Vulnerability to Depression and Cognitive Bias Modification

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Abstract

Background and Aims. Cognitive Bias Modification (CBM) has been found to be effective in promoting positive interpretations and mood in adults, including those with symptoms of depression and anxiety. However, only four studies have been conducted in adolescent populations. This study therefore aimed to further investigate the effects of CBM in adolescents, including those who have higher risk for developing depression by virtue of neuroticism. **Method.** This study adopted a between-groups experimental design across three time points. Seventy-four adolescents aged 16 – 18 were randomised into receiving either two sessions of CBM or control intervention. Their interpretation bias and mood were measured at baseline, immediately post-training and one week afterwards. Stress vulnerability was assessed using a novel experimental stressor; participants were also asked to report their daily mood and stressful events over one week. Feedback was collected. **Results.** The CBM group showed a greater reduction in negative affect than the control. In addition, the CBM group did not show the increase in state anxiety as seen in control participants. However, CBM did not show superior benefits in other outcome measures. Both groups displayed an increase in positive interpretations, a decrease in negative interpretations, and a reduction in depressive symptoms. The two groups did not differ in their responses to stress. Participants with higher scores on neuroticism showed higher levels of negative interpretation bias, mood symptoms and stress vulnerability. However, there was no evidence to suggest that neuroticism acts as a moderator of training effects. Feedback from participants was mostly positive. **Conclusion.** Overall, this study has *not* yielded strong supportive evidence for the use of CBM in healthy or vulnerable adolescents. Despite methodological limitations, this study has broadened the evidence base of CBM in adolescent

populations. It also represents an important step in developing CBM as a preventive intervention for vulnerable adolescents.

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CHAPTER ONE

Introduction

1.1 General Introduction

Depression is a serious mood disorder that affects nearly all aspects of normal functioning, with the core features as persistent dysphoric mood and/ or anhedonia (i.e. inability to experience pleasure), which coexist with disturbances of motivated and psychomotor behaviour, sleep, appetite, energy and libido, and in some occasions suicide (Diagnostic and Statistical Manual of Mental Disorders 4th edition; American Psychiatric Association, 2000). Sadly, depression is one of the most common mental health problems. According to figures published by the World Health Organisation (WHO, 2011), depression affects as many as 121 million people worldwide. In a study specifically looking at prevalence rates within Europe (Ayuso-Mateos et al., 2001), the urban areas of the UK were reported to have the highest rate (17.1%), a figure nearly double the average rate in Europe (8.56%). Notably, substantially higher rates were seen in the urban than rural communities, and in women compared with men (10.05% vs. 6.61%) although men had higher completed suicidal rates (WHO, 2011; Williams, 2001). Not only does depression cause great distress to the individuals affected and their families, depression is also considered as one of the leading causes of disability. It is estimated that by 2020, depression will be the second highest contributor to the global disease burden due to the loss of workplace productivity, costs of treatment and other associated costs (WHO, 2011).

The current mainstream treatments are antidepressant medications and psychological treatments, in particular Cognitive Behaviour Therapy (CBT). Treatments of 'lower intensity' such as computerised CBT, guided self-help, psycho-

education, and physical exercise group are also recommended for individuals suffering from milder forms of depression (see guidelines from the National Institute for Health and Clinical Excellence; NICE, 2004). Recovery rates reported so far (see below) are around 50% at best, highlighting the fact that about half of the individuals still experience depressive symptoms that reach clinical diagnostic criteria by the end of their treatment. For example, a study based on the routine clinical practice in 32 Improving Access to Psychological Therapies (IAPT) services in the UK reported a national average recovery rate of 42%, with considerable variability between 27% and 58% across sites (North East Public Health Observatory, 2010). These rates were consistent with the established efficacy of CBT in earlier studies (e.g., Clark & Ehlers, 1993; Shapiro et al., 1994). Similarly, recovery rates for antidepressants were reported as around 51% after publication bias was taken into account (Turner, Matthews, Linardatos, Tell, & Rosenthal, 2008).

Not only does depression appear to be a condition which is difficult to treat, it is highly recurrent (64%) even in this modern age of maintenance medication (Yiend et al., 2009). It has been estimated that 30 - 50% of the individuals with depression will experience a relapse as soon as 4 – 6 months following treatment (Thase, 1999). On average, those who suffer from one depressive episode will experience four lifetime depressive episodes of 20 weeks duration each (Judd, 1997). Given this high relapse rate, the illness is now viewed as a chronic lifelong mental health condition.

Taken together, depression affects a huge proportion of the population, is difficult to treat, and is highly recurrent. To add to the challenge, this battle often starts quite early in life, with more than 50% of individuals having their first depressive episode by the age of 25, and 25% by the age of 18 (Sorenson, Rutter, &

Aneshensel, 1991). Thus, it is absolutely vital that more research is done to further our understanding of risk mechanisms, with the ultimate aim to develop effective ways to prevent first onset of depression especially amongst vulnerable young people.

Historically, research on vulnerability to depression has been focused on identifying risk factors through large scale twin studies (e.g., Kendler, Gardner, & Prescott, 2002, 2006a; Kendler & Prescott, 1999). More recently a range of cognitive mechanisms have been shown to be associated with some of these risk factors and thus may play a key role in contributing to the development of depression (see section 1.2 below for details). For example, students with a high score on neuroticism, a well-known personality risk factor, have been found to show widespread negative biases in emotional processing both in behavioural (Chan, Goodwin, & Harmer, 2007) and neuroimaging studies (Chan, Harmer, Goodwin, & Norbury, 2008a; Chan, Norbury, Goodwin, & Harmer, 2009), and a subset of these biases were shown to be predictive of depressive symptoms within 18 months (Chan, Goodwin, & Harmer, 2008b).

These findings led to the hypothesis that the reversal of negative cognitive biases could reduce risk for depression. Indeed, a recently developed cognitive training programme known as Cognitive Bias Modification (CBM; Mathews & Mackintosh, 2000) has been shown to be effective in reversing negative interpretation biases and promoting positive mood. Although a large proportion of the studies have been done with healthy adult participants, there is increasing evidence that CBM could be adapted for use with individuals suffering from emotional disorders including anxiety and depression, as well as across a wider age range (see section 1.3 below for details).

Therefore, this thesis investigation aimed to study the effects of CBM on the cognitive style, mood, and emotional vulnerability in adolescents including those who have a high risk for developing depression by virtue of neuroticism. A novel paradigm was designed and piloted specifically in this study to measure the cognitive and emotional responses to an experimentally induced stressor. Both qualitative and quantitative feedback was collected from the participants to establish the feasibility and acceptability of this training programme. As noted earlier, this line of research will provide the prerequisite for developing effective strategies for preventing depression.

First, this introductory chapter aims to provide an overview and critical evaluation of the existing literature regarding vulnerability to depression (section 1.2) and the development of the Cognitive Bias Modification paradigm (section 1.3). Specifically, Section 1.2 will provide an outline of neuroticism and other risk factors identified by twin studies (section 1.2.1) as well as the cognitive mechanisms thought to be underlying these risk factors (section 1.2.2). This will be followed by a description of a systematic literature review in Section 1.3, in which the evidence base for the CBM to be used with individuals with clinical or sub-clinical mood disorders will be critically evaluated. This chapter will be concluded by outlining the objectives, hypotheses and methodology of this thesis investigation (section 1.4).

1.2 Vulnerability to Depression

To effectively prevent the first onset of depression, we need a thorough understanding of the aetiology of the illness. So far, research has identified the key high risk factors as family history of psychiatric illnesses, childhood abuse / neglect and the personality trait of neuroticism. These factors are believed to increase

depression when triggered by major stressful life events (see section 1.2.1 below). These research studies convincingly demonstrate factors involved in risk for depression. However, they do not inform us of the exact *mechanisms* whereby these high risk factors lead to depression.

In contrast, cognitive and biological theories of depression suggest mechanisms without necessarily the same emphasis on a coherent causal model. Specifically, cognitive theories emphasise the role of negative biases in information processing in the aetiology and maintenance of depression (Beck, Rush, Shaw, & Emery, 1979). In support of this, selective attention, interpretation and memory for negative materials have been reported in depressed patients and to a certain extent those who are at risk for depression and those who have recovered from it (Williams, Watts, MacLeod, & Mathews, 1997; see section 1.2.2 below).

Both of the research approaches above are important in further our understanding of the development of vulnerability to depression, and will be considered in further details in the following subsections.

1.2.1 Neuroticism and other risk factors for depression

The aetiology of depression in community samples has been intensively investigated in twin studies that can broadly distinguish genetic from environmental factors. Kendler's group has published an unparalleled account of the risk factors together with a comprehensive model of how they may be related. In a very broad outline, the key vulnerability factors appear to be neuroticism, family history of depression and early abuse / neglect or trauma, whereas the precipitating factors are adverse life events and difficulties. Working with these variables, episodes of major depression are moderately well predicted at 12 month follow up both in women

(Kendler et al., 2002) and men (Kendler et al., 2006a), although childhood parental loss and low self-esteem appeared to be more potent variables in the model of men than in women.

Amongst all, neuroticism is one of the most documented predictors for depression. Neuroticism is a major personality dimension measuring an individual's tendency to experience negative emotions (Eysenck & Eysenck, 1964; John, 1990). This personality trait is stable over adulthood (McCrae & Costa, 1990), and has a heritability of approximately 50% (Eysenck, 1990). High levels are associated with risk for depression when measured both cross-sectionally and prospectively. Specifically, in a large sample of female twins, one standard deviation difference in neuroticism was found to translate into a 100% difference in the rate of first onsets of depression over 12 months (Kendler, Kessler, Neale, Heath, & Eaves, 1993). Similarly, in a report based on a large Swedish twin sample (> 20,000 individuals; Kendler, Gatz, Gardner, & Pedersen, 2006b), neuroticism strongly predicted the risks for lifetime and first onset depression assessed in 25 year follow up. Although extraversion was also (inversely) correlated with depression in this sample, this was mediated by the correlation between neuroticism and extraversion; thus the overall results identified neuroticism as the exclusive personality risk factor for depression. Furthermore, the twin modelling conducted in these studies suggested that the association between neuroticism and risk for depression is largely due to shared genetic determinants.

Indeed, family inheritance has been defined as a reliable risk factor for depression. It has been estimated that by young adulthood up to 40% of the offspring of parents with a clinical mood disorder will have suffered a personal episode of depression (Beardslee, Verage, & Gladstone, 1998; Gotlib & Goodman, 1999;

Weissman, Fendrich, Warner, & Wickramaratne, 1992) or other forms of psychopathology (Weissman et al., 2006), which appears to be partially transmitted by genetic factors (Sullivan, Neale, & Kendler, 2000). Based on a large twin sample containing more than 3000 same-sex and different-sex twins, Kendler and Prescott (1999) estimated the heritability of liability to depression as 39%, which is similar for men and women, while individual-specific environment accounts for the remaining 61% of variance.

Clearly, environmental factors also play a crucial role in the aetiology of depression. The social origins of depression have been extensively investigated (Brown & Harris, 1978) and it has been suggested that depression is more common amongst those from the lower social classes (Murphy, 1982). The higher rates of depression within the lower social classes were in part due to their lack of social support and higher exposure to life stress (Brown & Harris, 1978; Dennis, Wakefield, Molly, Andrews & Friedman, 2005; Murphy, 1982). Indeed, there has been growing evidence that depression is often preceded by stressful life events (Hammen, 1991; Kendler, Karkowski, & Prescott, 1999; Kendler, Kuhn, & Prescott, 2004; Simons, Angell, Monroe, & Thase, 1993).

Amongst all, the link between childhood trauma and mood disorders later in life has long been acknowledged (Cicchetti & Toth, 1995; Post, Weiss, & Leverich, 1994). Childhood abuse or neglect was shown to have a strong negative impact on the social, emotional, behavioural, and cognitive development of children (Erickson & Egeland, 1996; Kaler & Freeman, 1994; Rogosch, Cicchetti, & Aber, 1995). Although historically considered as an ‘environmental’ factor, childhood abuse or neglect has been shown to have a direct impact on the neurobiological development in the early years, resulting in structural and functional differences in the brain that

will affect the fundamental way in which we process information and regulate emotion (Glaser, 2000; van der Kolk, 2003).

Nevertheless, many people who experience similar environmental stressors or early trauma do not develop depression (Kendell-Tackett, Williams, & Finkelhor, 1993). This realization is consistent with the diathesis-stress model, which states that depression is caused by a genetic vulnerability combined with the experience of stressful life events. In support for this, Caspi and colleagues (2003) found that a polymorphism in the 5-HT transporter gene interacts with stressful life events to predict depression. Neuroticism, as a genetically-mediated risk factor, has also been found to interact with adverse life events, such that individuals with a high neurotic trait are more sensitive to the depressogenic effects of adversity (Kendler et al., 2004).

Overall, research suggests that individuals who are genetically predisposed to depression are most likely to develop depression in the face of major stressful life events. While the above findings are robust and convincing, the approach is essentially observational. In addition, most of the risk factors identified above, such as family history and personality trait, are difficult to reverse or prevent. As such, prevention of depression requires more than simply knowing the risk *factors*. Indeed, it is important to draw upon the neurocognitive theories to fully understand the complexity of vulnerability to depression. One of the key advantages is that, whereas risk factors are relatively inalterable, the underlying neurocognitive mechanisms may be more modifiable.

1.2.2 Cognitive mechanisms underlying risk for depression

As noted above, the current thesis investigation aimed to test the hypothesis that vulnerability to depression could be reduced through modifying negative cognitive biases. This hypothesis was built upon research evidence that suggests cognitive biases as a stable vulnerability marker for depression. This subsection aims to outline, and critically evaluate, the theoretical debate and clinical implications around these research findings.

1.2.2.1 Cognitive biases in depression

Cognitive theories of depression emphasise the role of negative biases in information processing in the aetiology and maintenance of the disorder. Specifically, Beck proposed that, in depression, there are dysfunctional schemas which contain information about loss and failure, and the activation of such schemas results in selective processing of schema-congruent information (Beck et al., 1979). In support of this, negative biases for memory and interpretation, and to a certain extent attention, have been robustly seen in individuals suffering from clinical or subclinical depression both in experimental studies and clinical observations.

Attention bias was historically considered as more relevant for anxiety than depression (Mathews, 1990; Williams et al., 1997). Indeed, an attention bias for threat has been robustly found in anxious individuals using the attentional probe tasks (MacLeod, Mathews, & Tata, 1986; Mogg, Mathews, & Eysenck, 1992) or modified Stroop tasks (McNally, Reimann, & Kim, 1990; Mogg, Mathews, & Weinman, 1989). However, there has been emerging evidence that suggest a link between depression and attention bias when stimuli were more ‘depression-related’ and presented for a substantially longer period of time (Bradley, Mogg, & Lee, 1997;

Mathews, Ridgeway, & Williamson, 1996; Mogg, Bradley, & Williams, 1995). Based on these findings, it has been argued that depression is not associated with an attentional bias during the initial orientation as in anxiety (see MacLeod & Rutherford, 1992; Mogg et al., 1995), but instead may be characterized by the difficulty in disengaging attention from such materials.

While the findings of attentional biases in depression are controversial, memory bias is regarded as a reliable marker of depression. Earlier studies on autobiographical memory found that more negative events were recalled by depressed patients (Lloyd & Lishman, 1975). Although these findings were initially criticized for being confounded by the fact that depressed patients may have more negative experiences in the first place, the evidence for memory bias in depression was strengthened by later experiments using standard word lists or stories (Denny & Hunt, 1992; Watkins, Mathews, Williamson, & Fuller, 1992). Furthermore, not only have depressed individuals shown a bias towards negative information when they were asked to deliberately recall it ('explicit memory'), there has been increasing evidence arguing for the role of 'implicit memory' in depression using tasks such as the word stem completion task or lexical decision task (Bradley, Mogg, & Williams, 1994, 1995; Watkins, Vache, Verney, & Mathews, 1996). Notably, these studies also showed that memory bias could occur without conscious awareness, highlighting the automatic nature of the negative biases underlying depression.

Another cognitive marker for depression is negative interpretation bias, a tendency to interpret emotionally ambiguous information as more negative or less positive (Lawson, MacLeod, & Hammond, 2002). Earlier studies tended to use more explicit measures by, for example, asking individuals to report their interpretations of written ambiguous scenarios (Butler & Mathews, 1983; Cane & Gotlib, 1985;

Kavanagh & Bower, 1985). Although these studies yielded supportive evidence for the presence of interpretation biases in depression, they were criticized for being attributable to response biases (MacLeod & Mathews, 1991). Using more indirect measures (thus reducing the effect of the above confounding factor), depression has been associated with increased perception of sad faces (Bouhuys, Geerts, & Gordijn, 1999; Hale, 1998; Matthews & Antes, 1992), reduced perception of happy faces (Sloan, Strauss, Quirk, & Sajatovic, 1997; Sloan, Strauss, & Wisner, 2001; Suslow, Junghanns, & Arolt, 2001), or both (Gur et al., 1992; Surguladze et al., 2004). Apart from biases towards negative facial expressions, depressed individuals have also been seen to make more negative interpretations using a homophone task (Mogg, Bradbury, & Bradley, 2006) and schema-relevant ambiguous events (Dohr, Rush, & Bernstein, 1989). Negative biases measured by the Scrambled Sentences Test were found to be predictive of depressive symptoms 4 – 6 weeks later, after controlling for current or past depression (Rude, Wenzlaff, Gibbs, Vane, & Whitney, 2002). Furthermore, depressed individuals were found to show larger eye-blink reflex responses to auditory ambiguous stimuli, suggesting that interpretation biases are mediated through a highly autonomous processing pathway (Lawson et al., 2002). It should be noted that, despite the abundant evidence for the presence of interpretation biases in depression, a minority of studies did not illustrate this effect (e.g., Lawson & MacLeod, 1999), presumably due to methodological differences (e.g., use of different outcome measures) in these studies.

Interpretation bias is not an exclusive marker for depression. Indeed, negative interpretations have been widely implicated in social phobia (Amir, Foa, & Coles, 1998; Hirsch & Mathews, 1997, 2000) and generalized anxiety disorder (Eysenck, MacLeod, & Mathews, 1987; Mogg et al., 1994), although it has been suggested that

interpretation bias may manifest in slightly different forms in depression and anxiety (Huppert, Foa, Furr, Filip, & Mathews, 2003). This tendency to repeatedly make negative interpretations is believed to have long term harmful effects on emotional state (Beck & Clark, 1991).

Notably, negative biases discussed above appear to be particularly prominent when they were processed with reference to the self. This was seen in memory (Blaney, 1986; Mathews & MacLeod, 1994; Teasdale, 1988), attention (Segal, Gemar, Truchon, Guirguis, & Horowitz, 1995; Segal & Vella, 1990), interpretation of facial expressions (Bouhuys, Bloem, & Groothuis, 1995) and social situations (Hoehn-Hyde & Rush, 1982). These self-directed negative biases are thought to play a key role in sustaining the negative sense of self that characterizes the core depressive symptoms of shame, guilt, and self-blame (Tangney, 1993).

1.2.2.2 State vs. trait characteristics of depression

Hence, as reviewed above, depression is characterised by predominate negative biases. However, there has been a longstanding debate as to whether these are *state* or *trait* factors of depression, that is, whether they are correlates of current depressed mood or whether they are long term stable vulnerability markers preceding the onset of depression.

Mood induction experiments provide one way to disentangle state and trait factors. Following negative mood induction, healthy volunteers were found to display increased attention to negative stimuli (Bradley et al., 1997; Gotlib & McCann, 1984), increased interpretation of sad relative to happy faces (Bouhuys et al., 1995), and increased memory for negative materials (Mathews & Bradley, 1983; Sutton, Teasdale, & Broadbent, 1988; Teasdale & Fogarty, 1979). These results

suggest that mood directly modulates emotional processing, thus rendering support for the 'state' hypothesis. Consistent with this, the evidence that negative biases disappear following successful treatment also suggests a mood-dependent characteristic (Gotlib & Cane, 1987; Mikhailova, Vladimirova, Iznak, Tsusulkovskaya, & Sushko, 1996).

By contrast, cognitive biases that persist following recovery give strong support for the trait hypothesis. In particular, residual biases have been found in recovered patients in the facial expression recognition tasks (Bhagwagar, Cowen, Goodwin, & Harmer, 2004; Hayward, Goodwin, Cowen, & Harmer, 2005), which could predict subsequent relapse within six months (Bouhuys et al., 1999). However, these studies could not rule out a scar effect, so-called because the residual biases may be a consequence of depression, rather than implying occurrence before the onset of the first episode.

As mentioned above, evidence that cognitive biases are present in vulnerable individuals prior to the onset of depression are particularly relevant for the current thesis investigation. Indeed, earlier studies have illustrated cognitive biases in high risk populations. For example, individuals with higher scores on neuroticism tend to recall more self-depreciatory adjectives (Young & Martin, 1981) and sentences with negative tones (Lishman, 1972). Similarly, neuroticism was found to be correlated with negative interpretations for ambiguous information (Salemink & van den Hout, 2010). However, as neuroticism is often linked to dysphoric mood, it is again unclear as to the extent to which the cognitive biases observed are independent of mood states. In addition, most of these earlier studies on neuroticism were based on non-selective community samples using correlational analyses that could not clarify

causation. Some of these findings were further compromised by poor control for previous experience of depression in their samples.

More recent publications have shed light into this state vs. trait debate by illustrating widespread emotional processing biases in vulnerable (high neuroticism scores) never-depressed individuals (Chan et al., 2007), and a subset of these biases was shown to be predictive of depressive symptoms within 18 months (Chan et al., 2008b). Consistent with this, Alloy and colleagues (2006) recruited a sample of high risk vs. low risk college students by virtue of cognitive styles, and they found that depression was well predicted by these cognitive factors in a two and a half year follow-up. In addition, children of clinically depressed or anxious parents showed an attentional bias for negative words (Moradi, Neshat-Doost, Taghavi, Yule, & Dalgleish, 1999) and faces (Joormann, Talbot, & Gotlib, 2007; Pine et al., 2005), as well as a tendency to interpret ambiguous words and stories more negatively and / or less positively (Dearing & Gotlib, 2009). These findings are in line with the 'cognitive vulnerability hypothesis' proposed by cognitive theories of depression (Abramson, Metalsky, & Alloy, 1989; Beck, 1967).

As a conclusion to the state vs. trait debate, although these studies cannot completely rule out the state effect, they nonetheless provide very strong evidence arguing for the existence of trait markers of depression. Specifically, they showed that cognitive biases exist as trait vulnerability markers preceding the onset of depression, thus raising the hypothesis that preventive measures targeting directly on cognitive biases could be helpful in reducing risk for depression. This hypothesis will be further discussed in the next section.

1.3 Cognitive Bias Modification: A Systematic Literature Review

As discussed above, there has been robust empirical evidence to support the cognitive theories that depression and anxiety are associated with negative biases in information processing (Williams et al., 1997). Specifically, a tendency to interpret ambiguous situations negatively and / or a reduced tendency to make benign interpretations have been well documented in social phobia (Amir et al., 1998; Hirsch & Mathews, 1997, 2000), generalized anxiety disorder (Eysenck et al., 1987; Mogg et al., 1994), and depression (Butler & Mathews, 1983; Rude et al., 2002). This gave rise to the question of whether cognitive biases could be 'modified', and if so whether this could lead to changes in mood and emotional vulnerability associated with anxiety and depression.

To test part of this hypothesis, Mathews and Mackintosh (2000) developed a task known as Cognitive Bias Modification (CBM) to examine whether interpretation biases could be modified through repeated practice with prompts and corrective feedback. Though originally designed as an experimental paradigm, it rapidly attracted intense interest for its potential clinical use for the prevention and treatment of depression and anxiety disorders.

The evidence base for the clinical and subclincial use of CBM will be critically evaluated in this section through a systematic literature review. It will begin by outlining the development of CBM (section 1.3.1), followed by a description of the methods used in the systematic review (section 1.3.2), and finally the results generated and their theoretical and clinical implications (sections 1.3.3 – 1.3.4).

It should be noted that, in addition to interpretation biases, training paradigms have also been developed to target other information processing biases such as

attention (see Bar-Haim, 2010; Browning, Holmes, & Harmer, 2010; Hakamata et al., 2010 for a review) and memory (Joormann, Hertel, LeMoult, & Gotlib, 2009; Raes, Williams, & Hermans, 2009). The current study aimed to examine hypotheses in relation to interpretation biases, and as such the literature concerning attentional bias modification and other types of cognitive training programmes is beyond the scope of this review.

1.3.1 Overview of CBM studies

In the first study on CBM (Mathews & Mackintosh, 2000), participants were asked to read descriptions of ambiguous social situations with the emotional outcome resolved only by the final word. This final word was presented in fragment form for participants to complete, who would then answer a question designed to reinforce the designated interpretation. 'Positive training' prompted benign / positive interpretations, whereas 'negative training' encouraged negative interpretations.

An example of the training items is as follows:

Your partner asks you to go to an anniversary dinner that their company is holding. You have not met any of their work colleagues before. Getting ready to go, you think that the new people you will meet will find you…

The word fragment that followed was either *bo- -ng* (boring; negative training condition) or *fri- - d- y* (friendly; positive training condition). To reinforce the valenced meaning, the following comprehension question was asked:

Will you be disliked by your new acquaintances?

The correct answer was 'Yes' for the negative training condition and 'No' for the positive training condition. Feedback was given.

Following training, participants were found to interpret novel situations in the direction congruent with training. Notably, positive training was associated with reduced anxiety. This study was important in two ways. First, it demonstrated a direct causal link by which interpretation biases alter anxiety. Second, it suggested the possibility of reducing anxiety through positive interpretation training.

Since then these findings have been replicated and extended to show that interpretation training can survive the passage of time (up to 24 hours) and changes in environmental contexts (Hoppitt, Mathews, Yiend, & Mackintosh, 2010a, 2010b; Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Yiend, Mackintosh, & Mathews, 2005).

Other variations have also been developed. For example, some studies used homographs (Grey & Mathews, 2000; Wilson, MacLeod, Mathews, & Rutherford, 2006). In this paradigm, participants were exposed to a series of homographs (e.g. 'sink') each followed by a word fragment representing either a threatening ('drown') or a benign meaning ('basin'). Positive training involved making repeated positive / benign interpretations of the homographs; *vice versa* for negative training.

Another commonly used procedure is the word-sentence association task (Beard & Amir, 2008). In this task, participants were asked to determine, in repeated trials, whether a word (e.g. 'approving') and a sentence (e.g., 'your supervisor discusses your future') were 'associated'. Corrective feedback was given when the endorsed response represents a positive or benign resolution; using the above example, 'correct' will be shown following a response of 'Yes'.

Though originally designed to target anxiety, CBM was later adapted for depression (Holmes, Mathews, Dalgleish, & Mackintosh, 2006). In particular, this paradigm argued for the advantage of fostering positive interpretations through

promoting positive imagery. Instead of completing word fragments, participants listened to positively resolved scenarios while creating mental images. Despite the strong evidence supporting the role of mental imagery in interpretation (Holmes, Lang, & Deeprose, 2009), contradictory findings have also been yielded (Standage, Ashwin, & Fox, 2009; Vassilopoulos, Blackwell, Moberly, & Karahaliou, 2011).

