .97$. No between-group difference was observed for the targets and foils at pre-test, $t < 1$. Furthermore, no between-group differences were observed for the foils at post-test or follow-up, $t < 1$. These results indicated that, as hypothesised, participants in the positive CBM-I + C-CBT group endorsed positive targets more significantly than participants in the active control group at both post-test and two-week follow-up.

Table 2. Means (M) and standard deviations (SD) of bias scores for the target and foil sentences for each group at pre-test, post-test and two-week follow-up (*N* = 40)

	Positive CBM-I + C-CBT	Neutral CBM-I + C-CBT	*t*(2, 76)	*p*<	*d*
Pre-test					
Targets	−.34 (.78)	−.39 (.58)	.27	.85	–
Foils	.19 (.51)	.10 (.47)	.48	.59	–
Post-test					
Targets	.77 (.74)	.00 (.87)	4.12	.01	.96
Foils	.40 (.37)	.24 (.70)	.85	.36	–
Follow-up					
Targets	.85 (.58)	.20 (.76)	3.26	.01	.97
Foils	.41 (.55)	.34 (.46)	.32	.69	–

Notes: Negative scores represent less positive interpretations of ambiguous social scenarios and positive scores represent more positive interpretations of these scenarios.

d: Between-group Cohen's effect size estimates.

Table 3. Means (M) and standard deviations (SD) of the SPIN, CDS and WASA for each group at pre-test, post-test and two-week follow-up

	Positive CBM- + C-CBT	Neutral CBM-I	*F*(1, 38) + C-CBT	*p*
a) SPIN				
Pre-test	29.60 (7.78)	29.35 (6.79)	.01	.91
Post-test	24.40 (11.69)	26.40 (8.50)	.38	.54
Follow-up	20.95 (8.45)	22.90 (8.17)	.55	.46
b) CDS				
Pre-test	42.11 (16.21)	45.24 (15.70)	.23	.63
Post-test	37.69 (17.07)	42.76 (17.74)	.85	.36
Follow-up	33.95 (15.05)	40.80 (17.52)	1.76	.19
c) WASA				
Pre-test	12.60 (6.81)	13.13 (7.55)	.05	.81
Post-test	9.85 (5.96)	11.95 (7.10)	1.03	.32
Follow-up	8.20 (4.74)	10.15 (7.52)	1.05	.31

8. Social anxiety

The mean SPIN scores (Table 3(a)) were subjected to a two-way (2 × 3) ANOVA with the condition (intervention, active control) as the between-subjects factor and SPIN scores at three times (pre-test, post-test and follow-up) as the within-subjects factor. The results showed a significant time effect, $F(2, 76) = 24.84$, $p < .001$, but no significant effect of Group, $F(1, 38) = .25$, $p = .62$, or Group × Time interaction, $F(2, 76) = .72$, $p = .49$. Additionally, a one-way ANOVA revealed no significant between group differences on the SPIN means at pre-test, post-test and two-week follow-up. These results indicate that there were no significant between-groups differences on the SPIN means after the CBM-I and C-CBT training.

To investigate the significant time effect further, the gain scores were calculated by subtracting the means of SPIN at both post-test and two-week follow-up from the baseline (pre-test). These gain scores are shown in Table 4(a). The gain scores were subjected to one-sample *t*-tests to examine whether mean gain scores from pre-test to post-test and from pre-test to follow-up for each group were significantly different from nil differences, zero point.

The one-sample *t*-tests revealed a significant decrease in mean scores of the SPIN for the positive CBM-I + C-CBT condition from pre-test to post-test, $t(19) = 3.52$, $p < .01$, $d = .79$, and from pre-test to two-week follow-up, $t(19) = 5.11$, $p <.001$, $d = 1.14$. Similarly, the one sample *t*-test showed a significant decrease for the active control group from pre-test to follow-up, $t(19) = 4.63$, $p <.001$, $d = 1.03$, however, this difference only approached significance from pre-test to post-test, $t(19) = 1.99$, $p = .06$. These results indicated that participants in the positive CBM-I + C-CBT condition showed reductions in social anxiety scores at both post-test and two-week follow-up with a moderate and large effect size, respectively. However, this was only significant for the neutral CBM-I + C-CBT condition at two-week follow-up with a large effect size.

9. Cognitive distortions

The mean CDS scores (Table 3(b)) were subjected to a two-way (2 × 3) ANOVA with the intervention and control condition as the between-subjects factor and CDS scores at three times (pre-test, post-test and follow-up) as the within-subjects factor. The results showed a significant time effect, $F(2, 76) = 10.70$, $p < .001$, but no significant effect of Group, $F(1, 38) = .92$, $p = .35$, or Group × Time interaction, $F(2, 76) = 1.55$, $p = .$ Additionally, a one-way ANOVA revealed no significant between group differences on the CDS means at pre-test, post-test and two-week follow-up. These results indicate that there were no significant between-groups differences on the CDS means after the CBM-I and C-CBT training.

