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Reducing negative interpretations in adolescents with anxiety disorders: A preliminary study investigating the effects of a single session of cognitive bias modification training

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ABSTRACT

Anxiety disorders are globally prevalent, debilitating and onset in early life. Cognitive bias modification of interpretations (CBM-I) training has emerged as a targeted intervention for early emerging anxiety problems. While CBM-I can alter interpretational styles in unselected and clinical-analogue samples of adolescents, no studies have assessed its capacity to change biases in clinical samples. Here, we assessed training efficacy in ameliorating interpretation biases and anxious mood in adolescents with anxiety disorders. Twenty-eight Chinese adolescents meeting criteria for a current anxiety disorder were randomly assigned to receive positive or neutral CBM-I training. Training involved completing a word-fragment to resolve the outcomes of sixty ambiguous scenarios. During positive training, scenarios ended with benign/positive resolutions, but during neutral training, half of the scenarios were resolved positively and half negatively. Positively trained patients interpreted new ambiguous scenarios less negatively than the neutral training group although training effects were not observed on a questionnaire measure of interpretation bias. Training effects on mood were also absent. Before the clinical implications of CBM-I can be considered in adolescents, research needs to establish optimal training parameters for symptom-changes to occur.

1. Introduction

Anxiety disorders are prevalent and debilitating in youth in both Western (Merikangas et al., 2010) and non-Western societies (Li et al., 2008). Yet current front-line treatments of child and adolescent anxiety, such as cognitive behavioural therapy (CBT) yield highly variable outcomes (James et al., 2005) and have limited accessibility (Gunter and Whittal, 2010; Yin et al., 2009). Discovering innovative interventive tools that are appropriate for use in adolescents is therefore imperative. New therapeutic strategies should also preferably be easily deliverable and globally accessible.

Cognitive Bias Modification of Interpretations training (CBM-I) is grounded in data from developmental cognitive science showing that child and adolescent anxiety problems are associated with the tendency to draw threat-related interpretations of ambiguous materials (see Lau et al., 2012b for review). Research using different measures of interpretational style shows that anxious children and adolescents draw more negative meanings from ambiguous vignettes (e.g. Bögels and Zigterman, 2000) and

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endorse more threatening interpretations of homophones and homographs (e.g. Hadwin et al., 1997; Taghavi et al., 2000) – words that have both a neutral and threatening meaning (e.g. mug, which can be defined as a cup or being robbed) – compared to their less anxious counterparts. Youth with high levels of anxiety are also faster at making these negative interpretations (e.g. Muris et al., 2000). Combining this understanding with experimental medicine techniques, CBM-I training targets this interpretative selectivity through simple learning mechanisms, and have demonstrated that in unselected and clinical adult samples, these biases are plastic (Beard, 2011; MacLeod and Mathews, 2012). During CBM-I training, participants read scenarios describing everyday social and non-social situations. At the end of each vignette, participants complete a word fragment. Word completion resolves the ambiguity of the scenario in a benign/positive or negative direction. The direction of interpretation is reinforced by a comprehension question and can only be answered correctly if the participant has interpreted the situation in the intended direction.

CBM-I was first designed to investigate causality between negative interpretative styles and anxiety in non-anxious adults. Data supported cognitive theories that negative interpretations preceded symptoms (e.g. Mathews and Mackintosh, 2000; Salemink et al., 2007; Yiend et al., 2005), suggesting that these biases may be involved in the genesis and maintenance of anxiety problems. However, recent attention has turned to the effectiveness of positive CBM-I in the resolution of anxiety pathology (Beard, 2011). Promising evidence revealed that a single session of CBM-I reduced worry frequency in adults with generalized anxiety disorder (Hayes et al., 2010). Multisession CBM-I also showed enduring efficacy in ameliorating symptoms in socially anxious adults (Amir and Taylor, 2012).

Extending these studies to youth has revealed that: (a) negative training can also induce interpretation biases, leading to reductions of positive mood (Lau et al., 2011; Lothmann et al., 2011) and (b) positive CBM-I can increase resistance to stress, perhaps by generating more benign interpretative styles (Lau et al., 2012a). An emergent question is whether these interventions are effective in clinically anxious adolescents. Studying this population is indispensable, as many anxiety disorders have their roots in adolescence. Additionally, compare to adults and children, they experience unique neural, cognitive and environmental changes (Somerville et al., 2010), which may serve to moderate the benefits of CBM-I.