Taken together, CBM studies have varied in terms of the type of training materials, the medium of presentation, task instructions, as well as the amount and duration of training. Despite these methodological differences, there is consistent evidence that this training paradigm is effective in reversing negative interpretation biases that are believed to play a key role in the aetiology and maintenance of mood disorders. There is also accumulating evidence to suggest that this change in cognition could improve mood especially when tested under the provocation of stress. These findings led to a hypothesis that CBM could be developed for therapeutic use for anxiety and depression.

To test this hypothesis, the effectiveness of CBM has to be established in populations with clinical or at least sub-clinical symptoms or traits of anxiety and depression. Therefore, the following systematic literature review was conducted to evaluate the evidence-base for the clinical and sub-clinical use of CBM by identifying and critically reviewing publications that have investigated the effects of CBM on these populations.

1.3.2 Methods of the review

1.3.2.1 Search strategy

A literature search was conducted in two waves: the first took place between 27/10/2010 and 15/11/2010, and the second between 19/03/12 and 30/03/12.

Combinations of the key terms ‘interpretation bias’, ‘cognitive bias’, and ‘modification’ were searched in the following electronic databases on MetaLib (2000 to date): SCOPUS, ASSIA, Scirus, and PsycINFO. ScienceDirect and PubMed (both 2000 to date) were searched separately. Key journals (*Journal of Abnormal Psychology* and *Behaviour Research and Therapy*) were hand-searched using the above key terms (2000 to date). Websites of the research teams of the key authors (in alphabetic order: Amir, N., Beard, C., Hayes, S., Hirsch, C., Holmes, E.A., Hoppitt, L., Mackintosh, B., Mathews, A., Salemink, E., and Yiend, J.) and references of the retrieved papers were reviewed. The publication date cutoff was chosen because the first papers on CBM were published in 2000 (Grey & Mathews, 2000; Mathews & Mackintosh, 2000).

1.3.2.2 Selection criteria

Studies were considered for review if they met the following criteria:

- English language
- Reported original data (i.e., exclude reviews, commentaries, or theoretical discussions)
- Peer-reviewed journals (i.e., exclude conference proceedings or unpublished dissertations)
- Training targeted interpretation (i.e., exclude training exclusively targeting other types of information processing)
- Targeted anxiety and / or depression
- Sample selected based on clinical or subclinical levels of anxiety or depression symptoms or traits

1.3.2.3 Selection procedure

The electronic search identified 285 publications. After discounting duplicates, 67 remained. Abstracts were screened to verify if the selection criteria were met, and whenever ambiguities arose full texts were consulted. Finally, 19 papers (including two selected via references of retrieved papers) met the criteria and thus are included in this review.

1.3.3 Results of the review

To evaluate the evidence-base for the clinical use of CBM, studies are grouped according to psychological disorder and organised chronologically. Of the 19 studies, seven targeted Generalised Anxiety Disorder (GAD) including high trait anxiety, seven Social Anxiety Disorder (SAD), one Spider Phobia, one Panic Disorder, two Depression, and one Mixed Depression and Anxiety. Methodological characteristics and results of these studies are summarised in Table 1.

1.3.3.1 GAD and high trait anxiety

High trait anxiety is a vulnerability marker for anxiety and two studies have been conducted on this population. Mathews, Ridgeway, Cook, & Yiend (2007) is valuable in being the first to recruit high trait anxious participants. Randomisation was appropriately used to allocate participants to receive 4 sessions of CBM or a test-retest condition. Results were promising: Participants endorsed more positive / benign interpretations after training, and reported less trait anxiety after one week. The authors argued that this delayed effect was due to an interaction with real life stress, but this hypothesis was not directly tested as stress was not recorded. Furthermore, the test-retest control made it unclear whether the effects were due to

training or other non-specific factors. Results were further limited by the narrow range of self-rated outcomes measures.

The second study was Salemink, van den Hout, & Kindt (2009). Improving on the previous study, control participants were cued to endorse positive and negative interpretations with equal frequency. This provided better control over exposure to emotional materials, duration of testing and other factors. This study used a wider range of outcome measures, and emotional vulnerability was assessed with a laboratory stressor. Despite the more intense training schedule (8 consecutive days), this study yielded mixed results. Change in interpretation bias was detected by one task but not another; and this effect disappeared after 24 hours. Despite reductions in state and trait anxiety and general psychopathology, training had no effect on social anxiety or emotional vulnerability. These results did not lend support for the potential therapeutic use of CBM.

Instead of high trait anxiety, Hirsch, Hayes, & Mathews (2009) recruited participants who scored high on a worry scale. That half of the sample met diagnostic criteria for GAD made the study more clinically relevant. Both scenarios and homographs were used in training, which was problematic as the effect of each could not be differentiated. This study also failed to measure interpretation bias after training, although the outcome measures (thought intrusion, worry, and residual working memory) were relatively novel. Results suggested that training improved control over thought intrusions and worry, and thus freed up cognitive resources. This was demonstrated by an increase in residual working memory, although participants still displayed considerable levels of worry after training.

Further enhancing the clinical relevance of CBM research, Hayes, Hirsch, Krebs, & Mathews (2010) studied clinically diagnosed GAD patients. This study

improved upon the above by including interpretation bias as an outcome measure, but had the same drawback of combining two training paradigms. Results showed that training was successful in reducing negative interpretations and thought intrusions. Mediation analyses further suggested that changes in thought intrusions were mediated by the reduction in negative interpretations. However, there was no follow-up assessment, leaving the durability of effects unknown.

Steel et al. (2010) were the first to study individuals with clinically diagnosed schizophrenia and high trait anxiety. Each participant completed a single session of training and a single session of control in a counter-balanced order, with the two sessions at least 3 days apart. This within-subject crossover design increased statistical power and provided good experimental control. Ecological validity of the training was enhanced by having items modified to be relevant to the daily experience of people with schizophrenia. Results showed that training had no effect on interpretation bias or anxiety, thus rendering no support for the therapeutic use of CBM for this population, although the null effects could also be explained by an insufficient dose of training. Nevertheless, the positive feedback from participants was encouraging.

Similar to Hayes et al. (2010) above, Brosan, Hoppitt, Shelfer, Sillence, & Mackintosh (2011) studied individuals with clinically diagnosed anxiety disorders recruited from routine clinical practice, thus maximising the clinical relevance. This study was unique in providing CBM training for both interpretation and attention within a single study. Results showed a reduction in negative biases both in attention and interpretation as well as state and trait anxiety, although it was unclear whether the effect resulted from the attention or interpretation training. This study claimed to have shown a clinically significant reduction in anxiety based on the established

normative data of the questionnaire; this argument would have been stronger if clinical interviews were used. Finally, given the small sample size (N = 13) and a lack of control group, it might have been more appropriate to use a single case series design. Interestingly, most participants found the interpretation training more helpful than the attention training.

Hertel, Vasquez, Benbow, & Hughes (2011) attempted to unpack the mechanisms underlying the effects of CBM. Specifically, they tested a novel hypothesis that CBM works by impairing memory for negative resolutions. However, the results were presented amidst a mixture of 'non-significant trends', the interpretations of which were exaggerated on occasion. It was also doubtful whether the sample size (N = 40) was sufficient in supporting the amount of statistical comparisons carried out. Despite some evidence in support of the hypothesis, the effects were not robust across all analyses and the null effects on emotional states and responses to stressor were notable. Given the complexity of the paradigm, more piloting work would be beneficial before testing it directly on a population of anxious individuals. On a positive note, this line of research is helpful in furthering our understanding of the change mechanisms underlying CBM.

1.3.3.2 Social anxiety

The first study on social anxiety was Murphy, Hirsch, Mathews, Smith, & Clark (2007) using a sample with high scores on a social anxiety questionnaire. Strengths of this study included a direct comparison between positive and non-negative training (and an additional control condition) and appropriate use of randomisation. Results showed that the two types of training were equally effective in facilitating both positive and non-negative interpretations. When told of a

forthcoming social event, trained participants reported less predicted anxiety. However, this was measured by a simple self-rating and was not transferred to predictions of better performance in this perceived event. It remained unknown whether training could reduce anxiety during an actual event, and whether these results with a subclinical sample could be generalised into clinical populations.

Beard and Amir (2008) extended the above study by delivering 8 sessions of training instead of one. Positively, this study tested a new paradigm that used word-sentence association combined with corrective feedback, which was compared with an appropriately matched control. Results showed that training was successful in facilitating benign vs. threat interpretation and reducing social anxiety. These effects were durable for at least 2 days, which was encouraging. Mediation analyses suggested that the change in interpretation predicted change in social anxiety, although the authors admitted that the sample might be underpowered to draw more definite conclusions. Furthermore, outcome measures were entirely reliant on self-ratings and it was unclear whether results with this subclinical sample could be generalised to clinical populations.

Vassilopoulos, Banerjee, & Prantzalou (2009) is valuable as it was the only study with a child sample (age 10-11) using an age appropriate purpose-designed training. It also differed from the other studies by using non-computerised training materials. Participants were cued to endorse positive / benign interpretations of scenarios by corrective feedback. Training was shown to reduce negative interpretations, social anxiety and anticipated anxiety upon a perceived upcoming social event, although participants did not predict a better outcome of the event. Positively, these effects lasted for 2-3 days, which showed promising durability. However, the test-retest control made it inconclusive as to whether the effect was

due to training *per se*. The outcome measures were self-rated and it was unclear whether reduced predicted anxiety could be translated to reduced anxiety upon a real social event.

Amir, Bomyea, & Beard (2010) is theoretically interesting as it tested whether the interpretation training can modify other information processing biases, in this case attention. Attentional biases were measured in socially anxious participants after a single session of interpretation training, compared with a well-matched control. Consistent with their hypothesis, trained participants became faster to disengage attention from threat information. The authors argued that the training might have provided practice for participants to reject negative information while accessing benign information, which in turn facilitated participants to 'shift' their attention away from threats. However, durability was not assessed by follow-up. The major drawback was that it failed to measure change in social anxiety, thus conclusions on clinical use could not be drawn.

Turner et al. (2011) tested the effects of a single session of CBM with 8 adults experiencing social anxiety following recovery from psychosis. This study gave a clear rationale, and a single case series design was appropriately chosen for the exploratory purpose. Recruited from an early intervention service, it had high external validity. An appropriate stressor (i.e., walking in a busy place) was used, but mood was not measured afterwards. The findings were limited by the sample size, which were further compromised by missing data from 2 participants (i.e., 25% of the sample). Three participants displayed 'beneficial change in interpretive bias' but no details were given. Mood was measured by 4 sets of Visual Analogue Scales but only the mean score was presented. Feedback highlighted key challenges, such as the short-lived nature of the benefits and difficulty transferring learning to 'the real

world', which are useful information for developing future research and clinical applications.

Beard, Weisberg, & Amir (2011a) reported a randomised controlled trial investigating the combined effects of CBM for attention and interpretation (8 sessions) on a sample of 32 individuals with SAD. Similar to Brosan et al. (2011), the combined approach had the advantage of maximizing the clinical impact but the drawback of not being able to differentiate the effects between the two. This was further confounded by the fact that most participants were receiving varying forms of concurrent treatments. Results were encouraging, although they should be treated with caution until replicated by a larger trial. Improvement in social anxiety was noted, both in self-reports and in social functioning with moderate to large effect sizes, although effects on interpretation bias was not assessed. Moderate ratings were reported for credibility and acceptability. Again, participants rated the interpretation training more positively than attention training and 70% considered eight sessions as appropriate, which are very helpful knowledge for future CBM work.

The first and only qualitative study on CBM was reported by Beard, Weisberg, & Primack (2011b). Although feedback has been collected from previous studies, this study provided a systematic analysis. A qualitative methodology was appropriately chosen for the purpose and executed according to established guidelines for qualitative studies. A good balance of positive and negative comments from participants was reported: CBM was considered as 'easy' and 'straightforward', although some reported frustration and boredom. Overall, participants found the interpretation training more 'intuitive' and easier to perceive its relevance to anxiety than attention training, echoing the feedback from previous

studies (e.g., Beard et al., 2011a; Brosan et al., 2011). However, the generalizability of the results to the wider clinical populations was limited.

1.3.3.3 Spider phobia

Teachman & Addison (2008) extended the CBM research to spider phobia. Strengths of this study included appropriate use of randomisation with two control conditions. However, the sample was recruited based on a questionnaire rather than clinical diagnosis, thus limiting the generalisability to clinical populations. Training materials were adapted to be spider-related, which was good for the purpose but validation was not clearly reported. A key advantage is that the outcome measures moved away from self-ratings and predicted anxiety by including the actual emotional and behavioural response upon seeing a spider. Results showed that training successfully altered interpretations, but it did not lessen the anxious responses upon provocation. It was unclear whether this was due to insufficient training dose or that changes in interpretation do not translate into reduced phobia.

1.3.3.4 Panic disorder

Steinmain and Teachman (2010) was the only study that targeted panic disorder. Participants were individuals who scored high on a measure of anxiety sensitivity, a vulnerability marker for panic disorder (Ehlers, 1995). Again, training scenarios were purpose-designed but not validated. Positively, outcome measures included both subjective and objective measures of avoidance and fear during two tasks designed to provoke bodily sensations relevant to panic disorder. Although training was shown to reduce anxiety sensitivity, results on interpretation bias were mixed and training failed to reduce avoidance or fear upon provocation. It was

unclear whether these results were due to insufficient training dose, invalid training items, or that CBM is not effective in reducing this type of anxiety. Generalisability of findings to clinical populations was also uncertain.

1.3.3.5 Depression

Blackwell and Holmes (2010) was the first study on depression. It was highly clinically relevant due to its sample of clinically diagnosed participants. Single case series design was appropriately chosen for the exploratory purpose and allowed for adjustment to training based on feedback, although its lack of control group and small sample size ($N = 7$) inevitably limited the findings. A key strength is the use of multiple time points: participants completed a one-week baseline period and a two-week post-training follow-up. This provided a rich set of data. Four participants showed improvements in mood and / or interpretation bias. However, the visual inspection analysis made it difficult to draw definitive conclusions, in part due to the day-to-day fluctuations in mood and biases. The task to measure interpretation biases was purpose-designed but not validated. Overall, this study provided novel and promising results for the potential therapeutic use of CBM for depression, although results should be treated with caution until replicated by a larger scale controlled study.

Lang, Blackwell, Harmer, Davison, & Holmes (2012) extended the above by including a control group but otherwise following a similar methodology. The training was again imagery-focused but this time delivered via a combination of auditory, pictorial, and appraisal stimuli, with an effort to improve engagement. Results were encouraging, showing a significant reduction in depression, intrusive symptoms, and cognitive bias immediately post-training, although the evidence for

improvement in two-week follow-up was weak. It was also unclear to what extent the improvement was attributable to each of the three training components. At the time of writing, this study was the first and only controlled study with clinically depressed individuals. Although the results were limited by the small sample size (N =26) and limited evidence on the durability of the effects, this study represented a significant first step towards developing CBM as an effective treatment for depression.

1.3.3.6 Mixed depression and anxiety

Recognising that interpretation of ambiguity is only one form of cognitive bias, Lester, Mathews, Davison, Burgess, & Yiend (2011) validated a new form of CBM targeting 7 types of cognitive errors defined by clinical practice and theories (e.g., overgeneralisation, catastrophising). This study also argued for the need to develop CBM as a transdiagnostic tool given the high comorbidity between depression and anxiety presentations. One major advantage of this study was that new materials were developed from exemplars generated by therapists thus greatly improving the clinical relevance of the training materials. In experiment 2 of this publication, results illustrated the effectiveness of this CBM in reducing anxiety- and depression- related cognitive errors in students prone to these unhelpful thinking styles. One limitation was that the two sessions took place 5 – 9 days apart; it was unclear whether and how this might have affected the effects of training. The effects on emotional states and responses to stressors were mixed, with some only reported 'at trend levels', leaving it unclear whether successful modification of cognitive errors could eventually translate into mood benefits. This new CBM also needs to be

tested on the clinical population before conclusions could be made regarding its therapeutic potential.

Table 1.1. *Methodological Characteristics and Results of the 19 Studies with Clinical or Subclinical Samples of Anxiety and / or Depression*

Study	Sample	Design	Intervention	Training	Outcome Measures	Results
GAD and High Trait Anxiety						
Mathews et al., 2007	40 adults with high trait anxiety (subclinical)	Between-Subjects	4 sessions / 2 weeks training or test-retest control	Scenarios and word fragments	Interpretation bias; STAI–S; STAI–T *(after 1 week)*	Increased positive / benign interpretations; no change in state anxiety; reduced trait anxiety after 1week
Salemink et al., 2009	34 students with high trait anxiety (subclinical)	Between-Subjects	8 daily sessions training or control training	Scenarios and word fragments	Interpretation bias; 2 x VAS (depression, anxiety) post-stressor; STAI, SCL-90-R, FNE *(last 3 after 24 h)*	Mixed results on interpretation bias; reduced STAI and SCL-90-R but no change in FNE or stress vulnerability
Hirsch et al., 2009	40 adults with high worry scores (21 met GAD criteria) (subclinical / clinical)	Between-Subjects	1 session training or control training	Homographs and scenarios (auditory)	3 x VAS (anxiety, depression, happiness); Thought intrusion; Worry; Residual working memory capacity	No immediate mood change; reduced thought intrusions and worry; increased residual working memory
Hayes et al., 2010	40 adults with GAD (clinical)	Between-Subjects	1 session training or control training	Homographs and scenarios (auditory)	Interpretation bias; STAI; 3 x VAS (anxiety, depression, happiness); Thought intrusion and Worry	Reduced negative interpretations and thought intrusion; no immediate mood change

Steel et al., 2010	21 adults with schizophrenia and high trait anxiety (clinical)	Within-Subjects A-B design	1 session training and control (filter tasks)	Scenarios (auditory) and mental imagery	Interpretation bias; STAI-S	No effects on interpretation bias or state anxiety
Brosan et al., 2011	13 adults with anxiety disorders (clinical)	Within-Subjects A-B design	4 weekly training sessions	Word-sentence association (plus training for attention)	Interpretation bias; attentional bias; STAI; feedback	Reductions in negative attentional and interpretation bias; reduced state and trait anxiety scores
Hertel et al., 2011 (Experiment 2)	40 students with high trait anxiety (subclinical)	Between-Subjects	1 session training or control	Scenarios and word fragments	Memory recollection; 4 x VAS (depressed, tense, pessimistic, distressed)	Reduced recollections for negative resolutions; no effects on mood or emotional responses to stressor
Social Anxiety Disorder (SAD)						
Murphy et al., 2007	66 students with high scores on social anxiety (subclinical)	Between-Subjects	1 session positive, non-negative, or control training	Scenarios (auditory)	Interpretation bias; STAI–S; Self-rated anticipated anxiety and performance	Increased positive / non-negative interpretations; reduced anticipated anxiety but no effect on predicted performance or state anxiety

Beard & Amir, 2008	27 students with high scores on social anxiety (subclinical)	Between-Subjects	8 sessions / 4 weeks training or control training	Word-sentence association	Interpretation bias; SPAI-SP; STAI–T; BDI-II *(All after> 2 days)*	Increased benign vs. threat interpretations; reduced social anxiety; no effect on depression or anxiety
Vassilopoulos et al., 2009	43 children with high scores on social anxiety (subclinical)	Between-Subjects	3 sessions / 8 days training or test-retest control	Scenarios on cards with feedback	Interpretation bias; SASC-R; CDI; Self-rated anticipated anxiety & interpersonal liking *(All after 2-3 days)*	Reduced negative interpretation but no change in benign interpretations; reduced social and anticipated anxiety; no effect on depression or predicted interpersonal liking
Amir et al., 2010	57 adults with high scores on social anxiety (subclinical)	Between-Subjects	1 session training or control training	Word-sentence association	Interpretation bias; Attentional bias; STAI–S; BDI-II	Reduced interpretation and attentional bias to threat; no effect on state anxiety or depression
Turner et al., 2011	8 adults with SAD following psychosis (clinical)	Single case series	1 session training	Scenarios and word fragments	Interpretation bias (*after stressor*), 4 x VAS (depression, distress, relaxed, pessimism), Feedback (*After 1 week*)	All reported increase in positive mood, 3 participants showed 'beneficial changes' in interpretation bias, 3 reported experiencing benefits
Beard et al., 2011a	32 adults with SAD (clinical)	Between-Subjects	8 sessions / 4 weeks training or control training	Word-sentence association (plus training for attention)	LSAS-SR; behavioural assessment (impromptu speech); credibility and acceptability	Reduced self-reported social anxiety, better speech quality in behavioural assessment; moderate ratings on credibility and acceptability

Beard et al., 2011b	10 adults with SAD (clinical)	Qualitative	1 – 2 minutes demonstration of training materials	Word-sentence association (plus attention training)	LSAS (for screening); qualitative interviews	Greater understanding and engagement with interpretation than attention modification
Specific Phobia						
Teachman & Addison, 2008	61 students with high fear for spider (subclinical)	Between-Subjects	1 session training or control training or no training	Spider scenarios and word fragments	Interpretation bias; PANAS; Avoidance behaviour and self-rated fear upon seeing real spider	Increased positive and reduced threatening interpretations; no effect on mood, avoidance or fear upon seeing real spider
Panic Disorder						
Steinman & Teachman, 2010	75 students with high anxiety sensitivity (subclinical)	Between-Subjects	1 session training or control training or no training	Bodily sensation scenarios and word fragments	Interpretation bias; Anxiety Sensitivity, PANAS, Avoidance and subjective fear upon provocation	Mixed results on interpretation bias; reduced anxiety sensitivity but no effect on avoidance or fear upon provocation
Depression						
Blackwell & Holmes, 2010	7 clinically depressed adults (clinical)	Single case series	7 daily training sessions	Scenarios (auditory) with mental imagery	Interpretation bias; SCL-90-R; PANAS; BDI-II *(After 2 wks)*	4 participants improved mood and/or bias; BDI-II and SCL-90-R reduced over whole sample

Lang et al., 2012	26 clinically depressed adults (clinical)	Between-Subjects	7 daily training or control training	Scenarios with mental imagery via auditory, pictorial stimuli, and appraisals	Interpretation bias; IES; RIQ; HRSD; BDI-II; STAI-T (*last 2 after 2 wks*)	Reduced depression, interpretation bias and intrusions post-training; reduced anxiety in both groups; 'trend' for improvement in depression in 2 wks
Mixed Depression and Anxiety						
Lester et al., 2011 (Experiment 2)	70 students with cognitive errors related to depression or anxiety (subclinical)	Between-Subjects	2 sessions training or control training (over 5-9 days)	Scenarios and word fragments targeting 7 types of cognitive errors	Interpretation bias; STAI; BDI-II; PANAS; anticipated anxiety for stressor	Reduced cognitive errors, but mixed effects on mood and emotional responses to stressor

Note. Unless otherwise specified, studies were quantitative, outcomes were measured immediately post-training, and training materials were visually presented by computers. BDI-II = Beck Depression Inventory–II (Beck, Steer, & Brown, 1996); CDI = Children's Depression Inventory (Greek; Kovacs, 1992); FNE = Fear for Negative Evaluation Scale (Watson & Friend, 1969); HRSD = Hamilton Rating Scale for Depression (Hamilton, 1967); IES = Impact of Event Scale (Horowitz, Wilner, & Alvarez, 1979); LSAS-SR = Liebowitz Social Anxiety Scale - Self Report (Liebowitz, 1987); PANAS = Positive and Negative Affect Schedule (Watson & Clark, 1994); RIQ = Response to Intrusions Questionnaire (Clohessy & Ehlers, 1999); SASC-R = Social Anxiety Scale for Children–Revised (La Greca & Stone, 1993); SCL-90-R = Symptom-Checklist-90-Revised (Derogatis, 1992); STAI = State-Trait Anxiety Inventory (T = Trait, S = State; Spielberger, Gorsuch, & Lushene, 1970); SPAI-SP = Social Phobia and Anxiety Inventory – Social Phobia Subscale (Turner, Beidel, Dancu, & Stanley, 1989); VAS = Visual Analogue Scale

1.3.4 Discussion of the review

This review identified 19 studies with clinical and subclinical samples. This small number suggests a scarcity of research in this area. Specifically, these publications were unevenly distributed across disorders, with the majority focused on GAD (including high trait anxiety) and social anxiety. There was only one study each on panic disorder, specific phobia, and mixed depressive and anxiety traits. Alarmingly, only two studies were on clinical depression, rendering it difficult to draw definite conclusions for this disorder.

Four studies did not report interpretation bias as an outcome variable (Beard et al., 2011a, 2011b; Hirsch et al., 2009). All other studies, except Steel et al. (2010), supported the hypothesis that CBM is effective in altering interpretation biases. However, the effects on facilitating positive / benign interpretations versus reducing negative interpretations were not always reported clearly.

Five studies showed a delayed effect on reducing anxiety (Beard & Amir, 2008; Mathews et al., 2007; Salemink et al., 2009; Vassilopoulos et al., 2009) and depression (Blackwell & Holmes, 2010). These follow-up assessments were conducted between 24 hours and two weeks, suggesting promising durability. These authors argued that the delayed effect was due to an interaction with real life stress, but this was not directly tested as stress was not recorded.

Despite the absence of real life stress recording, 10 studies investigated the training effects on stress reactivity using experimental stressors but the results were mixed. For example, while being told of an upcoming event, trained socially anxious participants reported less predicted anxiety (Murphy et al., 2007, Vassilopoulos et al., 2009). However, while participants were actually engaged in stressful tasks, they

displayed similar negative responses to control participants. Therefore, there was only slight evidence to suggest an effect on stress reactivity.

In sum, there is strong evidence to suggest that CBM is effective in altering interpretation bias, although the results on mood and stress reactivity were mixed. These should be interpreted in conjunction with the methodological limitations discussed below.

1.3.4.1 Review of methodology

Sample. All studies demonstrated appropriate sample selection with clear inclusion and exclusion criteria. Approximately half of the studies recruited based on clinical diagnoses, which enhanced the generalisability of the findings to clinically populations. However, in most studies it was unclear how sample size was determined.

Design. Except Beard et al. (2011b), all studies used quantitative methods. The majority used a Between-Subject design, with the exception of 2 within-subjects design and 2 single case series studies. For those that used the former, randomisation and double-blindness were appropriately used. However, two of them used only a test-retest control, rendering it difficult to differentiate training effect from confounding factors. The majority used a matched placebo training, which provides a better control over exposure to emotional materials, demand characteristics, and attention from experimenters.

Training. There was a wide variation in training materials, medium of presentation, task instructions, and duration of training, making it difficult to compare the results across studies. Most studies adapted training items to suit specific client groups but failed to report a validation procedure.

Outcome measures. Interpretation bias was measured by mixed methods, and other outcome measures on mood and vulnerability were overwhelmingly reliant on self-reports, leaving results at risk of demand characteristics (MacLeod, Koster, & Fox, 2009). Some of the measures and experimental stressors were purpose-designed, which was appropriate but the validation process was unclear.