Table 4. Means (M) and standard deviation (SD) of the gain scores on the SPIN, CDS and WASA for the two groups (positive CBM-I + C-CBT and neutral CBM-I + C-CBT) from pre-test to post-test and from pre-test to follow-up

	Positive CBM-I + C-CBT	*d*	Neutral CBM-I + C-CBT	*d*
a) SPIN				
Pre-test to Post-test	−5.20** (6.59)	.79	−2.95 (6.64)	–
Pre-test to Follow-up	−8.65*** (7.57)	1.14	−6.45*** (6.24)	1.03
b) CDS				
Pre-test to Post-test	−4.42* (7.83)	.56	−3.23 (8.69)	–
Pre-test to Follow-up	−8.16*** (8.24)	.99	−4.44* (8.59)	.52
c) WASA				
Pre-test to Post-test	−2.75*** (2.86)	.96	−1.17 (2.83)	–
Pre-test to Follow-up	−4.40*** (3.76)	1.17	−2.97*** (3.27)	.91

Note: Cohen's *d* indicates the effect size. Significance levels (*p* values) indicate the differences of each gain score from zero, one-sample *t*-test, two-tailed.

*$p < .05$.

**$p < .01$.

***$p < .001$.

To investigate the significant time effect further, the gain scores were calculated by subtracting the means of CDS at both post-test and two-week follow-up from the baseline (pre-test). These gains scores are shown in Table 4(b). The gain scores were subjected to one-sample *t*-tests to examine whether mean gain scores from pre-test to post-test and from pre-test to follow-up for each group were significantly different from nil differences, zero point.

The one-sample *t*-tests for the intervention group revealed a significant decrease in mean scores of the CDS from pre-test to post-test, $t(19) = 2.52$, $p = .05$, $d = .56$, and from pre-test to follow-up, $t(19) = 4.43$, $p < .001$, $d = .99$. Similarly, a one sample *t*-test showed a significant decrease for the active control group from pre-test to follow-up, $t(19) = 2.06$, $p < .05$, $d = .52$, however, no such difference was observed from pre-test to post-test, $t(19) = 1.66$, $p = .11$. These results indicated that participants in the positive CBM-I + C-CBT condition showed reduction in cognitive distortions scores at both post-test and two-week follow-up with a moderate to larger effect size, respectively. Comparatively, this was only significant for the neutral CBM-I + C-CBT condition at the two-week follow-up with a moderate effect size.

10. Work and social adjustment

The means of the WSAS (Table 3(c)) were subjected to a two-way (2 × 3) ANOVA with the intervention and control conditions as the between-subjects factor and the WSAS scores at three times (pre-test, post-test and follow-up) as the within-subjects factor. The results showed a significant time effect, $F(2, 76) = 35.31$, $p < .001$. However, no significant effect of Group, $F(1, 38) = .57$, $p = .46$, or Group × Time interaction, $F(2, 76) = 1.96$, $p = .15$ was found. Additionally, a one-way ANOVA revealed no significant between group differences on the WSAS means at pre-test, post-test and two-week follow-up. These results indicate that there were no significant between-groups differences on the WSAS means after the CBM-I and C-CBT training.

To investigate the significant time effect further, the gain scores were calculated by subtracting the means of WSAS at both post-test and two-week follow-up from the baseline (pre-test). These gain scores are shown in Table 4(c). The gain scores were subjected to one-sample *t*-tests to examine whether mean gain scores from pre-test to post-test and from pre-test to follow-up for each group were significantly different from nil differences, zero point.

The one-sample *t*-tests for the intervention (positive CBM-I + C-CBT) condition revealed a significant decrease in mean scores of the WSAS from pre-test to post-test, $t(19) = 4.30$, $p < .001$, $d = .96$ and from pre-test to follow-up, $t(19) = 5.23$, $p < .001$, $d = 1.17$. It also demonstrated a significant decrease for the active control (neutral CBM-I + C-CBT) group from pre-test to follow-up, $t(19) = 6.43$, $p < .001$, $d = .91$, however, this difference only approached significance from pre-test to post-test, $t(19) = 1.86$, $p = .08$. These result indicated that participants in the positive CBM-I + C-CBT condition showed a significant improvement in work and social adjustment at both post-test and two-week follow-up with large effect sizes. This was only significant for the neutral CBM-I + C-CBT condition at the two-week follow-up with a large effect size.

11. Participants' awareness and evaluations of CBM-I

After the study was complete, 60 and 50% of participants in the intervention and control conditions, respectively, reported that the aim of the study was to reduce social anxiety. Majority of participants in both groups (90–100%) thought that the aim of C-CBT was to provide psychoeducation about social anxiety and reported the programme was beneficial. Fifty-five per cent of participants in the intervention condition mentioned that CBM-I aimed to train positive interpretations of social situations and the remaining 45% were unsure on what the CBM-I sessions were aiming to achieve. However, only 10% of participants in the neutral CBM-I condition reported positive resolutions of ambiguous scenarios and the remaining 90% were unaware of the purpose of CBM-I. Approximately 45% of the participants in the intervention group reported that CBM-I was beneficial, whereas 65% found it unhelpful and/or irrelevant. Only a quarter of participants in the control training reported CBM-I beneficial, whereas the majority (75%) found it to be unhelpful and/or irrelevant.