Despite these reasons, CBM-I research of symptomatic youth lag behind. Promising results have been reported with prepubescent children with high levels of social anxiety but using somewhat different training paradigms to those of adults (e.g. Vassilopoulos et al., 2009). One unresolved question is whether CBM-I could improve more deeply entrenched interpretation biases in adolescents meeting diagnostic criteria of anxiety disorders, and given their higher anxiety level, whether the training methods would be effective in producing instant improvements in their mood. Adult data tentatively suggest that individuals with clinical symptoms of anxiety may benefit more from such cognitive manipulations (Hakamata et al., 2010; Hallion and Ruscio, 2011).

To address this gap, the present study, for the first time, investigated the effectiveness of positive CBM-I training in altering interpretative styles, and consequently, improving negative mood in adolescents diagnosed with anxiety disorders. Consistent with existing CBM-I studies of adults and adolescents, we assessed post-training interpretative styles using the Interpretation Bias Test, which presented participants with novel vignettes (not viewed during training) unresolved for ambiguity. Participants were then given valenced "targets" to rate for familiarity to the original ambiguous scenarios. As these targets correspond to positive and negative interpretations of the ambiguous scenarios respectively, higher ratings to the positive targets reflect the endorsement of positive interpretations. However given this "surprise" recognition phase, it is difficult to administer the test at both pre- and post-training without affecting the validity of the latter assessment. Hence, we complemented this outcome measure by including a secondary questionnaire measure of interpretation biases – where multiple administrations were unlikely to affect its validity. Of note, post-training measures of interpretational style are mostly administered following a "filler" task, designed to neutralize any between-group mood differences that have emerged following training. This is a necessary step to disentangle the hypothesized effects – that mood alters as a result of training-induced changes in cognitive style from an alternative possibility – that differences in cognitive style simply reflect a mood induction effect following training. If CBM-I altered interpretative style, which then caused changes in anxiety, one would expect to see differences on interpretational style measures, even without mood differences.

Taken together, the aim of the present study was to assess the effects of CBM-I training on interpretation biases and mood in adolescents meeting diagnostic criteria of anxiety disorders. It was hypothesized that the positive CBM-I would reduce adolescents' tendency to endorse negative interpretations of ambiguous social scenarios compared to the neutral training. Moreover, positively trained patients, but not the neutral group, would show significant training-induced changes in interpretation biases and mood from pre- to post-training.

2. Method

2.1. Participants

This study recruited 28 adolescents (aged 12–17 years; mean = 14.5 years, SD = 1.75; 53.6% females; 100% Han Chinese, Table 1) who presented with a primary diagnosis of generalized anxiety disorder (60.7%) and/or social anxiety disorder (39.3%) at the Shanghai Mental Health Centre (SMHC). Diagnoses were determined by trained psychiatrists using the Chinese version of the Mini International Neuropsychiatric Interview for Children and Adolescents 5.0 (MINI Kid, Sheehan et al., 2006) which relies on DSM-IV criteria (American Psychiatric Association, 1994). All participants also scored above 23 on the Chinese version of the Screen for Child Anxiety Related Emotional Disorders

Table 1
Participant characteristics and training performance indices.

	Means (SDs)	
	Positive CBM-I	Neutral CBM-I
Demographics		
Sample size	16	12
Age	14.8 (1.8)	14.1 (1.68)
% Female	50	58.3
SCARED score	40.9 (8.95)	42.2 (9.17)
Training performance		
Word fragment RT (ms)	**8405 (2370.5)**	**10095.6 (1853.9)***
% Comprehension questions correct	90.2 (7.62)	90.7 (6.87)
Comprehension question RT (ms)	3240.1 (759.6)	3521.3 (979.1)

* $p = 0.05$.

Table 2
Clinical characteristics of adolescents received diagnoses of anxiety disorders.

	Primary diagnoses	
	Generalized anxiety disorder ($N = 17$)	Social anxiety disorder ($N = 11$)
Co-morbid diagnoses (%)		
Generalized anxiety disorder	17 (60.7)	3 (10.7)
Social anxiety disorder	5 (17.9)	11 (39.3)
Separation anxiety disorder	0 (0)	2 (7.14)
Major depressive disorder	4 (14.3)	3 (10.7)

(SCARED, Birmaher et al., 1997; Wang, 2005) using an average score from self and parent reports (mean score: 41.5, SD = 8.9). The cut-off score of 23 represented the top 20% of a sample of 2019 healthy children from 14 major cities of China (Wang, 2005).

We excluded patients with concurrent obsessive–compulsive disorder, Tourette's syndrome, mania, psychosis, and/or an IQ < 70. The numbers of patients meeting criteria for a secondary anxiety or depression diagnosis are presented in Table 2. All participants were native Mandarin Chinese speakers who reported no reading difficulties. Ethical approval was granted by the Ethics Committees of the SMHC. Adolescents provided written consents, and signed consent forms were obtained from parents of adolescents under 16 years old. Participants were randomly allocated to receive positive CBM-I ($n = 16$) or neutral CBM-I ($n = 12$) (Table 1). Training groups did not differ significantly in terms of age, gender, and SCARED score ($ps > 0.05$; Table 1).