Size of change. Effect size and clinical significance were not frequently reported, although this data have started emerging amongst the more recent publications. This trend is helpful for future research and consideration for clinical use.

1.3.4.2 Theoretical implications

Altogether, these findings illustrated that interpretation bias is malleable even in clinical and subclinical populations. This is remarkable as these populations are known to have stronger interpretation biases (see section 1.2.2).

The key theoretical question is this: How does CBM work? CBM was originally designed to be a cognitive training; the presumption was that CBM works by training people to interpret situations in a more positive and / or less negative way, which subsequently reduces negative mood. However, the causation between cognitive and mood changes has been a major point of debate. In particular, some suggested that changes in interpretation biases may have been mediated by mood changes instead. However, this hypothesis appeared to be unsubstantiated. First, many CBM studies have observed changes in interpretation biases without mood changes (e.g. Experiment 2 in Mathews & Mackintosh, 2000; Salemink, van den Hout, & Kindt, 2007b), suggesting that mood changes are not prerequisites for cognitive changes. Second, mediation analyses have illustrated that changes in trait

anxiety were mediated by cognitive changes (Salemink, van den Hout, & Kindt, 2010a). Third, studies using mood induction have shown that cognitive changes resulting from CBM training survived mood alteration (Salemink & van den Hout, 2010). The above therefore argued against the hypothesis that interpretation modification is mood-dependent.

If cognitive changes are not mediated by mood changes, what then are the mechanisms of change? Within this review, only one study (Hertel et al., 2011) was specifically designed to directly examine the change mechanisms. This study suggested that interpretation modification may work by reducing memory recollection for negative resolutions, although the results were confounded by a number of limitations (see section 1.3.3.1). Mathews and MacLeod (2000) suggested that repeated practice on accessing benign interpretations primes the cognitive process to select a benign over threatening meaning when encountering novel situations. However, some (e.g. Murphy et al., 2007) argued that the training effect is due to a similar process to conditioning (Rachman, 1977). In other words, some doubted whether participants have actually learned a new way to interpret ambiguous situations or whether they have simply been conditioned (via corrective feedback) to endorse a task-specific response. To illustrate that learning has taken place beyond conditioning, some studies have shown that the effects of CBM training could be generalised and transferred across environmental contexts (e.g. change in room, experimenter and setting, see Mackintosh et al., 2006) and domains (Salemink, van den Hout, & Kindt, 2010b). However, on the other hand, the cognitive effects of CBM were not replicated when interpretation biases were measured by tasks that did not resemble the training tasks (e.g. an implicit homograph task and questionnaires in Salemink, van den Hout, & Kindt, 2007a, a

vignette and video task in Salemink et al., 2010b). The evidence that the cognitive effects of CBM could not be generalised and transferred to other tasks lends partial support to the argument that participants may have simply learned a task-specific response.

While it remained unclear whether participants have learned a new way of interpretation or whether they have learned a task-specific response, it is clear that some kind of learning has taken place. The next question was therefore whether participants were consciously aware of the new 'rules' that they have acquired in the training procedure. Results were mixed. In Mathews and Mackintosh (2000), participants reported that they were not aware of the intention of the procedure, leading to the hypothesis that participants learn to apply the interpretation rule in an implicit way. This result also gave evidence that the effects of CBM were unlikely to be fully accountable by demand characteristics. By contrast, a later study found that participants were largely aware of the valence of their training materials; more importantly, this knowledge was found to partially mediate the cognitive effects of CBM (Salemink et al., 2007b). A recent review also suggested that for future clinical use, providing a clear rationale of the training may boost the benefits of the training (Beard, 2011).

In addition, recent research has also highlighted the important role of mental imagery in cognitive modification. In Holmes and Mathews (2005), participants listened to ambiguous situations resolved either positively or negative depending on training condition. Crucially, half of them in each condition were specifically asked to create mental imagery while the other half was asked to concentrate on the verbal meaning. Results suggested that mental imagery significantly increased the impact of negative training comparing with verbal processing. This evidence for the benefits of

mental imagery was later extended in a subsequent study where mental imagery was found to enhance the effects of positive training (Holmes, Mathews, Dalgleish, & Mackintosh, 2006). Mental imagery was also found to be more effective than verbal processing in protecting individuals against worsening of mood when challenged by a negative mood induction (Holmes, Lang, & Shah, 2009). This line of evidence was recently extended to clinical populations of depression and anxiety (Blackwell & Holmes, 2010; Lang, Blackwell, Harmer, Davison & Holmes, 2012).

Finally, it is important to note that CBM training for interpretation was shown to alter not only interpretation but also attention bias (Amir et al., 2010), suggesting that training effects are transferable across types of information processing. Two studies (Beard et al., 2011a; Brosan et al., 2011) also showed that CBM for interpretation and attention could be used in conjunction to maximise clinical impact, although it was unclear to what extent the benefits were attributable to each. Finally, these results showed a robust effect on interpretation bias despite the wide variation of training methods used, although it remains to be determined what the optimal training package is.

1.3.4.3 Clinical implications

That CBM can reduce symptoms up to two weeks is promising. Evidence appears to be particularly strong for reducing trait and social anxiety. However, it is not evident that CBM can protect participants against negative emotional and behavioural responses upon provocation, nor is the evidence sufficiently robust for specific phobia, panic disorder or other types of anxiety disorder. There have been encouraging results for depression, although evidence so far has been based on two studies only. To be clinically useful, the effects would eventually need to be

established outside the laboratory and beyond two weeks. Furthermore, CBM needs to be compared against active treatments such as Cognitive Behavioural Therapy or pharmacological treatment in terms of efficacy and cost-effectiveness. The current results show that this computerized training programme can be used by participants independently at home (e.g., Blackwell & Holmes, 2010; Lang et al., 2011), suggesting a high potential cost-effectiveness. Finally, there have been an increasing number of studies reporting feedback from participants, which revealed high levels of acceptability, although future studies will have to address some of the negative comments such as 'monotonous' and 'boring' (Beard et al., 2011a, 2011b; Blackwell & Holmes 2010; Brosan et al., 2011). This is important as acceptability and engagement are prerequisites for clinical application.

1.3.4.4 Conclusion and future research

In conclusion, research into the clinical and subclinical use of CBM for depression and anxiety is still at an early stage. Despite some promising evidence, results have been compromised by methodological limitations and thus need to be treated with caution until replicated. This review in particular highlighted three major gaps in research: First, there has been an alarming scarcity of CBM research for depressive symptoms or vulnerability. Second, this review identified only one study that examined the effects of CBM on children with subclinical symptoms of anxiety, highlighting the need to extend research into the younger age group. Last but not least, future research should seek to improve the measures for emotional vulnerability using both naturally occurring and experimental stressors. Indeed, the present thesis study was specifically conceptualised to address some of these issues.

This will be further described in the next and final section of this introductory chapter.

1.4 Thesis Investigation

Taken together, the above sections of this chapter illustrated a volume of literature in support of the hypothesis that cognitive biases are trait vulnerability markers preceding depression and anxiety (section 1.2). Recent development of CBM targeting on modifying these biases, especially interpretation biases, has yielded promising results, although further research is warranted to clarify the inconsistent findings regarding the training effects on mood and vulnerability. Our systematic literature review (section 1.3) further highlighted the potential of CBM to be developed as a therapeutic tool, but the findings so far have been concentrated on adults. As noted in a previous study: 'given developmental differences in cognitive maturation between adolescents, adults, and children (Blakemore, 2006, 2008), we cannot necessarily expect the same pattern of results to emerge in response to training in adults and children as in adolescents.' (Lothmann, Holmes, Chan, & Lau, 2011, p.25). Therefore, this final section of the Introduction will briefly review the evidence for interpretation biases in youth (section 1.4.1), followed by the studies examining the effects of CBM in this age group (section 1.4.2).

1.4.1 Interpretation biases in youth

Despite the relative scarcity of studies in youth comparing with adults, interpretation biases have been associated with symptoms of and risk for depression and anxiety in children and adolescents.

Specifically, Dearing and Gotlib (2009) illustrated that girls at risk for depression were more likely to make negative interpretations of ambiguous emotional information than girls at lower risk for depression. Here the vulnerable group consisted of 10 – 14 year old daughters of depressed mothers, whereas the comparison group consisted of girls of mothers with no history of depression. This risk factor was appropriately chosen based on the strong evidence that suggests parental depression as a risk factor for depression (Gotlib & Goodman, 1999); however, the authors also acknowledged that parental depression could also elevate risk for other types of psychopathology (Weissman et al., 2006) thus the results may not be exclusive to depression. One major limitation was that interpretation bias was only tested after a negative mood induction; it was therefore unclear whether vulnerability *per se*, without experimentally induced depressive mood, is associated with negative interpretation biases. In addition, a number of studies have illustrated negative interpretation biases in children and adolescents with clinical levels of anxiety. In Taghavi, Moradi, Neshat-Doost, Yule, & Dagleish, (2000), children and adolescents (age 8 – 17) with clinical diagnosis of GAD were asked to generate sentences using homographs (i.e. words that have both positive / neutral and negative meanings, such as 'hit' and 'tank'). Comparing with the non-clinical control group, these anxious youth generated more sentences consistent with negative interpretations. Consistent with this, the level of self-rated trait anxiety was found to be correlated with negative interpretation biases measured by a pictorial homograph task in a non-selected sample of typically developed children (age 7 – 9; Hadwin, Frost, French, & Richards, 1997). This association between trait anxiety and interpretation biases was similarly observed in Chorpita, Albano, & Barlow (1996).

Apart from homographs, interpretation biases could be indicated using ambiguous scenarios. For example, Barrett, Rapee, Dadds, & Ryan (1996) asked anxious children to interpret ambiguous situations and devise a behavioural plan. Results suggested that, comparing with non-clinical control participants, anxious children were more likely to interpret situations as threatening and subsequently more likely to adopt avoidant behavioural plans. Interestingly, interpretation biases appeared to be enhanced after interaction with parents indicating a role of family interactions in the cognitive processing of anxious children. Using the ambiguous scenarios approach, the role of interpretation biases has been demonstrated across different forms of anxiety. In particular, adolescents with elevated symptoms of social anxiety have been shown to be biased towards negative interpretations of ambiguous situations depicting social interactions comparing with adolescents with average level of social anxiety (Miers, Blote, Bogels, & Wastenberg, 2008). This tendency to interpret ambiguous situations in a negative way was also observed in children and adolescents with separation anxiety, social anxiety, and GAD (Bogels & Zigterman, 2000). Findings regarding the presence of interpretation bias in these three anxiety conditions were further extended in Waters, Graske, Bergman, & Treanor (2008). In this study, youth (7-12 years old) with separation anxiety, social anxiety and GAD were compared with an at-risk group (youth with parents who have anxiety disorders) and a non-clinical control group. Participants listened to ambiguous situations and were asked to rate the extent to which they thought each of the situations was dangerous; they were also asked to anticipate their emotional responses and their ability to deal with the situations if they happened to them in real life. Results suggested that those who had an anxiety disorder anticipated more negative emotions and less ability to cope with the situations comparing with the

other two groups (which did not differ from each other). The study therefore concluded that interpretation bias might be more a characteristic of current experience of anxiety rather than a vulnerability marker. By contrast, in a longitudinal study, interpretation biases were found to predict post-traumatic stress disorder symptoms in children prospectively (Ehlers, Mayou, & Bryant, 2003), thus supporting the claim that interpretation bias plays a role in the development of vulnerability.

The above studies investigated interpretation bias across a wide age group. It should be noted that, although interpretation bias has been indicated in both children and adolescents, research has suggested that age moderates the relationship between negative interpretation bias and anxiety such that the link appears to be stronger in older children and adolescents (above 11 years) than in the younger group (Cannon & Weems, 2010; Weems, Berman, Silverman, Silverman, & Saavdra, 2001). The clinical implication is that techniques designed to reduce depression or anxiety through reducing interpretation biases, such as CBM, are likely to be more effective in adolescents than in younger children.

1.4.2 CBM research on unselected youth population

Our systematic review indicated only one CBM study on children with elevated symptoms (Vassilopoulous et al., 2009). Even when unselected samples were included, only a handful of studies were found. Specifically, the effects of CBM on interpretation bias were replicated in four separate studies with healthy children (Lester, Field, & Muris, 2011a; Lester, Field, & Muris, 2011b; Muris, Huijding, Mayer, & Hameetman, 2008; Muris, Huijding, Mayer, Remmerswaal, & Vreden, 2009).

In Muris et al., 2008, 8-12 year old children were allocated to receive either positive or negative interpretation training in the context of a hypothetical space journey ('space odyssey'). Similar to the CBM paradigm used in adult studies, children were presented ambiguous scenarios. Each scenario was followed by two outcomes, depicting a positive and a negative resolution of the scenario. Children in the positive training condition received feedback of 'good' every time they endorsed the positive outcome, whereas those in the negative condition were reinforced to endorse the negative outcome. Results suggested that children in the negative condition perceived more threat in new ambiguous situations, suggesting that children, like adults, could be trained to make positive or negative interpretation. This training effect was found to be more prominent amongst those who had higher levels of anxiety. However, this study did not assess interpretation bias at baseline. Extending on this study, Muris and colleagues conducted a subsequent study; this time pre- and post- measures were included as well as a measure for avoidance tendency (Muris et al., 2009). Results showed that positive training led to a decrease in interpretation bias *and* avoidance tendency, whereas the negative training led to an increase in both. However, the authors acknowledged that the effect sizes were small. Unlike Muris et al., 2008, anxiety level was not indicated as a moderator in this study. Overall, the key criticism was that the ecological validity for this 'space odyssey' paradigm was doubtful; while the context of space journey might have helped engaging children, it was unclear whether children could transfer their learning to real life situations. In addition, the training effects on mood were not assessed, and results concerning the role of anxiety on training effects were mixed. Using one session, these studies were not able to test out the durability of the training effects.

In a study investigating the effect of interpretation training on animal fear (Lester et al., 2011a), the space odyssey was modified to present scenarios involving Australian marsupials. The training effect on interpretation bias was replicated; this study further suggested that positive training reduced behavioural avoidance assessed by a stress-evoking behavioural avoidance test. However, this benefit did not translate into reduction of anxiety or physiological response (measured by heart rate) towards the stressor. In a separate study conducted by the same research group (Lester et al., 2011b), participants were recruited across a wider age group (7 – 15 year old) and training materials involved scenarios targeting on both animal fear and social anxiety. Training effects on interpretation biases were again replicated. In particular, younger participants (age 7-10) were found to be more susceptible to the training that induced animal fear, whereas older participants (age 11-15) were more prone to acquire biases for social scenarios. This pattern of results highlighted that training materials need to be consistent with the type of anxiety that is age-sensitive. However, this study did not yield evidence for changes in mood or stress reactivity despite using two separate stressors.

The scarcity of CBM research is equally obvious in adolescent populations. So far, no study has tested the effects of CBM on adolescents at risk for emotional disorders. However, four studies have published results providing evidence that CBM could be used in this age group (Lau, Molyneaux, Telman, & Belli, 2011; Lothmann et al, 2011; Salemink & Wiers, 2011; Salemink & Wiers, 2012). All these studies employed the CBM training used in the original study (Mathews & Mackintosh, 2000) with scenarios adapted for use with younger people.

Lothmann et al., 2011 was the first CBM study to report that after positive training adolescents showed more positive and fewer negative interpretations

comparing with those who received negative training. This study also showed that positive training reduced negative affect. The negative training also appeared to reduce positive affect, although this effect was only significant amongst male participants suggesting that gender acts as a moderator of training effects on mood. By contrast, trait anxiety was not indicated as a moderator in this study. In a subsequent study using a similar design (Lau et al., 2011), the effect on interpretation bias was replicated. However, positive training was not shown to cause mood changes. Instead, negative training was found to reduce positive affect amongst those with low self efficacy scores, highlighting the moderating role of self efficacy in training effects. Again, trait anxiety was not indicated as a moderator. This second study was based on a small sample (N = 36), thus it was not clear whether it was sufficiently powered. These studies were valuable in extending the CBM research into adolescents. However, a number of key methodological limitations were indicated. First, there was no baseline measure of interpretation bias; second, mood was only measured by simple visual analogue scales rather than standardised instruments; third, training effects on stress reactivity were not tested; and finally, there was no follow-up assessment giving no indication for the potential durability of the training effects. These methodological limitations greatly weakened the validity and generalisability of the findings

Improving upon these studies, Salemink and Wiers (2011) employed a pre- and post- measure of both interpretation bias and state anxiety. Instead of comparing between positive and negative training conditions, this study compared positive CBM training with a placebo-controlled group. In line with the adult literature, this study showed that CBM was effective in facilitating positive and reducing negative interpretations. However, there was no effect on state anxiety. Further analyses

indicated baseline interpretation bias as a moderator such that the training effect was more prominent amongst those with higher levels of baseline bias. Similar to the above two adolescent studies, there was no evidence for trait anxiety acting as a moderator. However, again, this study did not test the effects of CBM on stress reactivity, nor did it examine the effects beyond a single session.

Using a subgroup of the above sample, Salemink and Wiers (2012) investigated the effect of regulatory control by administering the Stroop Task before and after training. As expected, this subgroup replicated the effect of CBM on interpretation bias. In addition, this study showed that threat related interpretation bias was most prominent amongst adolescents who had low levels of regulatory control *and* high levels of state anxiety; these adolescents also appeared to benefit most from CBM training. This study was the first adolescent study to move beyond a comparison between CBM and control condition by being specifically designed to investigate potential moderators. However, this study suffered methodological limitations such as the lack of follow-up assessments.

Taken together, the findings with the younger population replicated adult literature in suggesting that interpretation bias is modifiable; however, the effects on mood and vulnerability remained inconsistent. Notably, no adolescent studies recruited based on elevated symptoms of or risk factors for anxiety or depression. However, analyses were performed to compare between those who had higher vs. lower scores on trait anxiety (Lau et al., 2011; Salemink & Wiers, 2011), baseline negative interpretation bias (Salemink & Wiers, 2011), and self-efficacy (Lau et al., 2011). As mentioned above, the effects of CBM were more pronounced amongst adolescents who have lower scores on self-efficacy and higher levels of baseline negative interpretation; these findings lend preliminary support for the potential of

CBM to be developed as a preventive intervention for adolescents at risk, but they should be treated with caution until further replicated. Nevertheless, given the overall scarcity of research on youth, the relatively patchy pattern of results (especially around mood and vulnerability), and the various methodological limitations of previous studies, the effects of CBM on this age group need to be further replicated and extended before more definitive conclusions could be drawn.

1.4.3 Thesis investigation and research hypotheses

Therefore this study set out to further examine effects of CBM on adolescents. To address the limitations highlighted above, this study broadened the range of outcome measures to include not only interpretation biases and mood states, but also reactivity to stress both experimentally induced and naturally occurring outside the laboratory. These were assessed across three time points to enable comparison between baseline, immediately post-intervention and one week follow-up, with the latter included to test out the durability of the effects. Feedback was also collected to examine acceptability and identify areas for future improvement. A control group that received parallel sessions of placebo training was included to rule out unspecific effects of time. A non-selective sample of healthy adolescents aged 16 to 18 with no self-reported history of mental health illness was recruited and randomised to investigate the above. Based on the above, the key hypotheses were as follows:

1) ***Effects of CBM on Interpretation Bias:*** Compared with the control group, the CBM group would show a greater increase in positive interpretations and / or a greater reduction in negative interpretations following intervention.

2) ***Effects of CBM on Depression, Anxiety, and Affect***: Compared with the control group, the CBM group would show a greater reduction in depression, anxiety and negative affect, as well as a greater increase in positive affect following intervention.

3) ***Effects of CBM on Stress Vulnerability***: Participants in the CBM group would display a more positive response towards the experimental stressor (i.e., endorse more benign interpretations and report more positive affect and / or less negative affect). In addition, the CBM group would rate their mood more positively and report fewer stressful events during the follow-up period than the control group.

4) ***Role of Neuroticism***: One objective of this study was to explore whether CBM could be developed as a preventive tool for adolescents at risk for developing depression, by virtue of high neuroticism. Given that no previous research has investigated the effects of CBM on adolescents with high neuroticism, this study did not make specific hypotheses regarding the role of neuroticism. However, the key questions were:

    a) Would CBM be effective in modifying interpretation bias, mood, and stress vulnerability in participants with high neuroticism scores?

    b) Would the effects of CBM be moderated by the level of neuroticism?

CHAPTER TWO

Method

2.1 Design Overview

This study adopted a randomised between-groups experimental design with three time points. A sample of adolescents aged 16 to 18 years were recruited and randomised into receiving either two sessions of CBM training or control condition on consecutive days. Their interpretation biases and mood were assessed at baseline before the intervention (Time 1), immediately after the final session of the intervention (Time 2), and 1 week after the final session of the intervention (Time 3). To examine the effects of training on stress vulnerability, participants were exposed to a controlled experimental stressor after Time 2 assessment and their interpretation of, and emotional reaction to, the stressor were measured. In addition, during the week between Time 2 and Time 3, participants were asked to give daily self-ratings of their mood and report any positive or negative events that they experienced on each day via email or mobile phone text messages. In summary, the key independent variable was the type of intervention (CBM vs. control), and the dependent variables were interpretation bias, mood (depression symptoms, state anxiety, trait anxiety, positive and negative affect), stress vulnerability measured by reaction to experimental stressor (interpretation of stressor and emotional responses to stressor), and stress vulnerability measured by reaction to naturally occurring stress (daily reports of mood and positive and negative events).

2.2 Participants

2.2.1 Inclusion and exclusion criteria

Adolescents aged 16 to 18 who had the capacity to consent were considered eligible. Those who reported having any current or past diagnosed psychological disorders were excluded as these individuals might represent a different population to the one being targeted here. This study also excluded those who reported having severe reading difficulties or those who did not possess sufficient fluency in English to complete the tasks. These criteria were determined based on self-reports on the Screening Questionnaire (see below for details).

2.2.2 Screening and recruitment

Recruitment took place from a sixth form college in Cambridgeshire, UK. To advertise the study, the experimenter went to the college and gave a presentation about psychology and talked to the students about this study. A poster was put up on students' notice boards. The poster, together with the information sheet, was also circulated by email from the Head of Psychology to all the students (see Appendix A and B).

Interested students were asked to fill in a short Screening Questionnaire through the SurveyMonkey website to screen for eligibility. Specifically, this included questions about demographic information, history of psychological disorders or reading difficulties, self-perceived fluency in English, and the 12-item Neuroticism Scale of the Eysenck Personality Questionnaire (EPQ; Eysenck & Eysenck, 1975; see Appendix C). The adult version of EPQ was employed as it has

been shown to be a more reliable measure of neuroticism in this age group than its junior version (Pearson & Francis, 1984).

Out of the 149 students who filled in the questionnaire, six students were excluded due to self-reported reading difficulties or past diagnosed psychological disorders (three per each category). The remaining students were invited to participate in the study.

2.2.3 Sample size

The final sample consisted of 74 students (age range = 16 – 18, mean = 16.64, SD = 0.67). They gave written informed consent to participate in the study (see Appendix D). The majority were female (n = 67; 90.5%), ethnically White (n = 70; 94.6%), and considered English as their first language (n = 68; 91.9%). The mean neuroticism score was 5.36 (SD = 3.03). All of them reported themselves as 'fluent in English'.

To explore the role of neuroticism, at the second stage of the analyses, participants were divided into high neuroticism and low neuroticism subgroups using median split. Thus, the high neuroticism subgroup consisted of 37 participants with neuroticism scores above median, whereas low neuroticism subgroup consisted of the 37 participants with neuroticism scores below median.

2.2.4 Power calculation

The above sample sizes were determined using power calculations. For the overall non-selected sample, a power calculation was performed based on two previous CBM studies with adolescents using similar training materials (Lau et al., 2011; Lothmann et al., 2011). Both studies reported a large effect size ($d > 1.03$),

suggesting that a minimum of 14 participants per group (i.e. 28 participants in total) is required to reach a power of 0.8 as conventionally agreed to be acceptable (Howell, 2002).

In addition, to examine Hypothesis IV regarding the role of neuroticism, some analyses were conducted within the high neuroticism subgroup. A separate power calculation was performed to estimate the size required for this sub-sample. No previous CBM research has been conducted with adolescents with high neuroticism or other high risk factors; power calculation was therefore based on an adult study with anxious participants (Murphy et al., 2007). The calculation suggested that 10 participants per group are required to reach a power of 0.8.

Due to a possible publication bias in favour of reports with large effect size and concerns over attrition, this study therefore recruited beyond these limits.

2.2.5 Randomisation

Participants were randomised into receiving either two sessions of CBM training ('CBM group') or parallel sessions of control training ('Control group'), stratified by gender and neuroticism score, using a block randomisation approach with a computerised random number generator. The two groups were matched in age, gender, ethnicity, neuroticism scores, and language use (all p's > .12; see Table 2.1).

Table 2.1

Demographic Characteristics of the CBM (*n = 37) and Control* (*n=37) Groups*

Variable	CBM	Control	*t* or *z*	*P*
Categorical Variables				
Gender - Female	32 (86.5%)	35 (94.6%)	1.19	.23
Ethnicity - White	34 (91.9%)	36 (97.3%)	1.03	.30
English as first language	33 (89.2%)	35 (94.6%)	0.85	.40
Numerical Variables				
Age	16.51 (0.69)	16.76 (0.64)	1.57	.12
N Scores	5.49 (3.16)	5.24 (2.93)	0.34	.73

Note. For categorical variables, values represent number of participants and percentage (in brackets), and *z* was reported. For numerical variables, values represent group means and standard deviations (in brackets), and *t* was reported.

2.3 Intervention

2.3.1 CBM training

This study employed a modified version of the original CBM paradigm (Mathews & Mackintosh, 2000) specially adapted for use with adolescents with themes relating to peer and romantic relationships as well as educational and recreational achievements (Lothmann, et al., 2011). Two matched gender-specific versions were used for male and female participants. Based on evidence that imagery can enhance the effects of CBM (Holmes et al., 2006), each session started with a short 'imagination exercise', which asked participants to imagine biting into a

lemon. Participants were reminded regularly throughout the task to imagine the scenarios '*as happening to yourself*'.

The actual training phase started with a practice trial to help participants familiarise themselves with the task procedure. After that, participants read a series of ambiguous scenarios on a computer screen each ending with a word fragment. In the CBM training, the word fragment resolved the ambiguity in a positive way. For example: '*It is the first day of term. Your new teacher asks everyone to stand up and introduce themselves. After you have finished, you guess the others thought you sounded…*' followed by a word fragment '*cl-v-r'* (clever). Participants completed the word fragment by typing in the first missing letter, and then answered a 'comprehension question' designed to emphasise the positive resolution of the situation. With the above example, the comprehension question was '*Do you feel unhappy with your introduction?*' This question could only be answered correctly (in this case '*No*') if the ambiguous situation had been interpreted in the positive direction. Immediate feedback was given ('*Correct!*' or '*Wrong*!') to facilitate learning.