12. Discussion

Cognitive models of social anxiety propose that socially anxious individuals have cognitive vulnerability to social anxiety due to negative information processing biases (see Clark & McManus, 2002; Heinrichs & Hofmann, 2001; Hirsch & Clark, 2004 for reviews). One can assume that reducing cognitive vulnerability through modifying negative interpretative biases can reduce social anxiety symptoms. Previous research findings indicate that, in fact, it is possible to modify negative interpretation biases and reduce social anxiety through CBM-I positive training and C-CBT (e.g. Beard & Amir, 2008; Bowler et al., 2012; Khalili-Torghabeh et al., 2014; Mobini et al., 2014). Thus, the main aim of this study was to examine whether combining CBM-I positive training with C-CBT would produce enhanced positive effects on interpretative biases and social anxiety.

The results revealed that following the training sessions in both conditions socially anxious participants endorsed less negative interpretations of ambiguous social situations. However, the fact that participants in the positive CBM-I + C-CBT condition endorsed positive targets more than those in the neutral CBM-I + C-CBT condition suggests that providing positive CBM-I training considerably enhanced the positive effects on interpretative biases as compared to C-CBT alone. The finding that positive CBM-I facilitated positive interpretations of ambiguous scenarios is in line with previous research findings (e.g. Beard & Amir, 2008; Khalili-Torghabeh et al., 2014; Mobini et al., 2014; Murphy et al., 2007). Furthermore, the CBM-I induced positive changes in interpretative biases at two-week follow-up is in line with the results reported by previous studies suggesting these positive changes are sustainable beyond the training sessions at one-week (Mobini et al., 2014) and seven-week follow-ups (Khalili-Torghabeh et al., 2014).

Although majority (65%) of participants in the positive CBM-I + C-CBT condition expressed that they found CBM-I irrelevant and/or unhelpful, such opinions do not seem to prevent positive CBM-I changes. This is an interesting finding as it suggests that CBM-I can have positive effects even though participants may not necessarily find the programme helpful or relevant. This is consistent with the view that because CBM-I targets more habitual and automatic processing, participants may not have consciously realised the positive CBM-I effects (MacLeod & Mathews, 2012).

The results also showed that both the positive CBM-I + C-CBT training and neutral CBM-I + C-CBT training reduced social anxiety, however, larger effect sizes observed in the intervention group indicate that adding positive CBM-I to C-CBT enhanced the training effects on social anxiety (d = .79 and 1.14). The finding that both CBM-I and C-CBT reduced social anxiety is consistent with the previous findings (Beard & Amir, 2008; Khalili-Torghabeh et al., 2014; Mobini et al., 2014). However, it should be noted that despite reductions in the social anxiety scores in both conditions after the training the SPIN means still remained above the clinical cut-off point (>19). This suggests that a longer period of training sessions is possibly needed to produce greater effects on social anxiety symptoms.

One of the innovative aspects of this research was to examine whether changes in negative interpretation biases would result in reductions in cognitive distortions and social and work adjustment. The fact that we did not observe any group by CDS or WSAS interaction effect indicates no significant between-group differences on these measures after training. This suggests that participants in both groups showed reduction in negative thinking (cognitive distortions) and improvements in work and social adjustment. However, the larger effect sizes observed in the positive CBM-I + C-CBT group implies that adding positive CBM-I to C-CBT enhanced the training effects on modifying cognitive distortions (d = .56 and .99) and improving work and social adjustment (d = .99 and 1.17) in socially anxious participants.

Given the findings of the present study, it is important for future CBM-I research to pursue new directions in light of some limitations. One of the methodological limitations of this study was that participants in the control condition received C-CBT as an active treatment. Therefore, the future research should include a control group with no interventions (e.g. a waiting-list or placebo control).

Moreover, as this study used a non-clinical sample of socially anxious students as participants, the future research should replicate this study in clinical trials and investigate the clinical effectiveness of these interventions.

Despite aforementioned limitations, the present study is the first research to examine the effectiveness of an adjunctive computerised treatment using C-CBT and positive CBM-I training in social anxiety. Furthermore, this is the first study which examined the effects of CBM-I training on cognitive distortions and work and social adjustment in social anxiety. The present study also had the advantage of delivering CBM-I through a web-based online method. To our knowledge, there is only one other study which delivered CBM-I online (Salemink et al., 2014). Overall, the findings of present study imply that it is possible to combine two computer-based interventions which can be delivered via a web-based programme. This allows participants to access the programs from home and complete these psychological interventions on their own time.

13. Conclusion

In conclusion, the results provide evidence that a combined positive CBM-I + C-CBT programme reduced negative interpretations of ambiguous situations more than the neutral CBM-I + C-CBT condition. Moreover, it seems that adding positive CBM-I to C-CBT produced greater effect sizes indicating enhanced positive effects on social anxiety, cognitive distortions, and social and work adjustment as compared to the neutral CBM-I + C-CBT condition. However, a RCT over a longer period of time is needed to determine the clinical effectiveness of a combined positive CBM-I + C-CBT programme as a treatment for social anxiety.

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