2.2. Overall procedures

The overall procedures (Fig. 1) followed previous studies from our group (Lau et al., 2012a; Lothmann et al., 2011). Participants were briefed about the tasks procedures and requirements but not the purpose or potential benefits of the training.

To ensure that there were no baseline differences between adolescents in each training condition, participants completed a pre-training questionnaire measure of interpretative style and rated various mood-states using simple Visual Analogue Scales (VASs). To enhance the effects of CBM-I training, participants were instructed to imagine "through their mind's eye" that the training scenarios were happening to themselves (Holmes et al., 2009). To facilitate this, participants were given two visual imagery exercises before training. After training, participants again completed VASs, to assess immediate effects of training on negative and positive mood-states. This was followed by a 10-min picture filler task, administered to remove possible group differences in mood that might arise from training, thus avoiding confounding any training-related effects on interpretative style (Mathews and Mackintosh, 2000). To verify that there were indeed no group differences in mood, a third set of VASs was administered. An Interpretative Style Test consistent with all of our previous studies and those of adult studies (Mathews and Mackintosh, 2000) was administered to examine training effect on interpretation biases. Given the format of this assessment, it was difficult to administer this measure twice (i.e. at pre-training and post-training) without compromising the validity of the post-training score. We also selected an additional measure that was procedurally different from the training and test paradigms: the Interpretative Style Questionnaire, which was administered at pre- and post-training to assess changes in interpretative style on the *same* measure (but with different items). Participants were debriefed at the end of the study. All tasks were run on a laptop computer using E-Prime 2.0 (Psychology Software Tools, 2007). Translation of measures into Chinese was done by Chinese-English bilingual researchers. These were piloted in three adolescent patients to confirm their readability, relevance, and age appropriateness.

2.3. Measures

Assessment of mood changes: Twelve VASs were used to assess mood at three time-points of the experiment (T1–T3). Eight items for negative mood (nervous, sad, upset, worried, anxious, miserable, scared, and gloomy) and four items measuring positive mood (happy, calm, cheerful, and energetic) were taken from the Positive and Negative Affect Scales for children (PANAS-C, Laurent et al., 1999) to make up the completed VASs. Adolescents reported how much of each emotion they were feeling at