The training task was designed such that participants had to type in the first correct letter of the word fragment in order to proceed to the next trial; the accuracy for completing word fragments was therefore by default 100%. Training performance was thus measured by the remaining three variables across two training sessions: the accuracy for comprehension questions (percentage correct), reaction time for comprehension questions and reaction time for word fragments.

Training was self-paced and delivered across two sessions, each consisting of 40 training scenarios plus 8 'distractor' scenarios. The latter prompted participants to make neutral or negative interpretations, and were added to make the purpose of the

training less explicit (Lothmann et al., 2011; Mathews & Mackintosh, 2000). Thus, a total of 96 items were used. They were presented in a random order and across 4 blocks in each session to allow participants to take a short break in-between. All materials were presented on computers using E-Prime 2.0 software, which also recorded responses automatically.

2.3.2 Control condition

Participants in the control group received two parallel sessions of 'placebo training'. They were presented with the same scenarios as in the experimental group, except that this time the emotional ambiguity of the scenarios was *not* resolved. Using the above example of *'The first day of term'*, the matched control scenario was: '*It is the first day of term. Your new teacher asks everyone to stand up and introduce themselves. After you have finished, another person gets up to*' followed by a word fragment '*s-eak*' (speak). The corresponding comprehension question was '*Is it the first day of term?*' These items were developed to keep the valence of the items neutral, such that participants were not coached to interpret the ambiguous situations in any specific direction. This control training was intended to ensure that participants from the two groups were exposed to the similar materials and engaged in the same level of attention, activity, cognitive efforts, and time commitment.

2.4 Measures

2.4.1 Measures for interpretation bias

Interpretation bias was assessed using the Recognition Test in the original CBM paradigm (Mathews & Mackintosh, 2000) with materials again adapted for use

with adolescents (Lau et al., 2011; Lothmann et al., 2011). To reduce practice effect and repetition of materials, two matched sets of materials (versions A, B) were used in a counterbalanced order (ABA vs. BAB). Specifically, half of the participants from each intervention group were given Version A for the Time 1 assessment, followed by Version B at Time 2 and Version A again at Time 3. During the test, participants were first required to read a series of ambiguous situations similar to those in the training. This time a title was given to each scenario to facilitate later recognition, and participants were asked to pay particular attention to them. Similar to the training, participants were asked to imagine that each situation was happening to them. However, this time the word fragment did not disambiguate the situation. For example: '***Huge Party:*** *One of the most popular kids at class is going to have a huge party at his house this Friday. Your friend calls and asks whether you are going. You go to facebook to see whether he has sent you an inv-t-tion (invitation).*' Likewise the comprehension question did not emphasise the emotional meaning of the situation: '*Is one of the popular kids having a huge party this Friday?*'

In the subsequent recognition phase, participants were shown the titles of the scenarios again, each followed by 4 'recognition statements'. None of these statements used the exact words of the scenarios as previously presented but conveyed similar meanings. Two statements comprised 'targets' representing either a positive ('*You go to your profile and see that he has sent you an invitation*') or negative ('*You go to your profile and see he has not sent you an invitation*') interpretation. The other two statements, known as 'foils', were statements that conveyed similar emotional valence as the 'targets' but included information that was not explicitly given in the scenarios. The positive and negative foils for this sample item were, respectively, '*You go to your profile and see that he has sent you*

a friend request' and '*You go to your profile and see he has removed you from his list*'. Participants were asked to rate the similarity of each sentence to the scenarios previously presented on a 4-point scale ranging between '1 = not similar at all' and '4 = very similar'. A positive interpretation bias would be indicated by higher ratings for the positive than negative targets. The foil statements were designed to differentiate whether the training specifically modifies interpretation styles or whether it facilitates a general response bias towards valenced information (Mathews & Mackintosh, 2000). Thus, higher ratings for positive than negative foils would represent a general bias favouring positive information. All materials were presented on computers with E-Prime 2.0 software, which automatically recorded responses.

2.4.2 Measures for depression, anxiety, and affect

Three questionnaires were used; all were self-administered and each required only about 5 - 10 minutes to complete.

The Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) consists of two 10-item mood scales developed to provide brief measures of positive affect (PA) and negative affect (NA). Respondents rate the extent to which they are currently experiencing each particular emotion on a 5-point scale (1 = 'very slightly or not at all' vs. 5 = 'extremely'). These are summed up to give a Positive Affect Score and a Negative Affect Score; each ranges from 10 to 50 with higher scores representing higher levels of positive and negative affect respectively. Both scales have demonstrated acceptable reliability (Cronbach's α = .84 - .90), although the test-retest reliability was within a lower range (r = .39 - .71). The convergent validity was good (r = .89 - .95). Whereas the NA scale was positively correlated with established mood measures such as the Beck Depression

Inventory and the Spielberger State – Trait Anxiety Scale (*r's* ≥ .51), the PA scale was inversely correlated (though less strongly) with these measures (*r's* ≥ .35). The low inter-correlation between the two scales (r's ≥ .23) suggested reasonable discriminative validity and that the two scales are largely independent (Watson et al., 1988). In addition to the acceptable psychometric properties reported above, it was deemed to be an ideal measure for this study as it has been used in clinical research (e.g., Blackwell & Holmes, 2010) and studies with young people (e.g., Lothmann et al., 2011) and is quick and simple to use.

The Beck Depression Inventory, second edition (BDI - II; Beck, Steer, & Brown, 1996), is a 21-item scale measuring symptoms of depression validated for use with individuals aged 13 - 80. It is widely used both for clinical and research purposes, with scores indicative of severity of depression (0 - 13 = 'minimum'; 14 – 19 = 'mild'; 20 - 28 = 'moderate'; and 29 - 63 = 'severe'; Beck et al., 1996). Robust reliability and validity have been established, with excellent internal consistency (α = .91 for outpatients and .93 for college students), test-retest reliability (*r* = .93), and strong correlation with other measures of depression such as the Hamilton Depression Rating Scale (*r* = .71) (Beck et al., 1996).

The Spielberger State and Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) consists of two 20-item scales measuring, respectively, anxiety at a specific moment ('state anxiety') and anxiety as a general trait ('trait anxiety'). The State Anxiety and Trait Anxiety scores each range between 20 and 80, with higher scores representing higher levels of anxiety. Although reports of the psychometric information for this measure are not as complete as for the measures above, there has been sufficient evidence to suggest that this is a reliable and valid instrument. The test-retest reliability for the Trait scale (*r* = .86) was higher

than that for the State scale (r = .40 - .54), reflecting the different nature of anxiety measured by the two scales (Rule & Traver, 1983; Spielberger et al., 1970). Concurrent validity was also evidenced by a high correlation with other anxiety measures such as the Manifest Anxiety Scales (r = .85).

2.4.3 Measures for stress vulnerability

To examine training effects on stress vulnerability, participants' responses under provocation of two types of stressors were observed.

First, a controlled **Experimental Stressor** was used to observe participants' emotional reaction to, and interpretation of, real life ambiguous situations. It was designed specifically for this study to be a real life analogue to the training materials. Experimental stressors used in previous studies were deemed to be unsuitable as they mostly targeted anxiety. After the Time 2 assessment of mood and interpretation bias, participants were told that the computer will now analyse their data. After a brief pause, an error message was shown on the computer screen saying that '*We are sorry but we were unable to analyse your data. There is a possibility that some or all of your responses have not been properly recorded. This is a very unusual problem*'. This message was designed to be ambiguous and could be interpreted in a negative or benign way. Participants' interpretation of, and their emotional reaction to, this situation was subsequently measured. Specifically, participants were shown five possible explanations of why this error might have occurred and asked to rate on a 4-point scale how likely they think each of the explanations is ('1 = not at all likely' vs. '4 = very likely'). Three of the options represented negative interpretations by implying that it might be the participant's fault ('*You have not followed the task instructions correctly*', '*You have accidently pressed a button to delete the*

responses', '*You took too long to complete the task – time out*'), whereas the remaining two were benign interpretations ('*There was a temporary power cut*', '*This was a random hardware error*'). These statements were presented in a random order. To mask the true experimental purpose, the instruction was worded as a request to help experimenters to identify the problem '*While we are trying to recover your data, please could you answer a few questions to help us to identify the cause of the problem*.' The average ratings for the positive and negative statements (separately) were used as the outcome variables. In addition, emotional responses were measured by a subset of five items drawn from the PANAS (two from the PA scale: *Proud*, *Excited*; and three from the NA scale: *Distressed*, *Nervous*, *Guilty*). These items were specifically chosen for their potential relevance to the situation. As in PANAS, participants were asked to rate the extent to which they experienced each emotion at the moment on a 1 to 5 scale (1 = 'very slightly or not at all' vs. 5 = 'extremely'). Average ratings were calculated separately for the positive and negative affect. Towards the end of the session, a positive message appeared to neutralise any negative emotions caused by the stressor (see 'Ethical Considerations' below for details). This experimental stressor was used for an exploratory purpose; it was beyond the scope of this study to carry out formal validation prior to data collection. This will be further discussed in Chapter Four.

In addition to the experimental stressor, this study also included **a follow-up period** to examine the training effects on participants under the provocation of naturally occurring stress. In the week following the training phase, participants were asked to rate how they felt on each day using a 5-point scale (1 = 'completely miserable or stressed'; 2 = 'a bit miserable or stressed'; 3 = 'OK'; 4 = 'quite good'; 5 = 'really good'). Participants were also asked to give a short description of any

events that ‘made you feel particularly good or bad’. These were reported via email or mobile phone text messages, according to individual preferences, with a reminder sent by the experimenter on each day at 18:45 ± 30 minutes.

2.4.4 Feedback

To explore the acceptability of the CBM training and the other procedures used in this study, participants were asked to fill in a feedback form specifically developed for the purpose. This short questionnaire elicited both quantitative and qualitative comments. First, participants were asked to rate the extent to which they agreed with a list of three positive (‘fun’, ‘interesting’, ‘helpful’) and five negative (‘boring’, ‘harmful’, ‘dull’, ‘distressing’, ‘pointless’) descriptions of the study on a 5-point scale (1 = ‘very slightly or not at all’ vs. 5 = ‘extremely’); these descriptions were selected to be consist with the themes that had emerged from participants’ comments in previous studies (Beard et al., 2011b; Brosan et al., 2011).
Second, to establish whether participants were aware of the true purpose of the computer tasks, they were given a list of six possibilities (‘spelling’, ‘memory’, ‘concentration’, ‘interpretation of situations’, ‘reading speed’, and ‘others’) and asked to ‘tick’ all the categories that they think the computer tasks aim to measure. Finally, the feedback form asked participants whether they would recommend their friends to participate in the study, what they liked best about the study, what they liked least about the study, and if they have any other comments (see Appendix E).

2.5 Ethical Considerations

This study was approved by the Faculty of Medicine and Health Sciences Research Ethics Committee of the University of East Anglia (see Appendix F). The

recruitment procedure detailed above was intended to ensure that participants consented to the study entirely voluntarily without feeling pressured, and that they were fully informed. All data were kept confidential according to the requirements of the Data Protection Act. The intervention involved participants reading ambiguous situations and completing word fragments to resolve most of the situations in a positive (CBM group) or neutral (control group) way. The acceptability of this paradigm has been demonstrated in previous studies with clinical samples (Blackwell & Holmes, 2010; Brosan et al., 2011) and especially with this age group (Lau et al., 2011; Lothmann et al., 2011). Standardised brief self-rating scales were used for mood assessment; these have been widely used for research with both healthy volunteers and vulnerable samples. To neutralise any negative emotions caused by the experimental stressor, participants received the following positive message at the end of that session: '*We have now successfully recovered all your data. It was due to a random hardware error. Please be assured that it is* ***not*** *due to any mistake on your part. We do apologise for any inconvenience. If you wish to discuss this further, please let the experimenter know*.' This message was reinforced in the final debriefing form provided at the end of the study (see Appendix G). No participant raised any concerns. Thus, although this stressor might have caused uneasiness to participants, the impact appeared to be short-lived and of a mild intensity as intended. Participants were advised to talk to their parents, teachers, or GP should they have any concerns over their wellbeing; they were also given information about local services for young people (see Appendix H). In the Information Sheet, participants were given contact details of the experimenter and her supervisor, as well as information about how to raise a formal complaint should they have any concerns.

2.6 Procedure

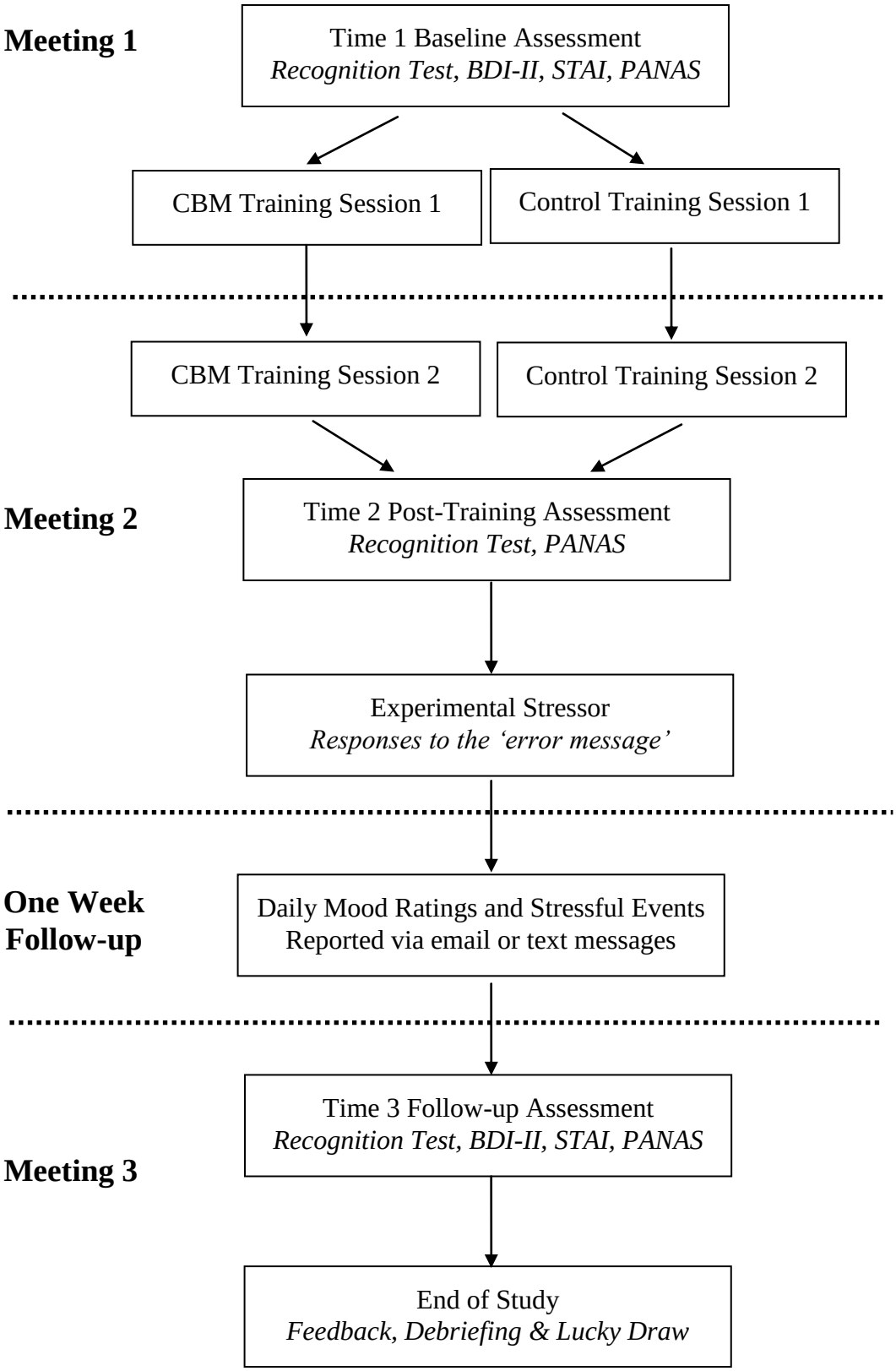
The overall procedure is shown in Figure 2.1. Participants met with the experimenter three times over two weeks. The first two meetings were held on consecutive days, although four participants (two from each group) attended them within the same day due to scheduling problem. At the first meeting (Time 1), participants were first required to complete the baseline assessment of interpretation bias using the recognition test and mood using the PANAS, STAI, and BDI-II. They then underwent the first session of the intervention (either CBM training or control condition). At the second meeting (Time 2), participants started by completing the second and final session of the intervention, followed by the post-intervention assessment of interpretation bias using the recognition test and mood using the PANAS. The other two measures, BDI-II and STAI, were not used here because these measures were not designed for repeated use within such a short period of time. After that the experimental stressor was administered. During the following week, participants were contacted on each day either by email or mobile phone text message (depending on indicated preference) to give daily self-ratings of mood and report any specific events. This procedure was explained to the participants at the end of the second meeting, both verbally and in writing (see Appendix I). The follow-up meeting took place one week after the intervention (Time 3), during which participants' interpretation bias using the recognition test and mood were again assessed using the PANAS, STAI, and BDI-II. Participants were then asked to complete the feedback form, thanked for their participation and received the debriefing form. The tasks were self-paced; on average the first two sessions lasted for about 35 minutes each, and the last session about 20 minutes. Participants were

not paid, but they were entered into a lucky draw for a £100 retail voucher when they completed the study.

All sessions were carried out by the same experimenter and took place in small groups (size ranging between 1 and 10) at a computer laboratory of the participants' college during their free time. All computer tasks were completed using college computers. Participants were discouraged from talking to each other during the sessions or discussing the study outside the sessions, and the seating was arranged such that they could not observe each other's responses. These were to protect confidentiality and to prevent potential collusion. Participants were blinded to the experimental condition to which they were assigned. Complete blinding of the experimenter was not feasible as the author was the only researcher in this study. To reduce experimenter bias, participants were given a sealed envelope which contained their Participant Identity Number and the group they were assigned to (labelled by a letter) and instructed to access the appropriate computer task independently. Likewise, the mood questionnaires were self-explanatory and thus did not require involvement of the experimenter. Thus, although the experimenter was present, participants completed all the components of the experiment autonomously. Notably, more than 10 participants sought advice from the experimenter when the error message appeared (as part of the experimenter stressor). In these instances, the experimenter responded with the same script by advising participants to follow the instructions from the computer with a neutral tone of voice and facial expression.

Figure 2.1.

Procedure Overview



2.7 Data Analyses

Data analyses were conducted using SPSS v 18.0. Statistical significance was defined as $p < .05$ (two tailed). Assumptions for parametric tests, normality and homogeneity of variance, were checked across the entire sample and within each experimental group using histograms, Kolmogorov-Smirnov tests and Levine tests. Whenever normality assumption was violated, data were transformed to normality using methods that were appropriate to the specific distribution of the data. If unsuccessful, non-parametric tests were used. Boxplots were used to screen for outliers. Data analyses are briefly outlined below; more details will be provided in the relevant sections in the next chapter on Results.

At the first stage of analyses, independent samples *t* tests were used to compare the two groups in terms of their baseline measures of mood and interpretation bias. Correlations between these baseline variables were also explored. Analyses were then carried out to examine the training performance. Each of the three outcome variables (accuracy and reaction time for comprehension questions, and reaction time for completing word fragments) was analysed using a repeated measures ANOVA with one between-subjects factor (Group: CBM vs. Control) and one within-subjects factor (Time: Session 1 vs. 2).

To test Hypothesis I regarding the training effects on interpretation bias, similarity ratings for target and foil statements in the Recognition Tests were analysed using a repeated measures ANOVA with two between-subjects factors (Group: CBM vs. Control; Order: ABA vs. BAB) and three within-subjects factors (Time: T1 vs. T2 vs. T3; Type: target vs. foil; Valence: positive vs. negative).

To test Hypothesis II regarding the training effects on mood, each of the outcome measures (BDI-II, STAI - State and Trait, PANAS - PA and NA) was

analysed with a repeated measures ANOVA with Group as the between-subjects factor and Time as the within-subjects factor.

To test Hypothesis III regarding the training effects on stress vulnerability, the two groups were compared, using independent samples *t* tests or Mann-Whitney *U* Tests (for non-parametric data), in terms of their interpretation of and emotional responses to the stressor, as well as their daily mood ratings and the number of positive and negative events reported during the one week follow-up period.

Finally, to explore the role of neuroticism, three analyses were performed: first, the above hypotheses were tested within a subgroup of participants with high neuroticism score (High N subgroup); second, this High N subgroup was compared with the Low N subgroup by repeating the above analyses with this variable of N as an additional between-subjects factor. Third, correlations were examined between N score and the training effects.

Significant interactions were followed up by independent or paired samples *t* tests (or non-parametric equivalence, i.e., Mann-Whitney *U* Tests or Wilcoxon Signed Rank Tests) for comparing between-subjects and within-subjects factors respectively. Effect size (Cohen's *d*) for the key findings was reported.

Preliminary analyses revealed that one participant (CBM group) performed very poorly in both training sessions (accuracy for comprehension questions > 3 standard deviations below mean). Low accuracy suggests that this participant might not have received the training as intended (either through disengagement or insufficient understanding of the task demand); this participant was therefore excluded from all analyses regarding training effects. Furthermore, one participant (Control group) did not attend Training Session 2 and was therefore excluded from the analyses for training performance. This participant, together with another seven

participants, did not attend Time 3 assessment. Out of these eight participants, three were from CBM group (8.1%) and five from Control group (13.5%); this group difference did not reach statistical significance, $z = 0.75$, $p = .45$. These participants did not differ from those who completed the study in terms of their demographic data and baseline measures of depression, anxiety, affect, or interpretation bias (all p's > .08). The sample size for each stage of the analysis will be clearly indicated alongside results in the next Chapter.

CHAPTER THREE

Results

3.1 Baseline Characteristics

The baseline characteristics for the CBM and Control groups are presented in Table 3.1. Transformation was carried out for BDI-II (by taking the square root) and PANAS-NA (by subtracting 10 and then taking the square root) to meet parametric assumption of normality. Independent samples *t* tests were used to compare the two groups in terms of their personality trait of neuroticism (N scores), baseline state and trait mood scores (BDI-II, STAI - State and Trait, PANAS - PA and NA), and pre-training interpretation bias. The inter-correlations between these variables were also explored using Pearson's correlation coefficients.

Results reported in this section were based on the full sample of 74 participants (37 per group). The two groups did not differ in baseline measures for personality trait, mood or interpretation bias (all *p*'s > .14; see Table 3.1). The mean BDI-II score in both groups was unexpectedly high even when compared with previous studies with vulnerable young people (e.g., Chan et al., 2007). As reported above, BDI-II data were non-normal (skewed to the right); medians were therefore more representative parameters to consider. As expected from a healthy volunteer sample, the median scores for CBM and Control (11 vs. 9) were both within the range of 'minimum depression' (Beck et al., 1996; see section 2.4.2). A pre-training interpretation bias index was computed by subtracting the mean similarity rating for negative targets from that for the positive targets, consistent with previous studies (e.g., Salemink & Wiers, 2011). Thus, positive scores indicated a tendency to endorse more positive than negative interpretations, *vice versa* for negative scores. Results revealed no group difference in pre-training interpretation bias (see Table

3.1). Although the scores for both groups were negative, they were not significantly different from zero (both *p*'s > .17) suggesting that the participants were *not* biased towards either positive or negative information before intervention.

Table 3.1

Baseline Characteristics of the CBM (*n = 37) and Control* (*n=37) Groups*

Variable	CBM	Control	*t*	*p*
N Scores	5.49 (3.16)	5.24 (2.93)	0.34	.73
Interpretation Bias	-0.12 (0.55)	-0.01 (0.57)	0.86	.40
BDI–II	14.11 (9.86)	11.84 (7.46)	0.94	.35
STAI–S	39.24 (9.40)	38.00 (9.92)	0.55	.58
STAI–T	44.59 (11.47)	43.62 (11.41)	0.37	.72
PANAS–PA	28.97 (5.48)	28.86 (5.75)	0.08	.93
PANAS–NA	15.08 (5.47)	13.73 (3.45)	1.48	.14

Note. Values represent group means and standard deviations (in brackets). BDI-II and PANAS-NA are presented as raw scores, but transformed data were used for analyses due to violation of normality assumptions.

The inter-correlations between the baseline characteristics are shown in Table 3.2. As expected, the five mood scales were strongly correlated with each other in the expected directions; that is, participants who experienced more depressive symptoms also reported higher levels of state and trait anxiety and negative affect. The only exception was that PANAS-PA did not correlate with BDI-II or PANAS-NA. The low correlation between the PA and NA scales of PANAS was consistent with the psychometric properties known for this measure (Watson et al., 1988; see section 2.4.2). In addition, N scores were correlated with all the mood measures and the baseline interpretation bias, such that participants with higher N scores demonstrated more depressive symptoms (BDI-II), higher levels of state and trait anxiety (STAI) and negative affect (PANAS-NA), less positive affect (PANAS-PA),

and notably higher levels of negative interpretation bias. Finally, negative interpretation bias was also associated with more depressive symptoms as well as state and trait anxiety.

Table 3.2

Inter-correlation between Baseline Mood Scores and Interpretation Bias at Pre-training Assessment (*N = 74).*

	1	2	3	4	5	6	7
1. Neuroticism	N/A	- .47**	.67**	.49**	.77**	- .35**	.23*
2. Interpretation Bias		N/A	- .45**	- .35**	- .41**	.15	- .19
3. BDI-II			N/A	.60**	.86**	- .16	.34**
4. STAI-S				N/A	.69**	- .33**	.65**
5. STAI-T					N/A	- .32**	.34**
6. PANAS-PA						N/A	.07
7. PANAS-NA							N/A

Note. Values represent Pearson correlation coefficients (*r*). Transformed data were used for the analyses of BDI-II and PANAS-NA scores due to violation of normality assumption. * denotes statistically significant correlation $p < .05$, ** denotes significance $p < .01$ (two tailed).

Taken together, randomisation successfully created two groups that were well matched at baseline; the results reported below could therefore be attributed to training effects without being confounded by group differences at baseline. Given the known comorbidity between depression and anxiety symptoms (e.g., Stein et al., 2001), it was not surprising that BDI-II and STAI scores were highly inter-correlated. Both of these measures were also correlated with negative interpretation bias, in line with the cognitive models of anxiety and depression (see section 1.2). Neuroticism is a measure of an individual's tendency to experience negative emotions (Eysenck & Eysenck, 1964; see section 1.2.1), and indeed N scores were strongly associated with higher scores on depression, anxiety and negative affect but lower scores on positive affect. One of the objectives of this study was to explore whether CBM could be developed as a preventive tool for adolescents at risk of depression by virtue of high neuroticism. The significant correlation between N scores and baseline negative interpretation bias confirmed that participants with a higher level of neuroticism had indeed shown a greater extent of interpretation bias, thus reinforcing the rationale behind testing the effects of CBM on individuals with high neuroticism (see section 3.6 below).