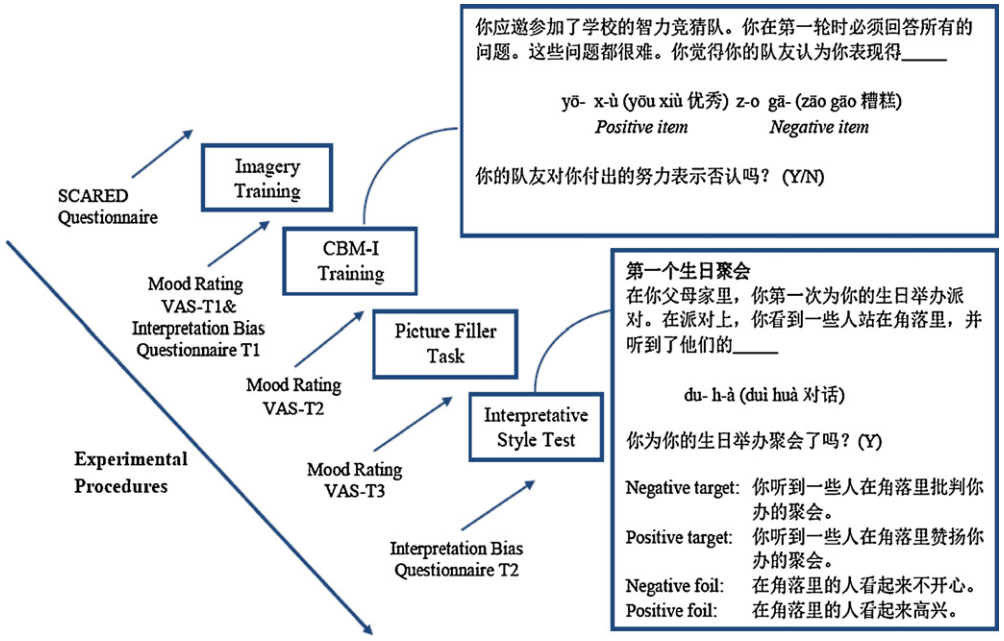

Fig. 1. Overview of experimental procedures. *Note*: An example of training scenario is (Chinese translation is presented in the figure): "You are persuaded to join the school quiz team. During the first round you must answer all the questions. The questions are hard and you feel that your team mates found your performance ____." Pinyin fragment "yō- x-ù (strong)" was provided for the positive item, and "z-o gā- (weak)" was provided for the negative item. The subsequent comprehension question was: "Do your team mates feel negative about your efforts?" The correct answer for positively trained adolescents was "No" while for negatively trained adolescents "Yes" was the correct answer. The test scenario "You are organizing your first real party for your birthday at your parents' basement. At the party, you see some people in the corner and hear them ___ (du- h-à, talking)" was presented under the title "First birthday party". The comprehension question was "Did you organize a party for your birthday? (Yes)". The following four statements were: "You hear some people in the corner praising the party (positive target); you hear some people in the corner criticizing the party (negative target); the people in the corner are looking pleased (positive foil); the people in the corner are looking miserable (negative foil). CBM-I = cognitive bias modification of interpretations training; SCARED = Screen for Child Anxiety Related Emotional Disorders; VAS = visual analogue scales; T1 = time 1; T2 = time 2; T3 = time 3.

that moment by marking on a line between "not (emotion) at all" (0 mm) and "very (emotion)" (100 mm).

2.4. CBM-I training task

The Chinese version of CBM-I was adapted from the training paradigm previously used in adolescents (Lothmann et al., 2011), drawing on age-typical scenarios relating to social concerns (within interpersonal relationships) or non-social worries (about educational and sport/recreational achievements). Roughly half of the items were social and the other half non-social. Minor modifications were made to increase the relevance of vignettes to Chinese adolescents.

The training session contained 60 trials presented in 5 blocks of 12 items. A practice trial was also administered. At the beginning of each block, participants were reminded to imagine situations as if they were happening to themselves. Each trial presented an ambiguous situation followed by a word fragment that completed the scenario. Participants were instructed to identify the word from the fragment as quickly as possible by typing in the first missing letter. The programme did not proceed until the participant had typed in the correct letter. Completing this fragment resolved the ambiguity of the scenario, giving positive, negative or neutral valence to the situation. In the Chinese version, the scenario was described using Chinese characters, while the word fragment was presented using Pinyin. Pinyin denotes the pronunciation of Mandarin Chinese, and is used as a linguistic system to transcribe the logographic form of Chinese into Roman alphabets (Snowling and Hulme, 2005). An example of one scenario was "You are persuaded to join the school quiz team. During the first round you must answer all the questions. The questions are hard and you feel that your team mates found your performance ____." Pinyin fragment "yō- x-ù (strong)" was provided for the positive item, and "z-o gā- (weak)" was provided for the negative item. Upon successful completion of the fragment, participants were required to respond to a comprehension question as quickly and accurately as possible by entering "Y" (for "yes") or "N" (for "no"). In this example, it was "Do your team mates feel negative about your efforts? ("N" for positive training and "Y" for negative condition)" The question could only be answered correctly if the participant has interpreted the situation according to its emotional implications. "Correct" or "Wrong" feedback followed. An example of the Chinese version of the training task is shown in Fig. 1.

In each block, participants in the positive training group received ten scenarios, which were resolved positively, one scenario that was resolved negatively and one scenario in which resolution resulted in a neutral description. Inclusion of training-incongruent and neutral items masked the purpose of training. Participants in the neutral training

group completed five positively valenced, five negatively valenced, and two neutral scenarios in each block. For both training conditions, one negative scenario and one positive scenario in each block were used as probes for comparing across training conditions. Specifically, reaction times (RTs) and accuracy to these probe items were analysed across groups to provide an assessment of training performance and an indirect measure of interpretative style. Of note, scenarios across training conditions were the same but scenarios in each block were presented randomly across participants.

2.5. Picture filler task

Participants viewed and rated the pleasantness of 60 non-emotional pictures on a scale between "very unpleasant" and "very pleasant" by typing in the number "1" to "9". Unrelated filler tasks were used to assuage positive or negative mood that might arise from generating benign or negative interpretations during training (Mathews and Mackintosh, 2000).

2.6. Post-training test of interpretative style

This measure comprised two parts. First, participants viewed 10 ambiguous social scenarios, each containing a title. Similar to training, these scenarios were also followed by completion of a Pinyin word fragment. Unlike training scenarios, completing the Pinyin fragments did not disambiguate the situations. The subsequent comprehension questions also had no reference to the emotional content of the vignettes. For example, under the title of "First birthday party", the scenario was "You are organizing your first real party for your birthday at your parents' basement. At the party, you see some people in the corner and hear them ___ (du- h-à, talking). The participant was then immediately asked "Did you organize a party for your birthday? (Yes)".