3.2 Training Performance

Training performance was measured by the accuracy for comprehension questions, reaction time for comprehension questions and reaction time for word fragments. There was no specific hypothesis concerning these variables; however, analyses were carried out to explore whether participants responded differently to the CBM vs. Control training, and whether their performance changed across the two sessions. Each variable was analysed using a 2 x 2 repeated measures ANOVA with

Group as the between-subjects factor (CBM vs. Control) and Time as the within-subjects factor (Session 1 vs. 2). The results reported in this section were based on a sample of 72 participants (36 per group).

The percentage of correct responses to comprehension questions, and the reaction times for comprehension questions and word fragments are presented in Table 3.3. Both groups achieved high levels of accuracy for comprehension questions (≥ 92%), suggesting good compliance to task demands. This variable required transformation (by subtracting it from 1 and then taking the square root) before normality assumption was met. Results suggested significant main effects of time and group, such that better accuracy was observed in the second session, F (1,70) = 10.63, $p < .01$, and in the CBM group, F (1,70) = 16.01, $p < .001$. The interaction did not reach significance, F (1,70) = .01, $p = .94$.

In addition to becoming more accurate, participants also improved in speed while responding to comprehension questions, as evidenced by a significant main effect of time, F (1,70) = 102.88, $p < .001$. There was no effect of group or interaction (both p's > .21).

Analyses on the reaction time for completing word fragments yielded a similar main effect of time, F (1,70) = 23.24, $p < .001$. Interestingly, a significant group by time interaction was found, F (1,70) = 8.49, $p < .01$, which was driven by a significant improvement in the CBM group, t (35) = 4.83, $p < .001$, but not in the Control group, t (35) = 1.59, $p = .12$. Nevertheless, there was no main effect of group, F (1,70) = .01, $p = .94$, suggesting that, when averaged across the two sessions, the two groups did not differ.

Table 3.3

Training Performance: Accuracy for Comprehension Questions, Reaction Time for Comprehension Questions and Word Fragments of the CBM (*n = 36) and Control* (*n =36) Groups*

	CBM	Control
% Correct Comp. Questions		
Session 1	94.3 (5.5)	91.8 (4.3)
Session 2	96.3 (5.1)	93.8 (4.2)
RT Comp. Questions (*ms)*		
Session 1	2145 (497)	2178 (487)
Session 2	1880 (498)	1837 (353)
RT Word Fragments (*ms)*		
Session 1	1533 (392)	1426 (372)
Session 2	1234 (191)	1352 (244)

Note. Values represent group means and standard deviations (in bracket). Percentage Correct for comprehension questions are presented as raw scores in this Table, although data of this variable were transformed to normality before parametric tests were applied.

In summary, participants improved over time in their training performance both in accuracy and speed, suggesting a possible practice effect. The CBM group was more accurate in their responses to comprehension questions, which could indicate that either this group was more motivated or that the comprehension questions were easier to answer in this task. Higher accuracy in the CBM group also means that this group would have received more positive feedback (‘Correct’) in

training. Therefore, this group difference in training performance could potentially mediate the training effects (Lothmann et al., 2011); further analyses were conducted to clarify this effect (see section 3.7 Additional Analyses).

3.3 Training Effects on Interpretation Bias (Hypothesis I)

Hypothesis I stated that, compared with the Control group, the CBM group would show a greater increase in positive interpretations and / or a greater reduction in negative interpretations following intervention. Interpretation bias was measured by the similarity rating for the positive vs. negative Target statements in the Recognition Test across Time 1, Time 2, and Time 3. Similarity ratings for the foil statements were recorded as a measure of response bias. As mentioned above, two versions of the Recognition Test were used in a counterbalanced order (ABA vs. BAB). Similarity ratings were submitted to a repeated measures ANOVA with two between-subjects factors (Group: CBM vs. Control; Order: ABA vs. BAB) and three within-subjects factors (Time: T1 vs. T2 vs. T3; Type: target vs. foil; Valence: positive vs. negative). The results reported in this section were based on a sample of 65 participants (33 from CBM, 32 from Control).

As expected, targets were rated as more similar than foils, F (1,122) = 149.43, $p < .001$. There was also a significant main effect of Time, F (2,122) = 3.18, $p < .05$, indicating that participants gave higher similarity ratings over time, and of Valence, F (2, 122) = 13.98, $p < .001$, with positive statements being rated as more similar than negative statements. However, these effects were qualified by a Time x Group interaction, F (2, 122) = 3.74, $p = .03$, such that the CBM group gave higher similarity ratings than the control group at baseline but not at later times, and a Time x Valence interaction, F (2, 122) = 14.10, $p < .001$, due to higher similarity ratings

for positive than negative statements at Times 2 and 3 but not at baseline. Most importantly, there were two significant interactions involving Type: Valence x Type, F (1, 122) = 72.42, $p < .001$, and Time x Type x Order, F (2, 122) = 17.38, $p < .001$. To further investigate these interactions involving Type, responses for foils and targets were analysed separately. This approach was in line with previous studies (e.g. Lothmann et al., 2011; Mathews & Mackintosh, 2000). The similarity ratings for the target and foil statements of the two groups are shown in Table 3.4.

Table 3.4

Similarity Ratings for the Positive and Negative Target Statements of the CBM (*n = 33) and Control* (*n = 32) groups across the Three Time Points.*

	Time 1	Time 2	Time 3
Targets - Positive			
CBM	2.44 (0.41)	2.53 (0.33)	2.59 (0.41)
Control	2.33 (0.40)	2.57 (0.51)	2.62 (0.52)
Targets - Negative			
CBM	2.57 (0.44)	2.37 (0.44)	2.37 (0.50)
Control	2.34 (0.47)	2.30 (0.50)	2.35 (0.52)
Foils - Positive			
CBM	2.19 (0.48)	2.38 (0.47)	2.36 (0.47)
Control	2.04 (0.49)	2.30 (0.51)	2.33 (0.54)
Foils - Negative			
CBM	2.12 (0.49)	1.92 (0.49)	1.98 (0.47)
Control	1.79 (0.36)	1.78 (0.38)	1.83 (0.42)

Note. Values represent group means and standard deviations (in brackets). Similarity ratings were based on a 4-point scale (1 = 'not similar at all' vs. 4 = 'very similar').

3.3.1 Interpretation bias measured by target statements

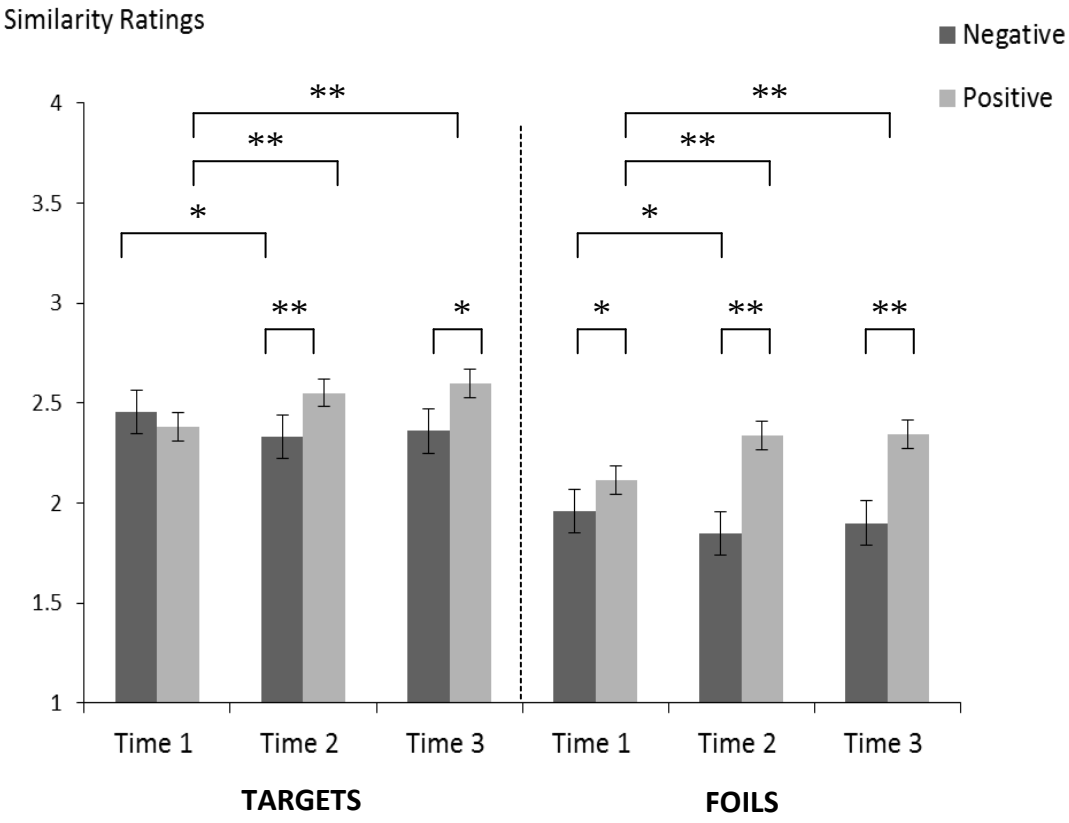
There was a significant Time x Valence interaction, F (2,122) = 10.10, p < .001, such that participants increased their ratings for positive targets, t (64) = 3.48, p < .01, d = 0.43, but reduced their ratings for negative targets, t (64) = 2.03, p < .05, d = 0.25, from Time 1 to Time 2. The increase in positive interpretation was still present at Time 3 (Time 1 vs. Time 3: t (64) = 4.23, p < .001, d = 0.52) but not the

decrease in negative interpretation (Time 1 vs. Time 3: t (64) = 1.57, p = .12, d = 0.19). Consistent with these, positive targets were rated as more similar than negative targets after intervention at Time 2, t (64) = 2.77, p < .01, and at Time 3, t (64) = 2.67, p =.01, but not at baseline, t (64) = 1.00, p = .32. Thus, both interventions appeared to be successful in increasing positive *and* reducing negative interpretations, and the effect was still present one week later (Time 3). However, the crucial Time by Valence by Group interaction was *not* significant, F (2,122) = 0.12, p = .89, suggesting that CBM was not superior to Control (see Figure 3.1).

In addition, there was a significant Time x Order interaction, F (2,122) = 6.09, p < .01. As seen in Figure 3.2, participants who received the Recognition Test in the ABA order gave higher similarity ratings than those in the BAB order both at Time 1, t (63)=3.28, p < .01, and Time 3, t (63)=2.10, p = .04. In other words, target statements in Version A were consistently rated as more similar than those in Version B, presumably due to differences in the way statements were worded. Thus, it appeared that the two versions of the Recognition Test were not completely matched. Given that those allocated to the ABA order would have completed more Version A, it was not surprising that this group also demonstrated overall higher similarity ratings (main effect of Order: F(1,61) = 4.15, p < .05).

Figure 3.1

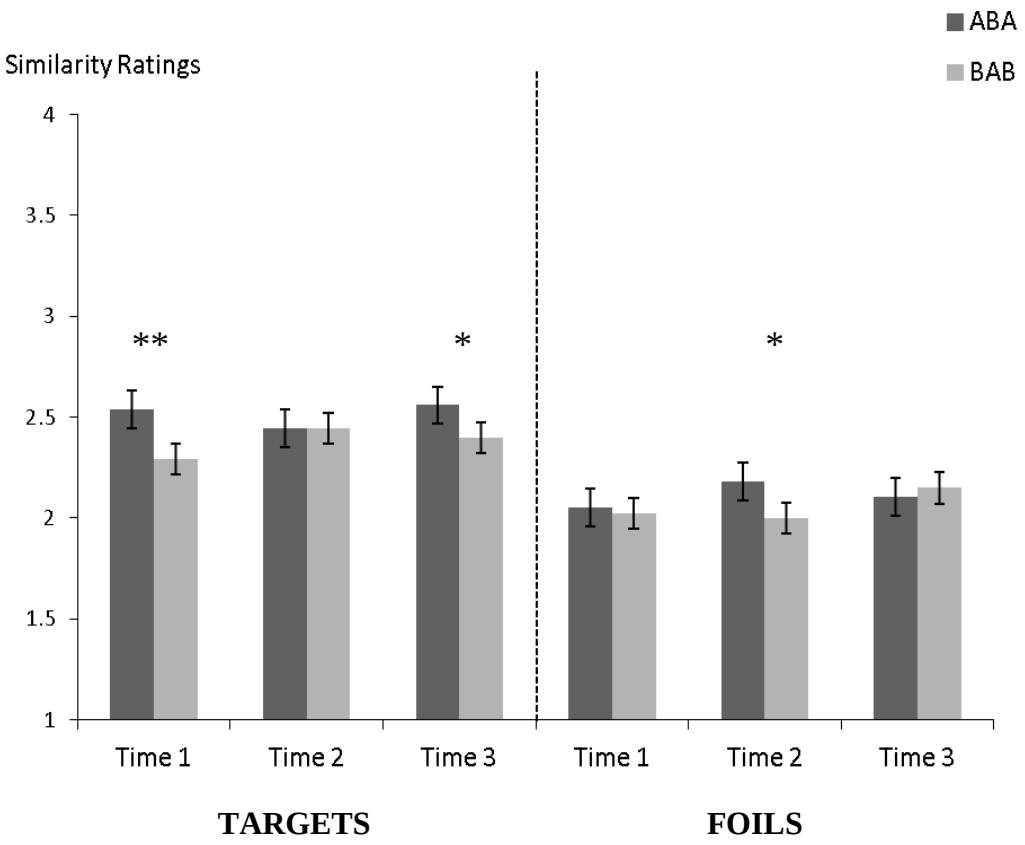
Similarity Ratings for Positive and Negative Target (left) and Foil (right) Statements



Note. Bars represent group means ± the Standard Error of Mean (SEM) of the CBM and Control groups (n = 33 vs. 32). Similarity ratings were based on a 4-point scale (4 = 'very similar' vs. 1 = 'not similar at all'). * denotes statistical significance $p <$ .05, ** < .01 (two tailed).

Figure 3.2

Similarity Ratings for Target (left) and Foil (right) Statements for Participants Receiving the Recognition Tests in ABA vs. BAB Order.



Note. Bars represent group means ± SEM. * denotes statistically significant difference $p < .05$, ** $p < .01$ (two tailed).

3.3.2 Response bias measured by foil statements

Similarity ratings for foil statements provided an indication of response bias. Results suggested a significant main effect of Valence, F (1,122) = 31.52, $p < .001$, and a significant Valence x Time interaction, F (2,122) = 13.98, $p < .001$. Follow-up analyses suggested that positive foils were rated as more similar than negative foils (i.e., a positive response bias) across all time points: Time 1, t (64) = 2.21, $p = .03$, Time 2, t (64) = 7.08, $p < .001$, and Time 3, t (64) = 5.23, $p < .001$. Notably,

participants showed *both* an increase in positive response bias, t (64) = 4.28, p < .001, *and* a reduction in negative response bias, t (64) = 2.01, p < .05, between Time 1 and Time 2. The increase in positive interpretation was still present at Time 3 (Time 1 vs. Time 3: t (64) = 4.49, p < .001) but not the decrease in negative interpretation (Time 1 vs. Time 3: t (64) = 1.04, p = .30). Thus, participants developed a greater response bias favouring the positive after the intervention, which persisted after one week (see Figure 3.1).

Similar to the targets, there was a significant Time x Order interaction, F (2,122) = 4.72, p = .01, though with a different pattern. Here, higher similarity ratings were demonstrated in those receiving the ABA order at Time 2, t (63) = 2.01, p < .05, but not at Time 1 or Time 3 (both p's > .58). Thus, it appeared that foil statements were rated as *less* similar in Version A than Version B (see Figure 3.2).

3.3.3 Summary of results on interpretation bias

Taken together, both CBM and Control groups demonstrated increased positive interpretations *and* reduced negative interpretations after intervention; the increase in positive interpretations was still apparent after one week. This enhanced positive bias was also observed in responses to foil statements suggesting that the intervention modified *both* interpretation and general response biases. However, inconsistent with Hypothesis I, there was no group difference.

3.4 Training Effects on Mood (Hypothesis II)

Hypothesis II stated that following intervention the CBM group would show a greater reduction in depression, anxiety and negative affect, as well as a greater increase in positive affect than the Control participants. These outcomes were measured by a range of self-reported questionnaires; BDI-II and STAI (State and Trait) were used at Times 1 and 3, whereas PANAS (PA and NA) was used across all three time points. The hypothesis was tested by entering each of these variables into a repeated measures ANOVA with Group as the between-subjects variable and Time as the within-subjects variable. As mentioned above, BDI-II and PANAS-NA scores were transformed to normality before parametric tests were applied. These analyses were based on a sample of 65 participants (33 from CBM, 32 from Control).

The group means and standard deviations of the following outcome measures are shown in Table 3.5.

BDI-II: There was a significant main effect of Time, F (1,63) = 11.51, $p < .001$, such that BDI-II scores reduced over time across the entire sample. However, there was no significant effect of group, F (1,63) = .63, p = .43, or interaction, F (1,63) = .28, p = .60.

STAI-S: Boxplots identified one outlier (CBM group), who was then excluded from analyses for this measure. Results showed a significant main effect of Time, F (1,62) = 4.51, p = .04, suggesting an overall increase in state anxiety. However, qualified by a significant interaction between Time and Group, F (1,62) = 4.86, p = .03, further analyses revealed that this increase in anxiety only occurred in the Control, t (31) = 3.08, $p < .01$, d = 0.54, but not in the CBM group, t (31) = 0.06, p = .96, d = 0.01. There was no significant effect of group, F (1,62) = .65, p = .42.

STAI-T: There were no significant effects (all *p*'s > .22).

PANAS-PA: There was again a significant main effect of Time, F (2,124) = 8.17, $p < .001$, suggesting an overall reduction of Positive Affect over time. There was no main effect or interaction with group (both *p*'s > .28).

PANAS-NA: Boxplots revealed one outlier (CBM group) who was subsequently excluded for analysis of this variable. Results suggested a significant reduction in Negative Affect over time, F (2,122) = 5.83, $p < .01$. Crucially, there was a significant interaction, F (2, 122) = 3.10, $p < .05$. Paired samples t tests were performed to clarify the interaction: CBM group demonstrated a reduction from Time 1 to Time 2, t (30) = 5.32, $p < .001$, d = 0.96, and then an increase from Time 2 to Time 3, t (30) = 2.09, $p < .05$, d = 0.37, although Negative Affect at Time 3 was still significantly lower than that at Time 1, t (31) = 2.05, $p < .05$, d = 0.36. By contract, no significant change between any time points was found within the Control group (all *p*'s > .09).

Table 3.5

Measures of Depression, Anxiety, Positive and Negative Affect across the Three Time Points.

	N	Time 1	Time 2	Time 3	Results
BDI-II					
CBM	33	13.24 (9.57)	-	12.09 (11.34)	Decrease
Control	32	11.50 (7.16)	-	9.63 (7.47)	Decrease
STAI-S					
CBM	32	38.03 (8.28)	-	37.94 (10.23)	No change*
Control	32	37.16 (8.73)	-	42.19 (10.81)	Increase
STAI-T					
CBM	33	43.76 (11.59)	-	42.81 (13.34)	No change
Control	32	42.88 (11.12)	-	42.31 (11.64)	No change
PANAS - PA					
CBM	33	29.39 (5.50)	28.01 (7.09)	27.55 (8.62)	Decrease
Control	32	29.16 (5.97)	26.72 (5.89)	24.81 (7.12)	Decrease
PANAS-NA					
CBM	32	14.06 (3.31)	11.87 (2.77)	13.16 (3.72)	Decrease*
Control	32	13.66 (3.26)	13.16 (3.30)	15.09 (5.64)	No Change

Note. Values represent group means and standard deviations (in bracket). BDI-II and PANAS-NA are presented as raw scores, but transformed data were used for analyses due to violation of normality assumptions. * denotes statistical significant group by time interaction $p < .05$ (two tailed).

In summary, there were mixed results regarding the training effects on mood. Notably, CBM group demonstrated a decrease in negative affect comparing with Control group, in line with Hypothesis II. Moreover, CBM group did *not* show the increase in state anxiety as seen in Control group. CBM also demonstrated a reduction in depressive symptoms measured by BDI-II; however, similar reductions were observed in Control participants suggesting that CBM did not offer superior effectiveness in reducing depressive symptoms. Neither group showed changes in trait anxiety. Unexpectedly, there was a general reduction in positive affect, probably reflecting boredom. These results will be further discussed in the next chapter on Discussion.

3.5 Training Effects on Stress Vulnerability (Hypothesis III)

Hypothesis III stated that participants in the CBM group would display a more positive response towards the experimental stressor (i.e. endorse more benign interpretation and report more positive affect and / or less negative affect). In addition, the CBM group would rate their mood more positive and report fewer stressful events during the follow-up period than the control group. Analyses reported in this section were carried out on a sample of 72 participants (36 per group).

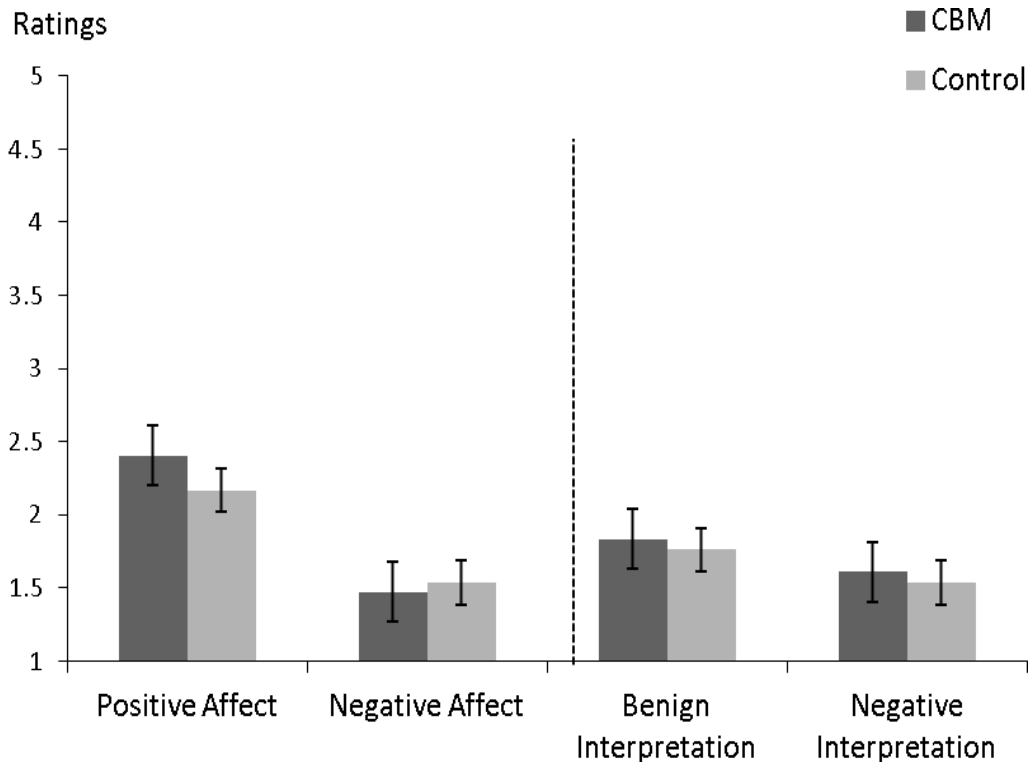
3.5.1 Responses to experimental stressor

The outcome measures for the experimental stressor were Interpretation (benign vs. negative) and Affect (positive vs. negative). Data of these variables were shown to be non-normal even after transformation; therefore non-parametric tests were used. Results from the Wilcoxon Signed Rank Tests suggested that participants

rated the benign explanations of the stressor as more likely than the negative explanations ($p < .01$), and they also reported more positive than negative affect following the stressor ($p < .001$). However, results from the Mann-Whitney *U* Tests showed that the two groups did not differ in their interpretation of or emotional reaction to the stressor (all *p*'s > .14; see Figure 3.3).

Figure 3.3

Responses to the Experimental Stressor



Note. Bars represent group means ± SEM *of the CBM (n = 36) and the Control (n = 36) groups.* Affect scores (left) were based on a 5-point scale with higher scores representing higher levels of positive and negative affect respectively. Ratings for the benign vs. negative explanations of the stressor (right) were based on a 4-point scale (1 = 'not at all likely' vs. 4 = 'very likely').

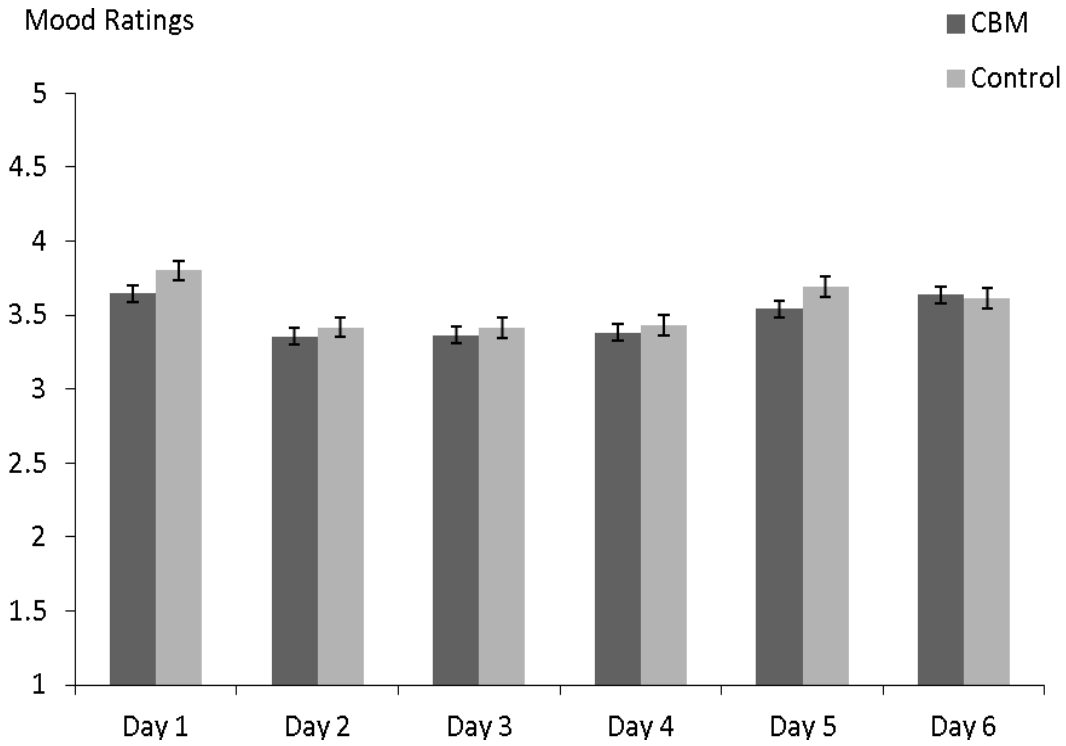
3.5.2 Responses to day-to-day stress

Responses to naturally occurring stress were assessed using a daily mood rating on a 5-point scale (1 = 'completely miserable or stressed' vs. '5 = really good') and the number of positive and negative events reported on each day during the follow-up period. Again, daily mood ratings were shown to be non-normal even

after transformation. Results from the Mann-Whitney *U* Tests revealed no group difference in mood ratings on any day (all *p*'s > .61; see Figure 3.4).

Figure 3.4

Self-reported Mood Ratings on Each Day of the Follow-up Period



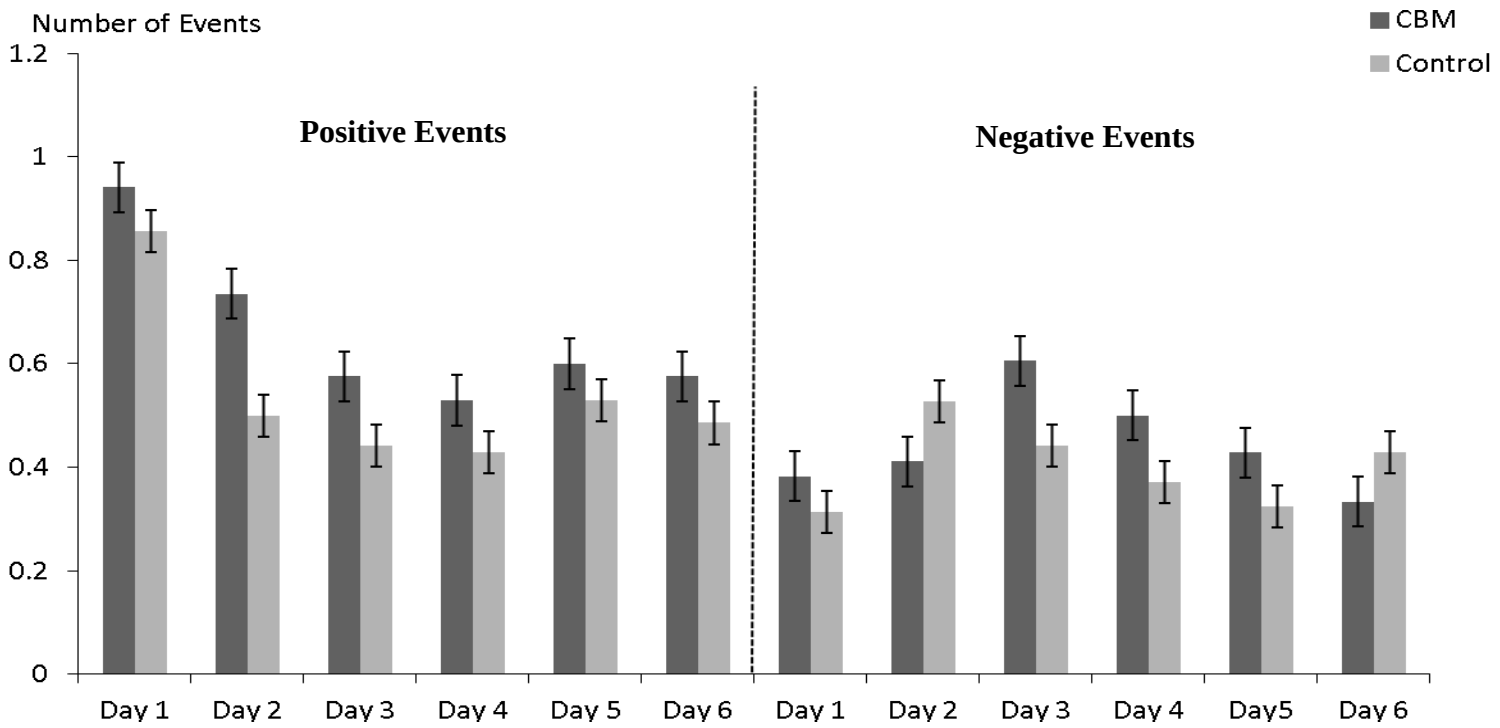
Note. Mood ratings were based on a 5-point scale (1 = 'completely miserable or stressed' vs. 5 = 'really good'). Bars represent the means ± SEM of the CBM and Control groups (n = 36 per group).

The average number of positive and negative events reported over the six days were analysed using a repeated measures ANOVA with Group (CBM vs. Control) as a between-subjects variable and valence as a within-subjects variable (positive vs. negative events). Results suggested a significant main effect of valence such that more positive than negative events were reported, F (1,70) = 6.21, p = .02. However, there was no effect of group or interaction (both p's > .27) suggesting that the two groups reported similar amount of positive vs. negative events during the follow-up period. The number of events reported each day did not follow a normal

distribution (even after transformation). To explore whether the two groups differed on a daily basis, multiple Mann-Whitney *U* Tests were performed: No group difference was found in the number of positive and negative events reported on each day (all *p*'s > .26). Interestingly, results from the Wilcoxon Signed Rank Tests showed a significant effect of time for positive events ($p = .01$) but not negative events ($p = .85$). As seen in Figure 3.5, this appeared to be due to a considerably larger number of positive events reported on Day 1. Closer inspection of the descriptions of the events reported by participants revealed that Day 1 coincided with a festival (Guy Fawkes Night); many participants reported attending parties or other types of celebration.

Figure 3.5

The Number of Positive (left) and Negative (right) Events Reported on Each Day in the One-week Follow-up between Time 2 and Time 3



Note. Bars represent group means ± SEM of the CBM (*n* = 36) and Control (*n* = 36) groups.

3.5.3 Summary of results on stress vulnerability

Overall, participants showed a positive response towards stress. They endorsed more benign vs. negative explanations of the error message used in the experimental stressor and reported more positive vs. negative affect after seeing the error message. During the follow-up week, they also reported more positive than negative events in day-to-day life. However, contrary to Hypothesis III, there was no group difference in the participants' responses to stress.

3.6 Role of Neuroticism

One of the main objectives of this study was to explore whether CBM could eventually be developed as a preventive tool for adolescents at risk for developing depression. The following analyses were therefore performed to explore the role of neuroticism, which is a well-known personality risk factor for depression (see section 1.2).

3.6.1 Analyses on high neuroticism subgroup

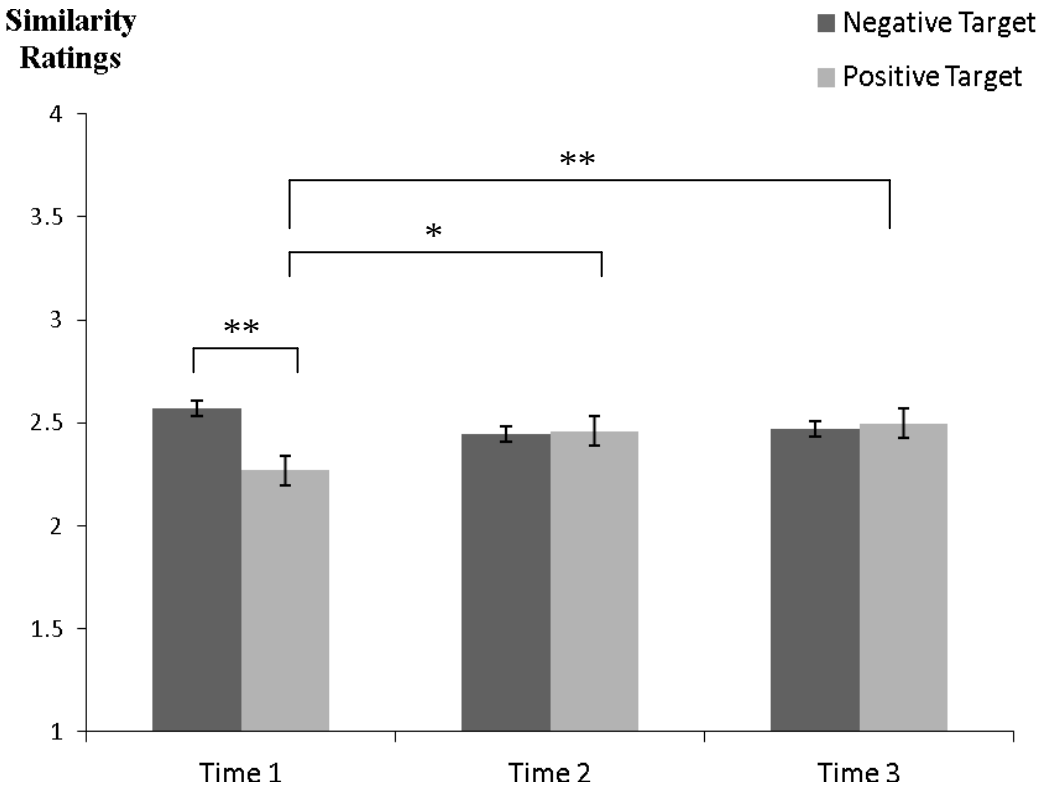
This subsection of the investigation therefore focused exclusively on participants who scored high on neuroticism. The key analyses on training effects (i.e. sections 3.3 – 3.5) were re-run within the high neuroticism (High N) subgroup of the sample using the median as the cut-off (i.e., N score ≥ 6). Taking attrition into account, the following analyses on interpretation bias and mood were based on 32 participants (16 per group) and analyses on stress vulnerability were based on 36 participants (18 per group). A higher cut-off point of N score ≥ 8, corresponding to one standard deviation above mean, was considered but deemed inappropriate as the sample size (15) would be unlikely to be sufficiently powered to support the current

analyses. Analyses reported below were based on the same methodological approach as above (i.e., the same variable was analysed by the same test).

Effects on Interpretation Bias: Results within this High N subgroup replicated the training effects on interpretation bias with a significant Time by Valence interaction, F (2, 56) = 4.65, p = .01, due to a significant increase in positive interpretations between Time 1 and Time 2, t (31) = 2.57, p = .02, which was still present at Time 3 (Time 1 vs. Time 3: t (31) = 3.04, p < .01). Unlike the full sample, no change in negative interpretation was observed (all p's > .17). In addition, this High N subgroup endorsed more negative than positive interpretations at baseline, t (31) = 2.79, p < .01; this negative bias then disappeared after intervention at Times 2 and 3 (p's > .84). As in the full sample, there was no interaction with Group suggesting that CBM and Control were equally effective in inducing the above effect (see Figure 3.6).

Figure 3.6

Similarity Ratings for Positive and Negative Target Statements within the High Neuroticism Subgroup (n = 32)



Note. Bars represent the means ± SEM for responses towards negative and positive target statements. Similarity ratings were based on a 4-point scale (4 = 'very similar' vs. 1 = 'not at all similar'). * denotes statistical significance $p < .05$, ** $p < .01$ (two tailed).

Effects on Mood: The mood scores within this High N subgroup are shown in Table 3.6. This subgroup resembled the full sample by showing an overall reduction in Positive Affect (main effect of time: $F(2,58) = 4.34$, $p = .02$) and no change in Trait Anxiety (all p's > .37). This High N subgroup also showed a similar pattern of decrease in BDI-II and increase in STAI-S but these effects no longer reached statistical significance (Main effect of Time for BDI-II: $F(1,30) = 2.92$, $p <$

.10; STAI-S: $F(1,30) = 3.31$, $p < .08$). The effect on Negative Affect in the full sample was not replicated here (all p's > .39).

Table 3.6

Measures of Depression, Anxiety, Positive and Negative Affect of the CBM and Control Participants (*n = 16 per group) within the High Neuroticism Subgroup*

	Time 1	Time 2	Time 3
BDI - II			
CBM	18.69(10.64)	-	18.88(12.99)
Control	14.31(7.85)	-	11.88(8.92)
STAI - State			
CBM	43.00(6.99)	-	45.31(11.53)
Control	40.88(9.11)	-	45.81(9.60)
STAI - Trait			
CBM	51.75(9.78)	-	52.31(11.46)
Control	49.13(10.47)	-	48.25(11.26)
PANAS - PA			
CBM	28.50(5.56)	28.07(5.86)	26.63(9.07)
Control	27.44(6.64)	28.13(6.93)	22.63(7.03)
PANAS - NA			
CBM	15.00(3.86)	14.27(5.39)	14.75(4.39)
Control	14.50(3.60)	14.25(3.64)	15.75(5.99)

Note. Values represent group means and standard deviations (in bracket). BDI-II and PANAS-NA are presented as raw scores, but transformed data were used for analyses due to violation of normality assumptions.

Effects on Stress Vulnerability: Similar to the full sample, this High N subgroup reported more positive than negative affect following the experimental

stressor, $z = 2.52$, $p = .01$. However, they differed from the full sample by rating the neutral and negative explanations as equally likely, $z = 1.23$, $p = .22$. The interpretation of, and emotional responses to, the stressor did not differ between those who received CBM vs. Control (all p's > .28). In the follow-up period, results revealed no group difference on the mood ratings on any day (all p's ≥ .10) or the number of events reported (all p's > .07).

3.6.2 Comparison between high vs. low neuroticism subgroups

While the above examined the training effects within the High N subgroup exclusively, this study was also interested in exploring whether neuroticism *moderates* the training effects. To test this hypothesis, participants were classified into High N vs. Low N subgroups, again using median split of their N scores (i.e., N score ≥ 6 vs. N score < 6), and the key analyses (sections 3.3 – 3.5) were re-run with Neuroticism (i.e., High N vs. Low N) as an additional between-subjects factor. This hypothesis would be supported if results yielded significant interactions between training effects and neuroticism. After discounting attrition, the following analyses on interpretation bias and mood were based on 65 participants (16 High N CBM, 16 High N Control, 17 Low N CBM, and 16 Low N Control); analyses on stress vulnerability were based on 72 participants (18 per group).

Interpretation Bias and Mood: There was a significant Valence by Neuroticism interaction, F (1,114) = 12.08, $p < .01$, due to High N participants endorsing *less* positive interpretations, t (63) = 2.63, $p = .01$, than the Low N participants. A significant main effect of N was also found across mood measures, such that High N participants demonstrated higher scores on BDI-II, F (1,61) = 22.25, $p < .001$, STAI-S, F (1,61) = 27.09, $p < .001$, STAI-T, F (1,60) = 43.11, $p <$

.001, and PANAS-NA, F (1,60) = 10.15, $p < .01$, than Low N participants overall. These results were expected based on previous findings on neuroticism (e.g., Chan et al., 2007; see section 1.2). However, neuroticism did not interact with training effects, thus there was no evidence to suggest that it acts as a moderator (see Table 3.7).

Table 3.7

Interpretation Bias and Mood of the High N (*n = 32) and Low N* (*n = 33) Subgroups*

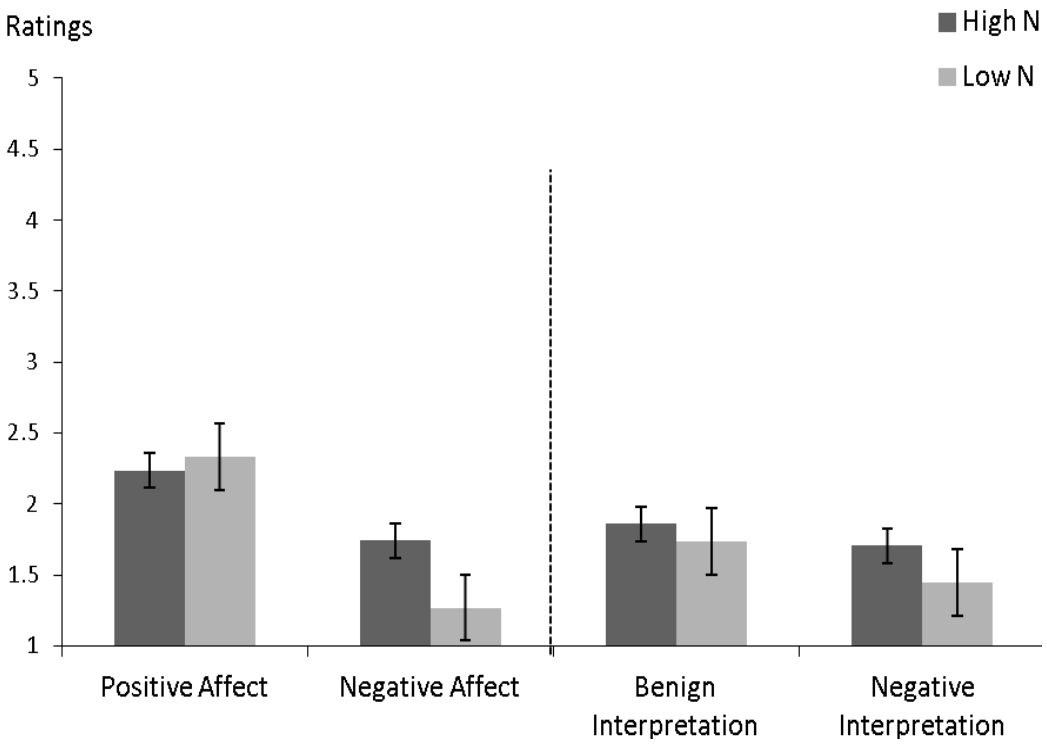
	Time 1	Time 2	Time 3
Similarity Ratings for Positive Target			
High N	2.27(0.39)	2.46(0.41)	2.50(0.48)
Low N	2.50(0.40)	2.64(0.43)	2.70(0.43)
Similarity Ratings for Negative Target			
High N	2.57(0.49)	2.45(0.44)	2.47(0.56)
Low N	2.35(0.42)	2.22(0.47)	2.26(0.42)
BDI-II			
High N	16.50(9.46)	-	15.38(11.52)
Low N	8.39(4.76)	-	6.52(4.15)
STAI - State			
High N	41.94(8.06)	-	45.56(10.44)
Low N	33.36(6.35)	-	35.61(9.67)
STAI - Trait			
High N	50.44(10.05)	-	50.28(11.36)
Low N	36.42(7.55)	-	34.84(7.84)
PANAS-PA			
High N	27.97(6.05)	27.06(6.40)	24.63(8.24)
Low N	30.55(5.10)	28.03(6.70)	27.73(7.52)
PANAS-NA			
High N	14.75(3.68)	14.26(4.49)	15.25(5.19)
Low N	13.03(2.53)	11.39(1.97)	13.15(4.27)

Stress Vulnerability: Limited by the non-parametric nature of most of the relevant variables, the neuroticism by training interaction could only be directly tested in the average number of events reported during the follow-up period. This analysis revealed no such interaction (all p's > .34). Using the Mann-Whitney U Tests, High N participants were shown to report more negative affect following the experimental stressor and endorsed more negative interpretations of the stressor comparing with Low N participants (both p's < .02; see Figure 3.7).

During the follow-up week, High N participants also reported more negative events on two of the days (p's ≤ .05; see Figure 3.8) although their daily mood ratings were similar to the Low N participants (all p's > .10).

Figure 3.7

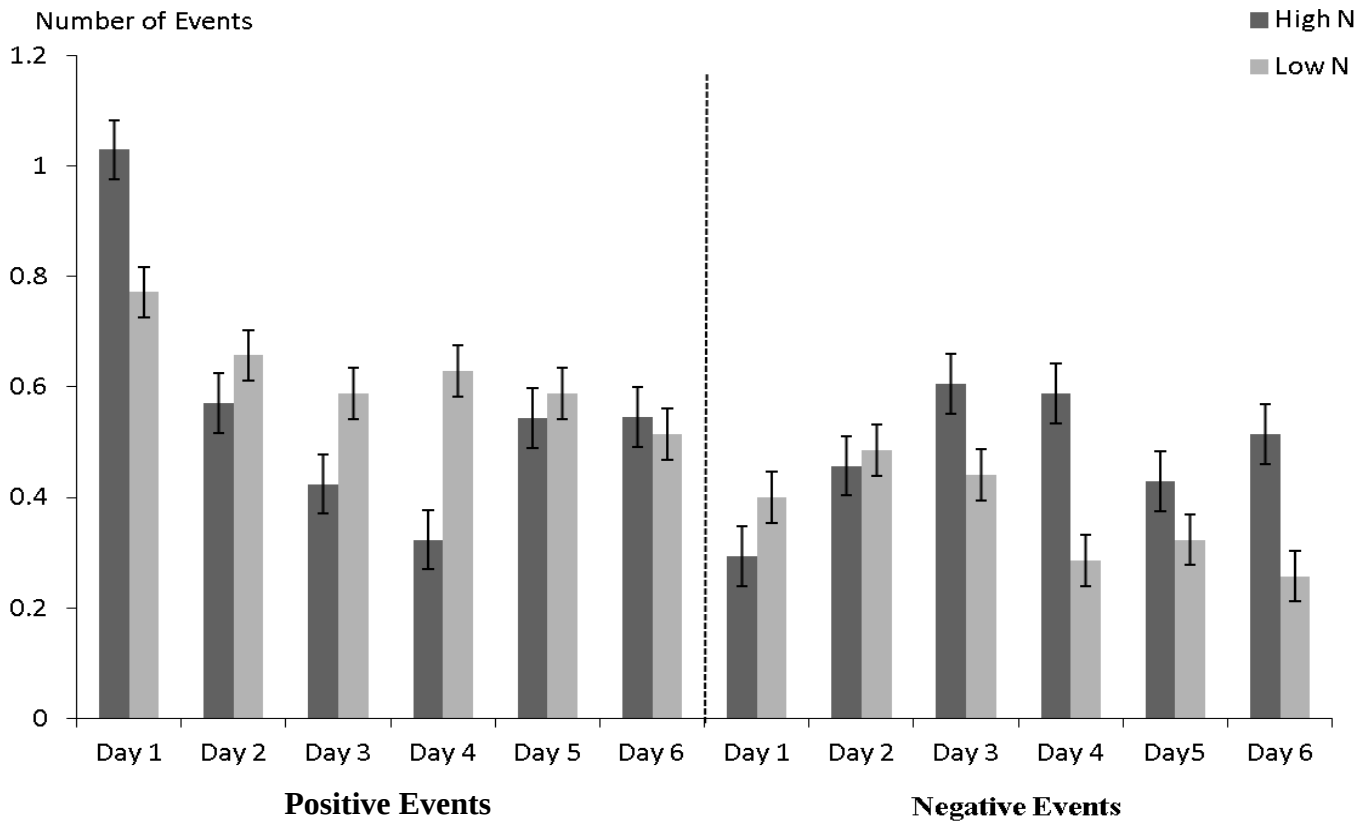
Responses to the Experimental Stressor



Note. Bars represent the mean ratings ± SEM of the High N and Low N Subgroups (n = 36 per group). Affect scores (left) were based on a 5-point scale with higher scores representing higher levels of positive and negative affect respectively. Ratings for the benign and negative explanations of the stressor (right) were based on a 4-point scale (1 = 'not at all likely' vs. 4 = 'very likely').

Figure 3.8

The Number of Positive (left) and Negative (right) Events Reported on Each Day in the Follow-up Period between Time 2 and Time 3.



Note. Bars represent the means ± SEM of the High N and Low N subgroups (*n* = 36 per group).

3.6.3 Correlations between neuroticism and training effects

Finally, correlation analyses across the entire sample of 74 participants were used to explore the relationship between neuroticism scores and the changes in interpretation bias and mood from before to after training. None of the correlations reached statistical significance (all *p*'s > .08) again suggesting that neuroticism does not act as a moderator of the training effects.

3.6.4 Summary of results on neuroticism

Findings in this section revealed that participants with higher neuroticism scores had higher levels of negative interpretation bias, depression, anxiety, and negative affect than those who had lower neuroticism scores. They also appeared to be more vulnerable in the face of stress: they were more likely to interpret the experimental stressor in a negative way and reported more negative affect afterwards; they also reported more negative than positive events in day-to-day life. The effects of CBM on interpretation bias were replicated in these vulnerable participants (i.e., the High N subgroup), although most of the effects on mood disappeared in part due to the reduced sample size. However, the direct comparison between High N and Low N participants and the correlational analyses did not yield evidence to suggest that neuroticism acts as a moderator of training effects.

3.7 Additional Analyses

As reported in section 3.2 above, the CBM group was more accurate in their responses to the comprehension questions during the intervention. This might potentially mediate any group difference in training effects (Lothmann et al., 2011). To test this hypothesis, the outcome measures that were found to have a group

difference, namely State Anxiety and Negative Affect, were re-analysed with accuracy (measured by the percentage of correct responses to comprehension questions) added as a covariate. Results were mixed: While the effect on State Anxiety remained unchanged, the interaction in the Negative Affect was no longer significant ($p > .10$). Thus, it appeared that the superior effectiveness of CBM in reducing negative affect was in part due to this group being more accurate in responding to comprehension questions during training. This mediating effect will be further discussed in the next chapter on Discussion.

3.8 Participants' Feedback

At the end of the last session, participants were asked to fill in a feedback form (see Appendix E). As seen in Figure 3.9, the two groups did not differ in the way they described the study. Overall, participants agreed with the positive descriptions to a greater extent than the negative descriptions.

When participants were asked to guess the purpose of the computer tasks, a vast majority (94%) correctly indicated 'interpretation of situations' as the purpose of the computer tasks, more than half indicated 'concentration' (59%) and 'memory' (55%), and less than 10% selected 'reading speed' or 'spelling'.

Reassuringly, all but one participant (98%) said they would recommend their friends to participate in the study.

When asked what their favourite part(s) of the study was, the most common replies were the questionnaires (20 participants; 30%) and that the study made them more aware of their feelings, personality, and / or the way they dealt with day-to-day situations (20 participants; 30%). Nine participants (14%) preferred the daily reporting of mood and events, whereas only five participants (8%) named computer

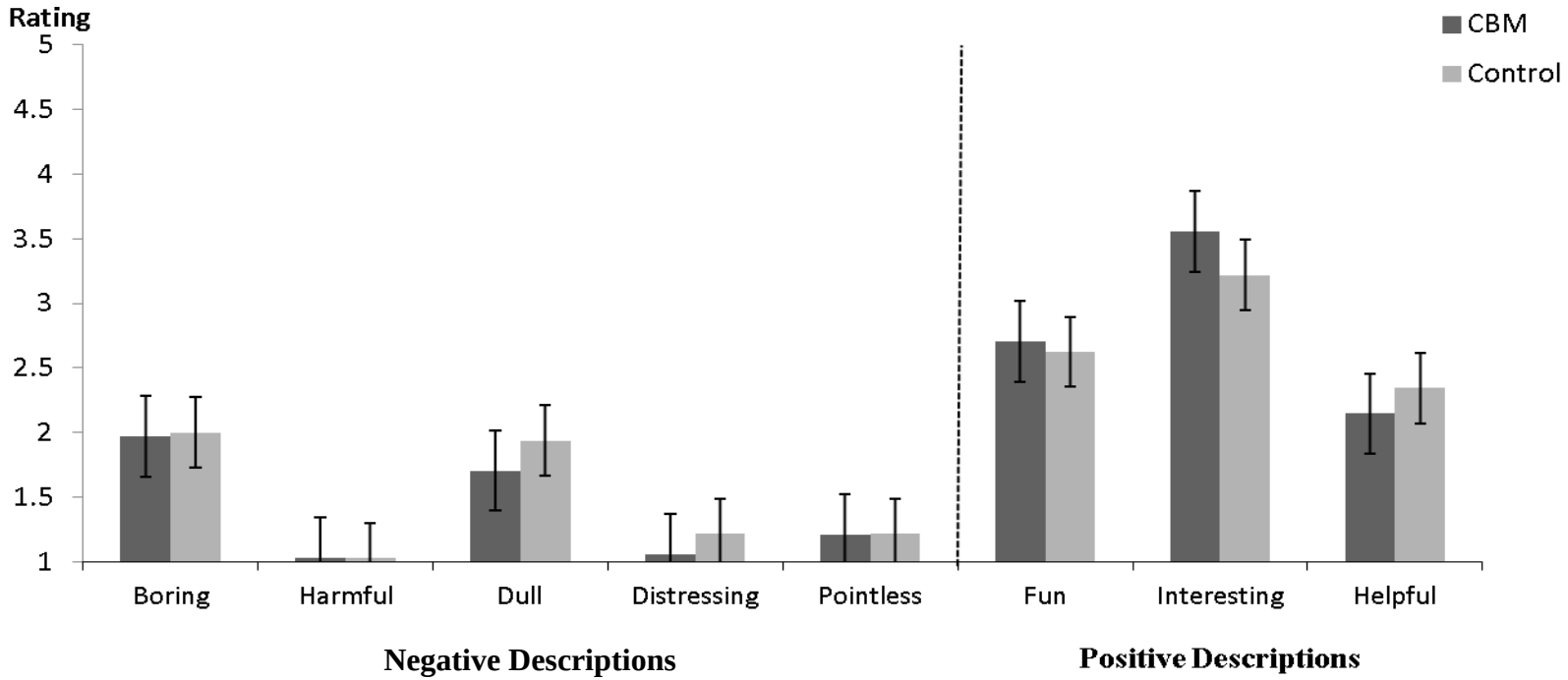
tasks as their favourite part(s) of the study. Interestingly, one participant (2%) mentioned the experimental stressor (‘the trick’) as the favourite part. Seventeen participants (26%) said they enjoyed the experience of participating in a psychology study, such as ‘the researcher is friendly’ and ‘the variety of tasks’, without mentioning any specific component of the study.