Second, the title of the previously displayed scenario was presented, followed by four statements resembling the scenario. Two of the sentences were "targets", conveying either a positive or a negative interpretation of the story. For example, a positive target was "You hear some people in the corner praising the party". "Praising" was substituted by "criticizing" for the negative target. The other two were "foils", which were positively and negatively valenced sentences but did not contain an interpretation of the previously viewed scenario (e.g. positive: "The people in the corner are looking pleased"; negative: "The people in the corner are looking miserable". Presentations of the four statements were randomized. Participants were asked to rate, using a four-point scale, how similar each statement was to the scenario presented in the first part (1 = not similar at all; 4 = very similar). Higher similarity ratings to positive targets versus negative targets indicate a more positive interpretative style. The foils were included to assess whether training induced a general response bias towards valenced sentences (Mathews and Mackintosh, 2000). The Interpretative Style Test showed high internal consistency (Cronbach's $\alpha = 0.81$).

2.7. Assessment of change in interpretative style

A 26-item Interpretation Bias Questionnaire was modified from an adult questionnaire (Stopa and Clark, 2000). Items consisted of vignettes describing ambiguous social and non-social scenarios (e.g. "You walk past a group of tourists and they start laughing" or "You reach for your wallet and cannot find it. What has happened to it?"). These were followed by three alternative interpretations, with one always being negative and two were benign (neutral and positive). Participants were asked to select the most likely explanation for the situation. The number of negative interpretations selected was summed. Thus, higher scores indicate a more negative interpretative style. Half of the items were completed before training and the other half completed post-training. Both halves had moderate internal consistency (Time One: Cronbach's $\alpha = 0.5$; Time Two: Cronbach's $\alpha = 0.66$). Scores across time-points were significantly correlated ($r = 0.46$, $p < 0.05$).

2.8. Statistical analyses

All statistical analyses were performed using PASW Statistics 18. Log-transformed data were used wherever assumptions of normality were violated.

In analyses of training performance, we compared adolescents receiving positive and neutral CBM-I on RTs to completing word fragments and RTs and errors to comprehension questions of positive versus negative probed items, using three mixed design 2×2 analyses of variance (ANOVA) models. These analyses followed those of Salemink and Wiers (2011) and can be used to support training efficacy.

Our second set of analysis assessed training effects on data from the Interpretation Bias Test using a sentence-type (target, foil) × sentence-valence (positive, negative) × training-condition (positive, neutral) mixed design ANOVA on similarity ratings. Of note, although the three-way interaction was not significant ($p > 0.05$), given prior data and a priori hypotheses, we nevertheless applied a sentence-valence-by-training-condition mixed design ANOVA to target and foil ratings separately (Lothmann et al., 2011).

Third, to assess whether training differentially changed interpretative style as measured by the questionnaires, a 2×2 mixed design ANOVA with one within-subjects factor (time: pre-training vs. post-training) and one between-subjects factor (training condition: positive, neutral) was performed on questionnaire scores.

Fourth, training-induced mood changes were examined using a time (pre-training, post-training) × training condition (positive, neutral) mixed design ANOVA, conducted separately for negative and positive mood (Lothmann et al., 2011). Independent samples *t*-tests were also conducted for positive and negative mood prior to completion of both measures of interpretative style (Fig. 1) to examine whether there were remaining mood differences between training groups that would confound assessment of interpretative style.

Significant interaction effects were followed up by using two-tailed paired- or independent-samples *t*-tests.

Effect sizes of within- and between-group differences were presented using Cohen's *d*. All analyses were conducted first without gender, age and training performance as covariates, and then repeated with inclusion of each variable at a time to see if these changed the pattern of results.

3. Results

3.1. Differences in training performance across training conditions

RTs to complete word fragments and comprehension questions were excluded for incorrect responses to comprehension questions (10.6%). Mean RT and accuracy data across training and probe scenarios in five blocks are displayed in Table 1. Since the positive training group was faster than the neutral group in completing Pinyin fragments ($t(26) = 2.04$, $p = 0.05$), RTs to word completion were included as a covariate in subsequent analyses of training effects on our various outcome measures.

For *RTs to word fragment completion*, data from one participant (female, positive) was excluded as an outlier (RTs > mean + 2SD). A probe-valence (positive, negative) × training-condition (positive, neutral training) mixed ANOVA on log-transformed data revealed a marginally significant probe-valence-by-training-condition interaction only ($F(1,25) = 3.62$, $p = 0.069$, $\eta^2 = 0.126$). Positively trained patients were faster in completing positive probe word fragments than negative ones ($t(14) = 2.46$, $p < 0.05$, $d = 0.723$), but there was no difference between positive and negative probes in the neutral training group ($p > 0.05$).