When asked what their least favourite part(s) of the study was, a large majority of participants (49; 74%) mentioned the computer tasks as being repetitive, too long, somewhat confusing or that the scenarios were ‘odd’ or stereotyped. Three participants (5%) said that they worried that they may get the answers wrong; two participants (3%) said the questionnaires were ‘too personal’ or ‘ambiguous’; finally one participant (2%) said that ‘I wasn’t sure what it was for’.

Participants were given space on the feedback form to leave ‘any other comments’. These comments largely echoed the themes that emerged in the responses to the questions reported above. On a positive note, many participants left a message saying ‘thank you for letting me take part’.

Figure 3.9

Feedback from Participants



Note. Bars represent the mean ratings ± SEM of the CBM and Control groups for each of the negative (left) and positive (right) descriptions based on a 5-point scale (1 = 'very slightly or not at all' vs. 5 = 'extremely').

3.9 Overall Summary of Results

Inconsistent with Hypothesis I, CBM training did not show superior benefits in interpretation bias comparing with Control group. Both groups showed an increase in positive interpretations and a decrease in negative interpretations. Results regarding the effects on mood were mixed. Consistent with Hypothesis II, CBM group demonstrated a greater reduction in negative affect than Control group. CBM group also reported a reduction in depressive symptoms; however, similar reductions were observed in Control participants. Neither group showed changes in trait anxiety. Unexpectedly, Control participants reported an increase in state anxiety; there was also a general reduction in positive affect in both groups. Encouragingly, some of the positive changes were still present one week after training, suggesting promising durability. However, the two groups did not differ in their responses to the experimental stressor and day-to-day stress, thus lending no support for Hypothesis III. Analyses on neuroticism suggested that participants with higher scores on this personality risk factor had higher levels of negative bias, mood symptoms, and stress vulnerability than those with lower scores. The effects of CBM on interpretation bias were replicated within this subgroup of High N participants. However, there was no evidence to suggest that neuroticism acts as a moderator of training effects. The effect size of the key findings was reported in the relevant sections above. Most of the effect sizes ranged between small to medium, except that a large effect size (d = 0.96) was found for the reduction in negative affect in the CBM group.

CHAPTER FOUR

Discussion

4.1 Overview of Discussion

The objectives of this study were two-fold. First, it aimed to further investigate the effects of CBM on cognitive bias, mood, and stress vulnerability in adolescents, following results from the literature review that highlighted the scarcity and methodological limitations of research in this age group. The key findings showed that the CBM group showed a greater reduction in negative affect compared with control group. In addition, the CBM group did not show the increase in state anxiety as seen in Control participants. However, CBM training did not show superior benefits in other outcome variables. Both groups displayed an increase in positive interpretations, a decrease in negative interpretations, a reduction in depressive symptoms, an increase in positive affect and no change in trait anxiety. There was no evidence to suggest that CBM reduces vulnerability to stress. Despite some patchy mood effects, overall this study has *not* provided strong evidence to support the effectiveness of CBM in promoting cognitive changes or reducing stress vulnerability in this age group.

The second aim of this investigation was to explore whether CBM could be developed as a preventive tool for adolescents at risk for developing depression, in particular those who have high levels of neuroticism, a well-known personality risk factor for depression. A direct comparison between those who have high neuroticism scores vs. low neuroticism scores confirmed the expectation that neuroticism was linked to more negative interpretation bias, depressive symptoms, anxiety and negative affect. However, results did *not* suggest that neuroticism acts as a moderator of the training effects; in other words, there was no evidence to suggest that

participants with different levels of neuroticism responded differently to CBM. Indeed, analyses within the high neuroticism subgroup replicated the cognitive changes found in the full sample, although the mood benefits became less apparent, presumably due to a reduced sample size.

These findings will be considered in further details below (sections 4.2 – 4.3), followed by a critique of the methodological issues (section 4.4). This chapter will then highlight the theoretical and clinical implications of the study with suggestions for future research directions (section 4.5 – 4.6) before it closes with the final conclusion (section 4.7).

4.2 Effects of Cognitive Bias Modification in Adolescents

4.2.1 Effects on interpretation bias

The finding that both CBM and control led to an increase in positive interpretations is novel in a number of ways. First, only two of the previous studies on adolescents (Salemink & Wiers, 2011, 2012) had reported measuring pre-training interpretation bias using the Recognition Test; therefore, this study was only the third study to directly test the hypothesis regarding changes in interpretation bias from before to after training in this age group. Second, this study illustrated that changes in interpretation were driven by *both* an increase in positive interpretations *and* a reduction in negative interpretations. This greatly contributes to the existing literature as the direction of change had not been always clearly indicated. Third, this study provided evidence that the increase in positive interpretation was still detectable, with a moderate effect size, one week after training. This result is noteworthy given that only two sessions of training were provided. At the time of

writing, this was the first study to illustrate the durability of the training effects in this age group.

One advantage of using the Recognition Test to measure interpretation bias is that it provides an indication of interpretation bias as well as general response bias. Indeed, the current results suggested that the training effect was extended to a general positive response bias, in line with previous findings (Lau et al., 2011; Lothmann et al., 2011).

However, the key finding was that CBM did not outperform control condition in fostering positive vs. negative interpretation. This result appeared to be inconsistent with the previous CBM studies with adolescents suggesting the superiority of CBM to control in this outcome measure (Lau et al., 2011; Lothmann, 2011; Salemink & Wiers, 2011, 2012). There are at least four possible explanations.

One possibility is that CBM might have been more effective than the control in inducing positive interpretation as hypothesised, but that the effect was too small to be detectable in the current sample size. Indeed, many previous studies compared CBM training with 'negative training condition' where participants were coached to repeatedly resolve ambiguous situations in a negative direction (e.g., Lau et al., 2011; Lothmann et al., 2011; Mathews & Mackintosh, 2000; Salemink et al, 2007a). Therefore, previous studies, including the two based on which the current sample size was determined (Lau et al., 2011; Lothmann et al., 2011), might have exaggerated the effect size of CBM. Indeed, a larger sample might be needed to detect the difference between CBM training and placebo control in this age group. For example, using a sample size of 170 (>80 per group), one adolescent study found that CBM is more effective in inducing positive interpretation compared with a placebo controlled group (Salemink & Wiers, 2011).

The second possibility is that that effect of CBM was limited by the lack of use of imagery. Research has shown that imagery enhances the effect of CBM (Holmes & Mathews, 2005; Holmes et al., 2006) and that children and adolescents are able to employ imagery when instructed (Harris, 2000; Kosslyn, Margolis, Barrett, Goldknopf, & Daly, 1990). Indeed, two of the previous CBM studies with adolescents (Lau et al., 2011; Lothmann et al., 2011) have included an imagination exercise before training; in particular, adolescents were instructed to close their eyes and imagine coming home after school and describe what they could see, smell, hear, taste, and touch. The present study has only used a brief imagery exercise, where participants were asked to imagine biting into a lemon. It is possible that a larger CBM effect could have been observed if further imagery exercise was involved. This limitation has also been acknowledged in another CBM study with adolescents (Salemink & Wiers, 2011).

The third possibility is that, although control participants were not coached to disambiguate the situations in either a positive or a negative way, the task did not actively prevent participants from endorsing a positive interpretation in their own mind. Indeed, the current sample showed a natural *positive* response bias at baseline (see Results section 3.3.2); it is therefore possible that the control condition had simply reinforced this pre-existing positive bias. In other words, although both control and CBM were shown to increase positive interpretations, these cognitive changes might have been mediated by different mechanisms. If this hypothesis were true, this would mean that the control intervention in this study has not provided a sufficiently neutral condition for comparison. Future studies may consider using a control condition that coaches participants to make equal proportions of positive, negative, and neutral resolutions. For example, in one adolescent CBM study

(Salemink & Wiers, 2011), control participants were asked to resolve 30% of the scenarios in a positive way, 30% in a negative way, and 40% in a neutral way; CBM was shown to lead to more positive and fewer negative interpretations than control.

Finally, it is possible that CBM does not offer additional benefit to placebo effect in the healthy adolescent population. This explanation is less likely given that the effect of CBM on interpretation bias has been robustly replicated in adult populations (see Introduction section 1.3) and more recently in adolescent studies (Lau et al., 2011; Lothmann et al., 2011; Salemink & Wiers, 2011, 2012). Nevertheless, CBM research with adolescents is still at an early stage, and, as discussed in the Introduction, given the developmental differences in cognitive processing we cannot necessarily expect the same pattern of results to emerge in response to training in adults as in adolescents (Blakemore, 2006, 2008; Lothmann et al., 2011). The current finding that CBM does not outperform control in inducing positive interpretations highlights that the effect of CBM in this age group is far from robust.

4.2.2 Effects on depression, anxiety and affect

The most notable result was that CBM demonstrated with a large effect size a greater reduction in negative affect than the control intervention, and this mood benefit lasted for at least one week following intervention. This result was consistent with a previous study with adolescents (Lothmann et al., 2011). However, further analyses showed that this effect no longer reached statistical significance when the training performance was controlled for, suggesting that this mood effect in CBM group was at least in part mediated by the better training performance in this group. Better accuracy in the CBM group during training could indicate that either this

group was more motivated or that the comprehension questions were easier to answer in this task. Higher accuracy in the CBM group also means that this group had received more positive feedback ('Correct') in training; this increased encouragement may explain the greater reduction in negative affect in the CBM group (Lothmann et al., 2011).

In addition, CBM group did not show an increase in state anxiety as seen in the Control group. This effect could not be merely attributed to the group difference in training performance, as confirmed by covariate analyses. A similar pattern of change in state anxiety (i.e., increase in control vs. no change in CBM group) has been previously found in Salemink et al., 2009, although in this previous study participants were highly anxious individuals and the control condition involved making negative resolutions of 50% of the scenarios. One explanation offered by the authors was that the study coincided with an examination period; therefore the lack of change in state anxiety in the CBM group (in contrast with the increase in anxiety in control) might indicate a protective effect of CBM against the examination stress. While this explanation could not be completely ruled out in the present study, it is not likely to be a sufficient explanation for the whole pattern of results. In particular, this would be inconsistent with the overall reduction in depressive symptoms measured by BDI-II and the lack of group differences in responses to stress (both experimentally induced and naturally occurring). Instead, the current finding on state anxiety appeared to reiterate the possibility that the control condition was not 'simply doing nothing'; the current result seemed to suggest that a repeated exposure to unresolved ambiguous events (as in the control condition) could elevate anxiety. It should also be noted that the lack of change in state anxiety in the CBM group is consistent with a previous study with adolescents (Salemink & Wiers, 2011).

Regarding depressive symptoms, both the CBM and control groups demonstrated a significant reduction one week following the intervention. Therefore, this study did not provide evidence to suggest that CBM offers additional benefits in reducing depressive symptoms. This was the first CBM study with adolescents to measure depressive symptoms using a validated questionnaire (BDI-II); therefore, this result should be treated as preliminary until further replicated. Review of the adult literature yielded mixed results: while some studies showed evidence for a reduction (e.g., Blackwell & Holmes, 2010; Lang et al., 2012), other reported no effects (Amir et al., 2010; Beard & Amir, 2008; Vassilopoulous et al., 2009). Taken together, there has *not* been consistent evidence to suggest that CBM could reduce depressive symptoms in adults or adolescents.

Neither group reported changes in their trait anxiety. This construct was intended to measure anxiety as a relatively stable trait, and therefore theoretically it was unlikely to be changed by two sessions of training. Indeed, previous studies had not always reported changes in trait anxiety (e.g., Beard & Amir, 2008; Hayes et al., 2010). Whenever changes in trait anxiety were implicated, they tended to be observed in studies that involved a higher dose of CBM training (four sessions or more; e.g., Brosan et al., 2011; Lang et al., 2012; Mathews et al., 2007; Salemink et al., 2009).

An unexpected finding was the gradual decrease in positive affect over the course of the experiment. This might reflect an increasing sense of boredom, a theme that emerged in the participants' feedback, and indeed more than two-thirds of the participants described the study as at least 'a little' boring. Indeed, the positive affect scale required participants to give a rating of feelings such as 'interested', 'excited', 'enthusiastic', 'alert', and 'inspired'. It was not surprising that these feelings reduced

after the sense of 'novelty' of participating in a research study wore off. Consistent with this hypothesis of boredom, a previous study also found that participants reported more negative feelings during the second half of the CBM training (Salemink et al., 2009).

Taken together, this study yielded mixed results regarding the effects of CBM on mood. Previous CBM studies with adolescents have yielded patchy results regarding the effects on mood; their results were further limited by the narrow set of outcome measures used in these studies. So far, only two adolescent studies have found some evidence for mood changes (Lau et al., 2011; Lothmann et al., 2011) but in both cases the effect might have been exaggerated because positive training was compared with negative training. In addition, these studies only showed changes in positive and negative affect using non-validated visual analogous scales. Salemink & Wiers, 2011 did measure state anxiety using a validated questionnaire but found null results. When adult studies on CBM were reviewed (see section 1.3), the mood effect was equally patchy and inconsistent. Whether CBM changes mood is indeed a complex question, involving multiple mediating and moderating mechanisms that need to be clarified in future studies.

4.2.3 Effects on stress vulnerability

Stress vulnerability was included in this study as an outcome measure. Specifically, the effects of the training were tested under the provocation of an experimental stressor and naturally occurring stressors in the follow-up period. Results suggested that participants reported more positive than negative affect following the experimental stressor, and they also tended to interpret the ambiguous error message used in the stressor in a neutral rather than negative way. These

cognitive and emotional responses suggest resilience to stress, although in the absence of a group difference it was unclear whether this was due to the intervention. A baseline measure would have been helpful in clarifying this, but one was not included as this stressor was still at the piloting stage of development. From an ethical point of view the results show that the stressor did not cause long-term harmful effects on participants. However, from an experimental point of view, they raise doubts as to whether the stressor was sufficiently intense to be a sensitive measure of stress vulnerability. The current finding regarding the null effect of CBM on stress reactivity is consistent with a volume of previous studies reporting that CBM has no effect on responses to stressors (e.g., Hertel et al., 2011; Salemink et al., 2009; Steinman & Teachman, 2010; Teachman & Addison, 2008). A small number of studies did yield supportive evidence; for example, CBM has been shown to protect participants from mood deterioration when challenged by a stress task (Wilson et al., 2006) or negative mood induction (Holmes, Lang, & Shah, 2009). However, many other studies that provided supportive evidence for the effects on stress reactivity only illustrated that CBM training reduced *anticipatory* anxiety in response to *imagined* upcoming stressful situations; it was unclear from these studies whether the benefits would translate into reduced *actual* anxiety upon the situation (Hirsch, Mathews, & Clark, 2007; Murphy et al., 2007; Vassilopoulous et al., 2009). Overall studies that employed a stressor varied a great deal in terms of the nature of the stressor and its outcome measures, rendering it difficult to compare across these findings. In light of these mixed findings, it is prudent to conclude that so far there has *not* been strong, consistent evidence to suggest that CBM is effective in reducing negative emotional responses to stress. It should also be noted that this study was the first to test this hypothesis in adolescent population.

Similar to the results for the experimental stressor, there was no evidence to suggest that CBM offered protection against naturally occurring stressors. The two groups gave similar daily mood ratings during the one week follow-up period and reported similar amounts of positive and negative events on each day. There was an overall tendency to report more positive than negative events, which could be due to the cognitive changes seen in both groups. However, this could not be directly tested due to the absence of a baseline measure. To be clinically useful, the effects of CBM need to be established outside the laboratory; despite the methodological inadequacies, this outcome measure represents an important first step in testing this hypothesis.

4.3 Vulnerability to Depression and Cognitive Bias Modification

The second objective of this study was to explore whether CBM could be developed as a preventive tool for adolescents at risk of developing depression. Therefore, participants with higher levels of neuroticism, a well-known risk factor for depression, were selected as a subgroup for further analyses. Results with this subgroup largely resembled the overall findings with the full sample, although some of the mood effects no longer reached statistical significance, presumably due to the reduced sample size. Notably, however, the changes in interpretation bias in this subgroup seemed to follow a different pattern. Whereas the full sample changed from no interpretation bias to a positive interpretation bias after training, the high neuroticism subgroup changed from a pre-existing negative interpretation bias to no interpretation bias. This pre-existing negative interpretation bias was expected based on previous research on neuroticism (Alloy et al., 2006; Salemink & van den Hout, 2010), and this difference seems to imply that a higher dose of training will be

required to bring about the same level of positive interpretation biases in this vulnerable subgroup. In addition, the cognitive changes observed in the high neuroticism subgroup were mainly driven by an increase in positive interpretation; the decrease in negative interpretation observed in the full sample was not replicated in the high neuroticism subgroup. This may imply that the tendency to make negative interpretations was more resistant to change in vulnerable individuals. If this were true, this would lead to major implications for the potential of CBM to be used as a preventive tool. Further studies should prioritise testing this hypothesis.

In a secondary analysis, participants with high and low neuroticism scores were compared directly. The current study defined high vs. low neuroticism using a median split. This method is widely used in previous research (Hertel et al., 2011; Lau et al., 2011; Salemink & Wiers, 2011). Neuroticism is a stable personality trait that is highly predictive of subsequent depression; it has been estimated that an increase by one standard deviation in the neuroticism score carries a hazard ratio for a depressive onset of 1.72 (Kendler et al., 2004). Thus, the mean difference of neuroticism scores between the high and low neuroticism subgroups of this study (7.79 vs. 2.81), corresponding to 1.64 standard deviation units, represented more than two-fold difference in risk for depression. Indeed, results confirmed that high neuroticism was associated with more negative cognitive bias, depressive symptoms, and negative affect. These were consistent with the known characteristics of neuroticism (Chan et al., 2007; Eysenck & Eysenck, 1964; Kendler et al., 1993, 2002, 2006a, 2006b), and further suggested that the median split had successfully created two groups that had significant differences in risk for depression. However, there was no evidence to suggest that the level of neuroticism moderated the effects of the interventions.

While neuroticism is a robust risk factor for depression, it has also been found to predict anxiety. For example, in a report based on a large sample of undergraduate students, a combination of high neuroticism and low extraversion was found to predict both depression and anxiety prospectively in three years (Gershuny & Sher, 1998). Sexton, Norton, Walker, & Norton (2003) further suggested that neuroticism is directly associated with symptoms of obsessive compulsive disorder, panic disorders and general worry; neuroticism was also found to predict anxiety symptoms through the mediation of anxiety sensitivity and intolerance of uncertainty. However, these results were based on non-clinical participants with cross-sectional measures rather than prospective measures. Nevertheless, these results were largely in line with previous theoretical models and empirical data suggesting neuroticism as a 'higher-order' factor that influences the development of a range of anxiety disorders (Barlow, 2000; Brown, Chorpita, & Barlow, 1998; Craske, 1999; Norton, 2002).

Hence, the current effects of CBM observed in high neuroticism subgroup may *not* be specific to depression. Indeed, this study found that, in addition to more depressive symptoms, the high neuroticism subgroup also had higher state and trait anxiety scores than the low neuroticism subgroup (see Results section 3.6.2). This was expected due to the known co-morbidity between depression and anxiety (Stein et al., 2001). Indeed, the co-morbidity issue has been a longstanding challenge to experimental design; studies that investigated anxiety or depression (or the vulnerability to these disorders) often had participants with elevated symptoms of both. For example, in a CBM study on social anxiety, Beard & Amir (2008) recruited participants based on high social anxiety scores; however, the mean baseline BDI score of the sample was above 20 indicating moderate levels of

depression. Similarly, in a study that investigated interpretation biases in girls at risk for depression based on parental history of depression, the authors acknowledged that the participants might also be at risk for developing anxiety or other types of psychopathology (Dearing & Gotlib, 2009).

In hindsight, one way to disentangle the effects on anxiety vs. depression could be to exclude participants with high scores on trait anxiety; however, this might result in a vulnerable sample that is arguably less typical. Future studies could consider using a risk factor that is more specific to depression. However, selecting a specific risk factor is itself a challenging task; this limitation was echoed by previous studies using other risk factors (e.g. parental history for depression, Dearing & Gotlib, 2009). Alternatively, future studies could consider using a longitudinal design involving a long term follow-up of vulnerable adolescents to differentiate the effects of CBM on risk for depression vs. anxiety.

4.4 Critique of the Methodology

The findings of the study should be considered in the context of the methodological strengths and weaknesses.

4.4.1 Sample

The current sample consisted of 16-18 year old adolescents recruited from a local sixth form college. Similar to many previous studies (e.g., Beard & Amir, 2008; Blackwell & Holmes, 2010; Brosan et al., 2011; Hirsch et al., 2009; Lang et al., 2012; Mathews et al., 2007; Teachman & Addison, 2008), the sample was predominately female and white, and therefore the results may not necessarily be generalizable to the wider adolescent population. Indeed, gender differences in the

effects of CBM have been implicated previously (e.g., Lothmann et al., 2011); however, this could not have been tested in the present study due to the small number of male participants.

This study sought to exclude those who had any current or past diagnosed psychological disorders as these individuals might represent a different population to the one being targeted here. Nevertheless, on average, the sample seemed to have an unexpectedly high score on the baseline measure of depression even comparing with previous studies with vulnerable volunteers (e.g., Chan et al., 2007). Although the median score was within the range of 'minimum depression', 24 (32%) participants reported a score above the conventional clinical cutoff point indicating depression (i.e., BDI-II > 13; Beck et al., 1996). These participants were not excluded because BDI-II cannot be used alone as a diagnostic tool. In hindsight, it might have been helpful to use a structural clinical interview to exclude participants with significant depressive symptoms during recruitment. This may reflect a volunteer bias such that individuals who experience more emotional disturbances may be more interested in trying to learn more about their problems through participating in a psychology research study. The level of depressive symptoms may act as a moderator for the effects of CBM; this hypothesis was not tested here as it was beyond the scope of the study.

Randomisation was appropriately used and resulted in two groups that were well matched in terms of baseline characteristics. This enabled this study to make conclusions regarding the effects of CBM without being confounded by irrelevant group differences at baseline.

The sample size was determined using a formal power calculation based on two previous studies with adolescents using similar training materials (Lau et al.,

2011; Lothmann et al., 2011). However, the effect size in these studies could have been over-estimated because CBM was compared against a negative training condition where participants were coached to repeatedly endorse negative interpretations. Therefore, the current sample may not have been adequately powered to detect some of the more subtle effects of CBM. Indeed, some of the key analyses were based on a reduced sample due to attrition, although the overall attrition rate in this study (11%) was comparable with previous studies (see Beard, 2011 for a review).

This study also provided useful information about the number of adolescents needed to be screened to recruit a given sample size. This study was advertised to *all* the students in a sixth form college. However, only 8% of the students expressed an initial interest in participating by completing the screening questionnaire. Out of these potential participants, 50% consented to take part. Future studies should take this information into consideration when planning recruitment.

To explore the effects of CBM in adolescents at higher risk of developing depression, those who scored above the median on the neuroticism scale were selected to represent a vulnerable subgroup. Neuroticism was chosen as an index of risk due to its known predictive power for depression (Kendler et al., 2002, 2006a, 2006b) and association with negative cognitive biases (Chan et al., 2007; Salemink & van den Hout, 2010). Indeed, the high neuroticism subgroup was found to have higher levels of negative interpretation bias and depressive symptoms than their fellow participants who had lower neuroticism scores, suggesting that the median split had successfully created two groups that had significant differences in risk. Future studies should consider using more extreme cut-off points, as in some of the previous studies (e.g. N score ≥ 8 vs. N score ≤ 3; Chan et al., 2007, 2008a, 2009).

This would further enlarge the difference in risk between the two groups, thereby increasing the sensitivity of the comparison to detect differences due to neuroticism. These cut-off points were deemed unsuitable in the current study given the current sample size. In addition, as discussed above, neuroticism has been indicated as a risk factor for anxiety as well as depression. Therefore, the current effects of CBM observed in the high neuroticism subgroup could be interpreted in the context of a general vulnerability to mood disorders.

4.4.2 Design and outcome measures

The current study adopted a repeated measures between-groups design, providing a rich set of data allowing comparisons *both* across time and between CBM and a matched control intervention. By contrast, many previous studies were limited by a lack of baseline assessment (Lau et al., 2011; Lothmann et al., 2011) or a lack of control group (Blackwell & Holmes, 2010; Brosan et al., 2011; Steel et al., 2011; Turner et al., 2011) rendering it difficult to establish the exact nature of change resulting from CBM. In this respect, this study in particular surpassed the four previous studies with adolescents. Specifically, baseline interpretation bias was not measured in two of the studies (Lau et al., 2011; Lothmann et al., 2011) and mood was only measured by unstandardized visual analogue scales (Lau et al., 2011; Lothmann et al., 2011) or one single measure (i.e., STAI; Salemink & Wiers, 2011, 2012). The current study greatly expanded the range of outcome measures including standardised questionnaires for depression, state and trait anxiety, as well as positive and negative affect. All of these were measured before and after intervention, although the measures for depression and anxiety were only used at baseline and one week following training because these measures were not intended to be used

repeatedly within a short period of time. The Time 3 assessment was particularly valuable in establishing the durability of the training effects, especially since the full range of outcome measures were repeated at this point.