For *performance accuracy on comprehension questions*, a significant probe-valence-by-training-condition interaction emerged ($F(1,26) = 7.73$, $p = 0.01$, $\eta^2 = 0.229$). Patients who received neutral training were less accurate in responding to comprehension questions for the positive probe scenarios than those for the negative ones ($t(11) = 3.32$, $p < 0.01$, $d = 1.23$). They were also more accurate in answering comprehension questions for the negative probe scenarios than the positively trained patients ($t(16.6) = 3.19$, $p < 0.01$, $d = 1.08$). No significant main effects were found ($ps > 0.05$).

For *RTs to comprehension questions*, two outliers (female, neutral; male, positive) were removed from the analysis (RTs > mean + 2SD). There was a significant main effect of probe valence ($F(1,24) = 5.86$, $p = 0.05$, $\eta^2 = 0.196$), indicating that the participants across both training groups were faster to respond to comprehension questions for negative probe scenarios than positive probe scenarios ($Mean_{Positive} = 3.47$, $SD_{Positive} = 0.143$; $Mean_{Negative} = 3.38$, $SD_{Negative} = 0.146$). No other significant main or interaction effects were found ($ps > 0.05$).

The effects of training conditions on performance on probe scenarios did not change when include age and gender as covariates.

3.2. Training effects on the post-training measure of interpretation bias

For *targets*, data from one participant (female; neutral training) was excluded as an outlier (similarity ratings for positive items < mean − 2SD). The 2 (positive, negative sentences) × 2 (positive, neutral training) mixed ANOVA revealed a significant main effect of sentence-valence ($F(1,25) = 40.2$, $p < 0.001$, $\eta^2 = 0.616$) but this was qualified by a significant sentence-valence-by-training-condition interaction ($F(1,25) = 5.16$, $p < 0.05$, $\eta^2 = 0.171$, Fig. 2). While both training groups assigned higher similarity ratings to positive than negative targets (Positive: $t(15) = 6.64$, $p < 0.001$; Neutral: $t(10) = 2.71$, $p < 0.05$), this effect was larger in the positive-trained group ($d = 2.64$) than in the neutral-trained group ($d = 1.27$). Although the training groups did not show significant differences in their endorsement of the positive targets ($p > 0.05$), positively trained patients perceived negative targets as less similar to the ambiguous testing scenarios than those who received neutral training ($t(25) = 3.19$, $p < 0.01$, $d = 1.26$). Of note, including age, gender, or RTs to Pinyin completions as covariates did not change the pattern of results.

For *foils*, data from one adolescent (male; positive) was excluded as an outlier (similarity ratings for negative sentences > mean + 2SD). The sentence-valence (positive, negative) × training-condition (positive, neutral) mixed ANOVA displayed a significant main effect of sentence-valence ($F(1,25) = 32.4$, $p < 0.001$, $\eta^2 = 0.565$). The sentence-valence-by-training-condition interaction was marginally significant ($F(1,25) = 3.64$, $p = 0.068$, $\eta^2 = 0.127$). Again, both training groups perceived positive foils as more similar to the test scenarios than the negative ones (Positive: $t(14) = 5.72$, $p < 0.001$; Neutral: $t(11) = 2.53$, $p < 0.05$), but the effect was smaller in the neutral than the positive training condition ($d_{positive} = 2$; $d_{neutral} = 0.83$). There were no significant differences between training groups in negative or positive foil ratings ($ps > 0.05$). The result patterns did not change when age, gender, or mean word completion RTs were entered as covariates.

3.3. Training effects on changes in interpretation bias questionnaire

A time (pre-training, post-training) × training condition (positive, neutral) mixed ANOVA conducted on log-transformed interpretative style scores found no significant main or interaction effects (Table 3), with age, gender, and RTs to Pinyin completion included as covariates.

3.4. Changes in mood measures

Ratings of negative and positive mood at each time point are presented in (Table 3). Data were log transformed before analysis. Independent samples *t*-tests conducted for negative and positive mood at T3 revealed no significant mood differences between training groups (all $ps > 0.05$). In examining training-induced mood changes, a time (pre-training, post-training) × training-condition (positive, neutral) mixed ANOVA revealed a significant main effect of time ($F(1,26) = 5.21$, $p < 0.05$, $\eta^2 = 0.167$), suggesting that *negative mood* reduced from pre- to post-training across both training groups ($Mean_{T1} = 2.33$, $SD_{T1} = 0.411$; $Mean_{T2} = 2.16$, $SD_{T2} = 0.475$). For *positive mood*, there were no significant main or interaction effects

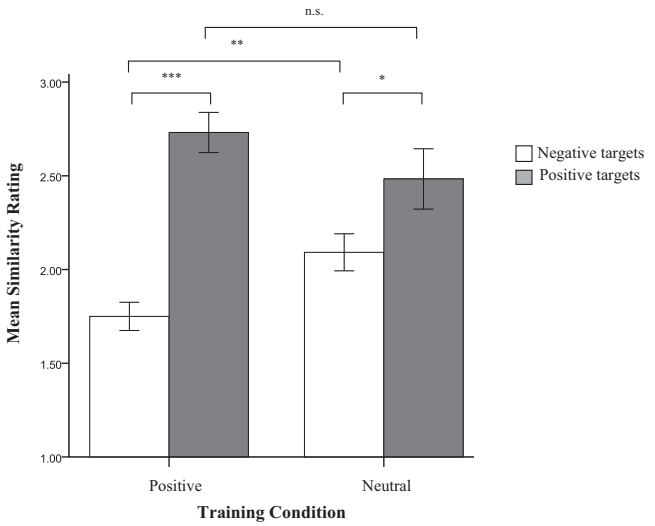

Fig. 2. Similarity ratings assigned to positive and negative targets by positive and neutral training groups in the post-training Interpretative Style Test. Higher ratings represented greater similarity of the description to the ambiguous test scenario. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$, n.s. = non-significant. Error bars: ±1 standard error.

Table 3
Scores on Interpretation Bias Questionnaires pre- (Q1) and post-training (Q2) and negative and positive mood rated before training (T1), after training (T2), and before testing (T3).

	Means (SDs)[a]				
	Q1	Q2	T1	T2	T3
Positive CBM-I	0.525 (0.155)	0.47 (0.253)			
Negative mood			**2.35 (0.352)**	**2.24 (0.295)**	2.17 (0.413)
Positive mood			2.36 (0.131)	2.37 (0.104)	2.35 (0.164)
Neutral CBM-I	0.505 (0.322)	0.493 (0.332)			
Negative mood			**2.3 (0.493)**	**2.05 (0.641)**[*]	1.92 (0.674)
Positive mood			2.29 (0.124)	2.3 (0.155)	2.31 (0.137)

[a] Log-transformed data were used for data analyses. For interpretation bias scores, higher values represent greater number of negative interpretations made to the social scenarios. Mood ratings were evaluated in millimetres on visual analogue scales. Higher values represent more intense mood.
[*] Negative mood declined from T1 to T2 across all participants ($p < 0.05$).

revealed. Neither set of results varied when gender, age, or RTs to Pinyin completion were included as covariates.

4. Discussion

This study is the first to assess the efficacy of CBM-I – a training technique grounded in developmental cognitive science data – in adolescents with clinically significant anxiety. Consistent with results in clinically anxious adults (e.g. Amir and Taylor, 2012; Hayes et al., 2010), positively trained patients interpreted ambiguous scenarios in the post-training Interpretative Style Test less negatively than those in the neutral condition (although training group did not affect ratings of positive targets). During training, those receiving positive training were significantly faster to solve Pinyin fragments providing training-congruent (i.e. positive) resolutions than they were at training-incongruent (i.e. negative) resolutions of ambiguous scenarios. This difference did not characterize those receiving neutral training. Positively trained patients also made more errors to comprehension questions following training-incongruent items compared to the neutral group. Although positive CBM-I, through its repeated presentations of benign interpretations, was effective in producing adaptive interpretational styles in adolescents with more severe anxiety, they need to be interpreted with caution, as training-induced alterations on interpretation bias questionnaire scores and mood were not observed.

Our data suggest that targeting early emerging interpretative styles in clinically anxious youth may be viable. Targeted interventions may be especially fruitful during adolescence. Adolescence may on the one hand be a developmentally sensitive period of protracted brain maturation and associated plasticity (Casey et al., 2005), but on the other, a period in which long-term trajectories can be laid down. Thus, information-processing biases may be particularly plastic but are also known to produce persisting emotional perturbations in the absence of change (Leonardo and Hen, 2008). In particular, biased interpretations of social situations can cast negative effects on how young people frame their subsequent behaviours, resulting in a cyclical process that leads to more deeply embedded biases (Crick and Dodge, 1994). CBM-I provides extensive exposure of benign interpretations of social information, which in turn may induce an automatic learned positive bias (Hoppitt et al., 2010). Intriguingly, this type of

reinforcement-learning is not dissimilar to the learning processes by which children and adolescents acquire negative cognitions in the first place. Indeed, children and adolescents may model the cognitive styles of their anxious parents, thus vicariously learning threat biases (Lester et al., 2010). Over time, these biases may become habitual. Using a similar learning process of constructing a habitual interpretative style during a developmentally sensitive juncture, CBM-I training might alter the trajectory of pathological development and provide longer lasting benefits for adolescents.