Interpretation bias was measured by the recognition test, a measure that has been widely used in CBM studies. It was based on the original task (Mathews & Mackintosh, 2000), specifically adapted and validated for use in adolescents (Lau et al., 2011; Lothmann et al., 2011). To minimise practice effects and increase engagement (through greater variety), two versions of the test were used; one of these was newly developed and obtained through personal communication with one of the key researchers in CBM research with adolescents (J. Lau). However, our results showed that the two versions were not completely matched, presumably due to differences in wording. This difference has not affected the findings of the current study, due to the appropriate use of counterbalancing. However, further work is necessary to improve the matching of the two versions before they can be used in future studies.

A particular novelty of this study was the measurement of stress vulnerability *both* inside the laboratory and in 'the real world', which involved piloting a controlled experimental stressor specifically designed for the purpose *and* asking participants to report their mood and events on a daily basis through mobile phone text messages.

Experimental stressors used in previous studies mostly targeted anxiety. This study aimed to explore the effects of CBM on vulnerability to depression; a stressor was therefore specifically developed to capture the type of negative biases relevant to depression. In particular, cognitive theories emphasise the role of cognitive biases towards a negative sense of self (e.g., 'it is all my fault') in maintaining depressive

symptoms such as self-criticism and sense of worthlessness (Beck et al., 1979). Based on this theoretical understanding of depression, the current stressor therefore comprised an ambiguous error message that could be taken to imply that participants may have done something wrong resulting in the loss of data (e.g., 'press the wrong button' and 'take too long to respond'). This error message was also conceptualised with the intention to provide a real life analogue to the CBM training. In other words, by creating an ambiguous situation similar to the scenarios used in the intervention, the error message provided a means to directly examine whether the increase in positive interpretations shown in the recognition test was translatable to an increased tendency to interpret real life ambiguous situations in a positive way. It was also designed to be age appropriate and fit into the context of the experiment. Some participants (> 10) asked the experimenter for advice when they saw the error message, suggesting that the error message was reasonably believable. Apart from this face validity, a formal validation procedure was not carried out as this stressor was only at a piloting stage. Furthermore, participants' emotional responses were only measured by a simple Likert scale; further studies should develop more sophisticated ways to give a more accurate measure. Thus, although the stressor has high potential to be a useful instrument to assess stress vulnerability, further work is needed to establish its reliability and validity before it could be used as a robust experimental tool.

In addition to the experimental stressor, this study further explored the effects of CBM on responses to real life stress by asking participants to rate their mood and report events on a daily basis during the week that followed the training. Again, the mood ratings were based on a simple Likert scale; the precision could be enhanced by using more standardised mood measures. The events reported over one week

provided very valuable information regarding the day-to-day life of adolescents; future CBM research should refer to these qualitative descriptions when developing further age-appropriate training materials. An inspection of the descriptions of these events highlighted the importance of academic work (e.g. meeting deadlines for assignments), social participation (e.g., going to parties), romantic relationships, and pursuits of interests (e.g., music, drama, and sports) in contributing to the daily emotional experiences of young people. Encouragingly, these same themes had already been featured in the CBM training for adolescents (Lothmann et al., 2011) including the current study. However, these descriptions also highlighted considerable individual differences, arguing for the advantage of using individualised training materials (Beard, 2011). In support of this, on the feedback form, some participants did comment that they found some of the training scenarios irrelevant to themselves. Furthermore, there is room for improvement in the clarity of the instructions; participants could be given more specific guidelines as to the amount of detail they should report. Interestingly, about half of the participants chose to give these daily ratings and events through mobile phone text messages rather than email. The response time was prompt compared with email, in many cases almost instant. The compliance rate was high, minimising loss of data. Feedback suggested that participants not only found this part of the experiment acceptable, many of them found it enjoyable and engaging. This study is valuable in establishing the acceptability and feasibility of using mobile phone text messages as a means of collecting data, which has particularly high potential for future research with adolescents.

Similar to many previous studies, the outcome measures for mood in this study relied heavily on self-reported measures, which were potentially susceptible to

response bias and demand characteristics. Future studies should consider broadening the range of outcome measures to include more objective scales. Given that this study aimed to explore the potential for CBM to be used as a preventive tool in individuals who are vulnerable but not currently depressed, it would have been helpful to include instruments such as those employed in positive psychology (Seligman, Steen, Park, & Peterson, 2005). This would help investigating the effects of CBM beyond the measurement of symptoms.

4.4.3 Intervention

This study compared CBM training with a placebo-controlled condition. In contrast to two of the four previous CBM studies with adolescents (Lau et al., 2011; Lothmann et al., 2011) where positive training was compared with negative training, the current study provided a more accurate indication of the effectiveness of CBM training. However, as discussed above, the control condition used in this study might not be sufficiently 'neutral' as it might have reinforced participants' pre-existing biases. By contrast, two previous CBM studies with adolescents asked control participants to resolve 30% of the scenarios in a positive way, 30% in a negative way, and 40% in a neutral way (Salemink & Wiers, 2011, 2012). This method might be more appropriate as a placebo-control. Notably, this study surpassed all four previous studies with adolescents by delivering the training and assessing its effects beyond a single session. Specifically, two sessions of training were provided, determined based on both theoretical and practical considerations. Although a substantial body of literature has shown that one single session of training is sufficient in inducing changes in cognition and / or mood, larger effect sizes and longer durability tended to be found in studies using multiple sessions (Beard, 2011).

From a feasibility perspective, the number of sessions was decided upon after taking into account the college's concerns over the burden to students (e.g., time) and availability of resources (e.g., limited computing facilities). Although the current effect sizes may be limited by the relatively small dose of training, this study is valuable in establishing the acceptability and feasibility for two sessions of training in this population of adolescents.

4.4.4 Acceptability and ethical considerations

This study contributed to the emerging evidence for acceptability of CBM through the collection of participants' feedback (e.g., Beard et al., 2011a, 2011b; Blackwell & Holmes 2010; Brosan et al., 2011), and was the first to systematically report feedback by adolescents. The feedback form (see appendix E) included a rating scale to provide a quantitative measure of the level of acceptability, while at the same time eliciting qualitative feedback by asking participants to indicate their favourite and least favourite parts of the experiment as well as providing space for participants to leave 'any other comments'. This was comprehensive, although in hindsight it would have been helpful to ask whether participants believed in the error message (i.e., the experimental stressor). Despite the overall positive feedback received from participants, some of the negative feedback such as 'repetitive' and 'somewhat boring' need to be addressed in the future development of CBM.

The most unexpected finding of this study was that control participants reported an increase in state anxiety, suggesting that repeated exposure to ambiguous unresolved scenarios could have a potential negative impact on mood. Further investigation is warranted in clarifying this effect and its ethical implications.

Finally, it is positive to note that the experimenter has liaised closely throughout the course of the study with the members of staff from the college where recruitment and data collection took place. Specifically, the Head of Psychology was consulted from an early stage of the research regarding the acceptability and feasibility of the study; staff members from the IT department were also consulted regarding the best way to manage data protection while using the college's computing facilities. The experimenter has arranged to disseminate the findings to the participants by giving a presentation at the college. These efforts in maximising the involvement of the public in the design and execution of research are in line with the guidelines for good research practice (Medical Research Council, 2005).

4.5 Theoretical and Clinical Implications

Notably, the two groups did not show differential cognitive changes but yet they displayed different changes in negative affect and state anxiety. This was largely in line with previous research suggesting that state mood (but not trait) could be *directly* modified by CBM, possible via exposure to valenced materials (Salemink et al., 2010a). The present study thus supported this claim that cognitive changes are not prerequisites for changes in mood states.

The primary implication of this study is that positive interpretation bias can be induced in adolescents, including those who have higher levels of vulnerability to depression. The latter is particularly remarkable given that these vulnerable adolescents were shown to have stronger pre-existing negative interpretation biases. Prior to this study, only four CBM studies had been conducted with adolescents. These adolescent studies, including the present investigation, do not simply represent a replication of the adult literature. Instead, it has been suggested that the role and

nature of cognitive biases may vary across different developmental stages (Cole & Turner, 1993; Turner & Cole, 1994); therefore, it cannot be assumed that the effects of CBM documented in the adult literature would necessarily be applicable to the younger populations. Indeed, the neuropsychological findings have lent support for the argument that cognitive styles may be more malleable in adolescence than in adulthood because of the greater neural plasticity in younger individuals (Blakemore, 2006).

From a clinical perspective, adolescence is the developmental stage in which the onset rates for anxiety and depression rapidly increase (Gregory et al., 2007; Kim-Cohen et al., 2003; Sorenson et al., 1991). More research has been called for to develop preventive measures or early interventions for this age group (Sahakian, Malloch, & Kennard, 2010). Specifically, research has shown that cognitive biases act as a trait vulnerability marker for depression (Chan et al., 2007) and that they are predictive for depressive responses to stress in adolescence (Cole & Turner, 1993; Turner & Cole, 1994). Therefore, preventive tools focusing on modifying cognitive biases, such as the CBM, have a particularly high potential for being beneficial to adolescents at risk for developing emotional disorders. It should be noted that, although the CBM being studied here targeted interpretation bias, as mentioned in the Introduction there is also a CBM programme designed to modify attention biases (see Bar-Haim, 2010; Browning et al., 2010; Hakamata et al., 2010 for a review). It is beyond the scope of this thesis to compare the effectiveness of the two different types of CBM; however, it is noteworthy that previous reports have suggested that participants from clinical samples have found the CBM for interpretation more engaging and relevant to their problems (e.g., Beard et al., 2011b; Brosan et al., 2011). This feedback suggested that CBM for interpretation has greater face validity

and thus illuminated its potential to be developed as a preventive tool. At the time of writing, this study was the first to examine the effects of CBM on adolescents at risk for depression by virtue of neuroticism. Despite the limitations discussed above, this study represents an important first step in developing preventive tools for adolescents at risk for developing emotional disorders.

The 'cognitive vulnerability hypothesis' developed from the cognitive theories of depression (Abramson et al., 1989; Beck, 1967; Beck et al., 1979) suggests that individuals who exhibit negative cognitive patterns are at increased risk for depression particularly when they are confronted with stressful life events. It is therefore of the utmost importance that the effects of CBM is tested under provocation of stress. However, none of the studies that tested this hypothesis so far, including the present investigation, have provided clear evidence to suggest that CBM can protect vulnerable individuals against negative emotional and behavioural responses upon stress provocation. The lack of convincing evidence for the effects on stress vulnerability suggests that CBM is far from ready to be used as a preventive intervention. This study also highlighted the need for piloting effective ways to record emotional consequences of day-to-day stress, such as using mobile phone messages, as well as developing experimental stressors that are tailored to provoke clinically-relevant presentations.

This study echoed the existing literature in suggesting that effects of CBM on mood changes were mixed. The pattern of results argued against the hypothesis that cognitive changes were mediated by mood. Instead, it illuminates the complexity of the mechanisms of change. This study identified training performance as a mediator for mood changes, suggesting that engagement and / or amount of positive feedback received during training could affect the emotional consequences of training. This

study has also tested the hypothesis that neuroticism is a moderator, although the current findings have not yielded evidence to support this hypothesis. Previous studies have explored other mediators and moderators such as severity of depressive symptoms (Lang et al., 2012), level of baseline negative interpretation bias and trait anxiety (Salemink & Wiers, 2011), and self efficacy (Lau et al., 2011). However, results were patchy and limited by methodological issues. Further research is warranted to further clarify the mechanisms of change.

Finally, although cost-effectiveness has not been formally calculated, this and previous research have shown that CBM could be used independently at home or at college (e.g., Blackwell & Holmes, 2010; Lang et al., 2011) with minimal input from therapists suggesting relatively low costs. This is an obvious advantage for CBM to be developed as a preventive intervention.

4.6 Future Research

As emphasised in this report, more research is needed to further establish the effectiveness of CBM in adolescents. The finding that CBM does not outperform placebo-control in most outcome measures suggests that the effects of CBM in adolescents are far from robust, and further replication is needed. Future research should address the limitations discussed above. Recruiting participants based on trait vulnerability markers, such as neuroticism, family history of depression, or high levels of negative cognitive biases, would improve the sensitivity of detecting changes that are more clinically relevant. As discussed above, selecting a suitable vulnerability marker is itself a challenge; future studies, especially those aiming to study the effects of CBM on vulnerability, should consider using a longitudinal design with long term follow-up. If the hypothesis that CBM can reduce

vulnerability were true, we would predict that the effects could be seen most prominently when vulnerable individuals are challenged by stress. Longitudinal follow-up with accurate measures of stressful life events would help testing this hypothesis. Another way to test this hypothesis is to improve validity of experimentally induced stressors. This study has piloted ways to assess responses to stress; with further validation, the experimental stressor and the recording of responses to day-to-day life stress used in this study could be developed into a robust measurement.

One of the main challenges facing CBM research is that so far there has not been compelling evidence that fostering positive interpretations could translate into significant benefits for mood and vulnerability. This appears to be one of the major obstacles for CBM to be developed as a clinical tool. Although individual studies have explained their null results in the context of methodological issues, it is important to consider how we may improve the effectiveness of CBM in a broader sense. In particular, future research needs to address the negative comments, especially 'boring', 'repetitive', and 'stereotypical', and in general to improve engagement and compliance to ensure that individuals receive the optimal benefits.

First, future research could examine whether individually tailored materials would produce stronger effects than standardised materials. One way to test this hypothesis is to ask participants to rate the extent to which they find the training items relevant to themselves. The hypothesis would be supported if the self-relevance ratings correlated with the size of training effects. Alternatively, standardised and individually tailored materials could be directly compared; however, this may pose methodological challenges (e.g. it might be difficult to match the two conditions in terms of emotional salience). If individualised materials

were found to be superior, it would be helpful for researchers or clinicians to work collaboratively with each individual to develop the training materials (e.g. making use of materials collected through structural clinical interviews or personal diaries).

Second, the effectiveness of CBM may also depend on the schedule of training. Further research is required to examine what the optimal delivery schedule is (i.e. whether it should be delivered in an intense way or a small dose per day). Although this could be tested through randomised controlled studies, the delivery schedule should also be tailored according to individual learning style.

Furthermore, future research could also explore creative ways to deliver the training. The most widely used paradigm so far has been written scenarios that required individuals to fill in word fragments. This is not fully accessible to individuals who have reading difficulties, the younger age group, or those who intellectual disabilities. This is also language-specific, rendering it difficult for CBM to be developed as a more universal tool. Some studies used auditory presentations (see Table 1.1) which addressed some of these limitations. Future studies could also consider using other media such as videos. This study has also demonstrated that mobile phones are an acceptable and useful way to engage young people in research; future studies could explore whether training could be delivered directly through this medium.

Providing a more explicit rationale for the training may also help encouraging individuals to apply what they learn from the CBM training to real life situations (Beard, 2011). This process could be facilitated through, for example, forming a support group or online forum where CBM users could discuss what they learn from the training and how they may transfer their learning to real life.

In the longer term, the effectiveness and cost-effectiveness of CBM needs to be compared with other approaches, such as computerised CBT and other self-help interventions, before decisions could be drawn as to whether this could be rolled out routinely as a clinical tool.

4.7 Conclusion

Taken together, this study improved on previous CBM research with adolescents by including multiple assessments from baseline to one-week follow-up, expanding the range of outcome measures, piloting ways of measuring stress vulnerability, and establishing acceptability through the collection of feedback. At the time of writing, this study was the first to examine the effects of CBM on adolescents with high neuroticism, as well as to explore the potential interaction between this personality risk factor and the effects of CBM. The key findings showed that the CBM group showed a greater reduction in negative affect compared with control group. In addition, the CBM group did not show the increase in state anxiety as seen in Control participants. However, overall this study has *not* provided strong evidence to support the effectiveness of CBM in promoting changes in interpretation biases or reducing stress vulnerability in this age group. It is positive to note that participants' feedback was mostly positive suggesting good acceptability, although future CBM research needs to prioritise improving upon some negative comments such as 'boring' and 'repetitive'. Despite the methodological limitations, the present investigation has broadened the hitherto narrow evidence base of CBM in adolescent populations. It also represents an important step in exploring the potential of CBM to be developed as a preventive intervention for vulnerable adolescents.

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Appendix A
Poster for Recruitment

University of East Anglia

Personality & Thinking

Psychologists at the University of East Anglia would like to invite young people to take part in a research project to answer this question:

How does personality affect the way we interpret situations?

You must be:

- Aged 16 years or older
- Fluent in English, have no severe reading difficulties

The study will last for 2 weeks. We will ask you to:

- Fill in some questionnaires about your mood
- Do some computer tasks that involve, e.g. completing words

To say thank you for taking part, you will be entered into a lucky draw. The winner will receive a £100 Amazon voucher.

If you would like to take part or would like to find out more about the research, please contact Dr Stella Chan (Email: stella.chan@uea.ac.uk).

University of East Anglia

Personality and Thinking

Information Sheet for Participants

Version 2 (19 / 07 / 2011)

Invitation to Participate in the Study

Thank you for your interest in participating in the study. Before deciding if you want to take part, it is important that you understand what this research involves. Please take time to read all the information below. If you would find it helpful, you can talk to other people about participating in the research. Please feel free to ask us any questions.

Purpose of the Research

In everyday life, we come across a lot of information. People have different styles in the way they interpret situations. This may affect the way people think and feel about themselves and the world. This research aims to find out how young people with different personality characteristics interpret situations, and whether this changes over time.

Who is organising the research?

This research is conducted by Dr Stella Chan, who is currently a Trainee Clinical Psychologist at the University of East Anglia (UEA) and has previous experience working with young people. She is supervised by Prof Shirley Reynolds, Professor of Clinical Psychology and Co-Director of the Doctoral Programme in Clinical Psychology.

Who can take part in it?

We are recruiting young people (aged 16 or above) with different personality characteristics to take part. To find out whether you are eligible for the study, we will ask you to complete a short questionnaire online. This will only take about 5 minutes.

Do I have to take part in the research?

Appendix B
Information Sheet for Participants

Taking part in this research is completely voluntary. If you decide to take part, we will ask you to sign a consent form to show that you have agreed to participate. You are free to change your mind and stop taking part in the research at any time.

What will happen to me if I take part and what will I have to do?

This study will run across 2 weeks. You will meet with our researcher, in groups, three times in total. All meetings will take place at your school during your free time. Details are given as follows:

Week 1 **Meetings 1 & 2**

You will meet with the researcher twice on two separate days (each about 1 hour). At each meeting, you will complete 1-3 short questionnaires and 2 computer tasks.

Week 2 **Meeting 3**

During the week after meeting 2, we will contact you via text message or email each day and ask you to rate your mood and tell us any events that you find particularly cheering or upsetting that day. Towards the end of this week, you will meet with the researcher for the third time (about 1 hour) and complete 3 questionnaires and 1 computer task. We will also ask you to give us some feedback about our study.

What are the possible problems or risks if I take part in the research?

The computer tasks and questionnaires mentioned above have often been used in research, so we do not think there will be any problems or risks for you. However, you are free to stop participating at any time without having to give a reason.

What are the possible benefits of taking part?

This study will help us understand more about how young people think. As a token of thanks, you will be entered into a lucky draw for a prize (a £100 Amazon voucher) upon completion of the study.

Will my taking part in this research be kept secret?

Yes, all the information we collect from you and about you is confidential. All information will be anonymised, and kept in a locked filing cabinet in a secure office or stored electronically in computers that are password protected. Only the researchers will know your name and be able to identify you. The information that we collect from you will be looked after by the researchers for 5 years. Then it will be destroyed securely by shredding any paper records and permanently deleting information held on computer. The findings of the study may be published in academic journals or presented in conferences. However your name or other personal identifiable information will **not** be disclosed.

What if there is a problem?

If you are worried about anything to do with the research or if you have any questions, please do not hesitate to contact Stella Chan (Email: stella.chan@uea.ac.uk). We will do our best to answer your questions. You may also find it helpful to speak with your teachers or parents. If you are still unhappy and want to make a complaint, you can contact Prof Shirley Reynolds (s.reynolds@uea.ac.uk) who is the supervisor of the researcher.

Who has reviewed the research?

This research has been approved by the Research Ethics Committee of the University of East Anglia (Faculty of Health). This committee is an independent group of people who aim to protect your safety, rights, well-being and dignity.

How can I take part in this research or find out more about it?

If you would like to participate in this research or want to find out more about it, please contact Dr Stella Chan by email (stella.chan@uea.ac.uk). Thank you!

Appendix C
Screening Questionnaire

Personality & Thinking: Screening Questionnaire

If you are interested in taking part in this study, or wish to find out more about it, please fill in this questionnaire. This will help the researchers to find out whether you are suitable to participate in the study. By completing this questionnaire, you will *not* commit yourself to take part in the study.

Part I: Basic information, language use, and health

Name	
Gender / Age	
Contact details (email and / or phone number)	
Is English your first language?	
Do you consider yourself fluent in English?	
Do you have severe reading difficulties?	
Have you ever been diagnosed with a mental illness?	

Part II: Personality Characteristics
Please answer each question by putting a circle around the "YES" or the "NO" following the question. There are no right or wrong answers, and no trick questions. Work quickly and do not think too long about the exact meaning of the questions.

PLEASE REMEMBER TO ANSWER EACH QUESTION

Does your mood often go up and down?	YES	NO
Do you ever feel "just miserable" for no reason?	YES	NO
Are you an irritable person?	YES	NO
Are your feelings easily hurt?	YES	NO
Do you often feel "fed-up"?	YES	NO
Are you often troubled about feelings of guilt?	YES	NO
Would you call yourself a nervous person?	YES	NO
Are you a worrier?	YES	NO
Would you call yourself tense or "highly-strung"?	YES	NO
Do you worry too long after an embarrassing experience?	YES	NO
Do you suffer from "nerves"?	YES	NO
Do you often feel lonely?	YES	NO

Thank you very much for filling in this questionnaire, our researcher will contact you shortly.

Appendix D
Consent Form

Participant Identification Number for the Study: _____

University of East Anglia

CONSENT FORM

Title of Project: Personality and Thinking

Name of Researchers: Dr Stella Chan, Prof Shirley Reynolds

Please initial box

1. I confirm that I have read and understood the information sheet dated 19.07.2011 (v2) for the above research. I have had the opportunity to consider the information, ask questions and receive satisfactory answers. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason. ☐

3. I agree to take part in the above research. ☐

_____	_____	_____
Name of Participant	Date	Signature
_____	_____	_____
Name of Researcher	Date	Signature

Feedback Form

Thank you very much for completing the study. We would love to hear how you have found the study. This will help us improve our research in the future.

I. How would you describe the study? Please indicate the extent to which you agree with each description using the scale from 1 to 5.

	Very slightly or Not at All	A Little	Moderately	Quite a Bit	Extremely
Boring	1	2	3	4	5
Fun	1	2	3	4	5
Harmful	1	2	3	4	5
Interesting	1	2	3	4	5
Helpful	1	2	3	4	5
Dull	1	2	3	4	5
Distressing	1	2	3	4	5
Pointless	1	2	3	4	5

II. We are interested to hear what you think the purposes of the computer tasks are. Please tick all the categories that you think the computer tasks aim to measure.

Spelling	☐	Interpretation of situations	☐
Memory	☐	Reading speed	☐
Concentration	☐	Others:_____	

III. Would you recommend your friends to participate in the study? Yes / No

IV. What did you like best about the study? _____

V. What did you like least about the study? _____

VI. Other Comments: Please tell us anything that you want the Researchers to know.

Appendix F
Confirmation of Ethics Approval

Faculty of Medicine and Health Sciences Research Ethics Committee

University of East Anglia

Stella Chan
Doctoral Programme in Clinical Psychology
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19th October 2011 2011

Dear Stella

Vulnerability to Depression and Cognitive Bias Modification (Personality and Thinking)
Reference 2010/2011-46

Thank you for your e-mail dated 19th October notifying us of the amendments you would like to make to your above proposal. These have been considered by the Chair of the Faculty Research Ethics Committee and we can now confirm that your amendments have been approved.

Please can you ensure that any further amendments to either the protocol or documents submitted are notified to us in advance, and also that any adverse events which occur during your project are reported to the Committee.

Please can you also arrange to send us a report once your project is completed.

Yours sincerely

Yvonne Kirkham.

Yvonne Kirkham
Project Officer

Appendix G
Debriefing Form

Personality and Thinking

Dear Participants,

Thank you again for participating in this study. We truly appreciate your time and effort. I hope you have found this an interesting experience. As a token of thanks, your name will be entered into a lucky draw for a £100 Amazon voucher at the end of the study.

As we mentioned in the Information Sheet, this study aims to explore how young people interpret ambiguous information, and how this may be linked to their personality and psychological well-being. The computer tasks we asked you to complete were designed to look at your style of interpreting ambiguous information. The questionnaires were to help us understand how your mood is in general and how it changes on a day-to-day basis. *There were no right or wrong answers in either the computer tasks or questionnaires.*

As in many research studies, it is often more helpful to look at your responses as a whole group rather than on an individual basis. Therefore, we do not routinely give participants individual feedback. However, if you are interested, we will be happy to write to you again after the end of the study to tell you what we find.

Thank you again for your support for our study. Please feel free to contact me if you have any questions or concerns. I would like to take this opportunity to wish you all the best.

Yours sincerely,

Dr Stella Chan
Trainee Clinical Psychologist, University of East Anglia
Email: stella.chan@uea.ac.uk

Appendix H
Email to Participants about Local Support for Young People

Dear Participants,

Thank you very much for taking part in the study. I am hoping to come back next year and give a talk about the findings of the study, and I hope to see many of you there. For the time being, if you have any questions or concerns about the study, please contact me.

As you may recall, I asked you to fill in some questionnaires during the sessions. They were intended to find out more about your mood and wellbeing at that time. Sometimes filling in questionnaires may make people more aware of their feelings. If completing the questionnaires has left you with any concerns or questions there are a number of places and people whom it might be useful to contact. For example, 'Centre33' is a local organisation that provides support to young people in Cambridge. You can find out more details from their website (http://www.centre33.org.uk/).

You might also find that your parents, teachers, college nurse, or GP are able to help.

May I take this opportunity to wish you all the best for Christmas and the year to come.

With best wishes,
Stella

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Dr Stella Chan, Trainee Clinical Psychologist (Email: stella.chan@uea.ac.uk)
Supervised by Prof Shirley Reynolds, University of East Anglia (Email: s.reynolds@uea.ac.uk)

Appendix I
Written Instructions for Daily Reporting of Mood and Events

Thank you very much for completing Sessions 1 and 2 of the study. From today onwards until we meet again next week, I will send you a text message or email each day and ask you to answer two questions.

I. First, we will ask you to rate how you feel on each day on a scale of 1 – 5.

    1 = Completely miserable or stressed
    2 = A bit miserable or stressed
    3 = OK
    4 = quite good
    5 = really good

II. Second, we will ask you if there is anything that happened on each day that made you feel particularly good or bad. Your answer would be 'Yes' or 'No'. If your answer is yes, please give a short description (e.g., 'failed a test', 'party with friends', 'someone gave me a hard time').

THANK YOU!