However, several issues call for further investigation. First, it is unclear whether training impacted interpretational styles specifically or if they created a more general training-congruent response bias. Data from the Interpretation Bias Test showed no 3-way interaction, suggesting that the differential training effects on positive and negative sentences did not vary between targets and foils. Although these findings suggest more general training effects, post hoc *t*-tests suggested important training differences: significant between-training-group difference only emerged to negative targets but not negative foils, suggesting some specific effects of training on interpretations. Secondly, training manipulation did not change patients' interpretation biases from pre- to post-training as measured by the Interpretation Bias Questionnaires. Although the discrepancy in results obtained using the two measures of interpretative styles is not unprecedented (Salemink et al., 2007, 2009), as the post-training test is procedurally similar to the training tasks, the generalizability of the modified interpretative styles should be inferred with caution.

It was disappointing but perhaps not surprising to find an absence of training-induced changes in negative or positive mood. This could be because our simple visual analogue measure of mood was too crude, and future studies may wish to adopt more sensitive measures of symptoms. Prior evidence with typically developing adolescents has been mixed regarding to the training effects on mood: while some supportive findings have emerged (Lau et al., 2011; Lothmann et al., 2011), these have generally been inconsistent (Salemink and Wiers, 2011). Positive CBM-I may not directly impact mood, but instead, according to diathesis-stress theories, may reduce emotional vulnerability when encountering stressful events (Hallion and Ruscio, 2011). This conceptualization is supported by studies with healthy adults and adolescents adopting various experimental stressors (e.g. Lau et al., 2012a; Murphy et al., 2007) and should be considered for use, under carefully controlled, ethically appropriate conditions in studies of clinically anxious adolescents. Another possibility is that for mood to change, repeated training sessions may be necessary. Previous studies that successfully modified interpretation biases and symptoms administered multiple training sessions for an extended period of time (Amir and Taylor, 2012; Vassilopoulos et al., 2009). It is crucial for future research to introduce multisession training to determine the optimal dosage of CBM-I for clinically anxious adolescents (Beard, 2011).

Another possibility for weaker training effects in our study may relate to our control training condition, designed based on prior adult studies (e.g. Steinman and Teachman, 2010) to create a 'neutral' group upon which to compare the positive-training group results against. However, whether presentation of equal numbers of positive and negative resolutions is really 'neutral' within a patient group is questionable. As it has been suggested that clinically anxious individuals may benefit more from such cognitive manipulations (Hallion and Ruscio, 2011), the neutral training used here may have affected the tendency to select positive interpretations. In turn, this may reduce between-training-group differences on outcome measures, explaining the absence of training differences on positive target ratings. An alternative control training condition could simply contain neutral resolutions of all vignettes.

A final question concerns whether these data from a Chinese sample using an interface comprising Chinese characters and Pinyin are generalizable. Although presenting work fragments in a Pinyin format matches well with existing CBM-I paradigms, the required translation from reading training scenarios in Chinese characters to processing Pinyin might explain somewhat larger RTs in word fragment completion in the present study. This might have in turn affected the facilitating effect of positive training on positive probe fragment completion and reduced the training efficacy and adolescents' motivation in general.

Notwithstanding these limitations, our study supported the plasticity of interpretation biases in adolescents diagnosed with anxiety disorders. Moreover, data were extended to a Chinese sample, increasing the applicability of CBM-I to non-Western societies, with different linguistic constraints. Although we applied the same set of training materials to adolescents with a variety of anxiety symptoms and those with secondary diagnoses of major depressive disorder, future studies may wish to deliver condition-specific training scenarios that depict somatic symptoms, interpersonal interactions, educational and recreational activities to investigate whether maximal changes in interpretative styles and symptoms can be elicited in recipients with a specific anxiety profile (MacLeod and Mathews, 2012). Indeed, previous CBM-I paradigms in adults have successfully mitigated symptoms of generalized anxiety disorder (Hayes et al., 2010) and social anxiety disorder (Amir and Taylor, 2012)

In summary, the current study revealed that adolescents who received positive CBM-I subsequently made fewer negative interpretations of new ambiguous scenarios than those who received neutral training, although training-induced changes in interpretation bias questionnaire scores and mood measures were unclear. Before these implications of training efficacy can be realized, it is crucial for future research to determine the parameters for optimizing CBM-I effects in symptomatic adolescents.

Conflict of interest statement

All authors report no financial interests or potential conflicts of interest.

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