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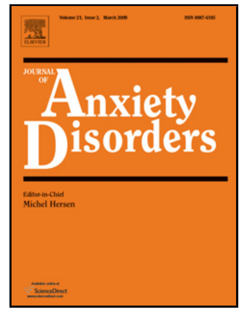

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Effects of appraisal training on responses to a distressing autobiographical event

Marcella L. Woud[a], Armin Zlomuzica[a], Jan C. Cwik[a], Jürgen Margraf[a], Lorika Shkreli[a], Simon E. Blackwell[a], Thomas E. Gladwin[b], & Thomas Ehring[c]

a. Mental Health Research and Treatment Center, Department of Psychology, Ruhr-Universität Bochum, Massenbergstrasse 9-13, 44787 Bochum, Germany

b. Department of Psychology and Counselling, University of Chichester, Chichester, United Kingdom

c. Department of Psychology, LMU Munich, Leopoldstrasse 13, 80802 Munich, Germany

Corresponding author: Marcella L. Woud, Mental Health Research and Treatment Center, Department of Psychology, Ruhr-Universität Bochum, Massenbergstrasse 9-13, 44787 Bochum, Germany. E-mail: marcella.woud@rub.de, phone: +49 (0)234 32 - 21502, fax: +49 (0)234 32 – 14369

Highlights

- PTSD is characterized by dysfunctional appraisals.
- CBM-App can modify such appraisals and analogue posttraumatic stress symptoms.
- Effects of CBM-App following a distressing autobiographical event was examined.
- CBM-App changed explicit but not implicit appraisals.
- CBM-App reduced intrusion distress and overall posttraumatic stress symptoms.

Abstract

Dysfunctional appraisals are a key factor suggested to be involved in the development and maintenance of PTSD. Research has shown that experimental induction of a positive or negative appraisal style following a laboratory stressor affects analogue posttraumatic stress symptoms. This supports a causal role of appraisal in the development of traumatic stress symptoms and the therapeutic promise of modifying appraisals to reduce PTSD symptoms. The present study aimed to extend previous findings by investigating the effects of experimentally induced appraisals on reactions to a naturally occurring analogue trauma and by examining effects on both explicit and implicit appraisals. Participants who had experienced a distressing life event were asked to imagine themselves in the most distressing moment of that event and then received either a positive or negative Cognitive Bias Modification training targeting appraisals (CBM-App). The CBM-App training induced training-congruent appraisals, but group differences in changes in appraisal over training were only seen for explicit and not implicit appraisals. However, participants trained positively reported less intrusion distress over the subsequent week than those trained negatively, and lower levels of overall posttraumatic stress symptoms. These data support the causal relationship between appraisals and trauma distress, and further illuminate the mechanisms linking the two.

Keywords: appraisal; trauma; Cognitive Bias Modification; autobiographical memory; intrusions; implicit associations

1. Introduction

Cognitive Models of Posttraumatic Stress Disorder (PTSD) emphasize the crucial role of negative trauma-related appraisals in the onset and maintenance of PTSD (e.g., Brewin, Dalgleish, & Joseph, 1996; Dalgleish, 2004; Foa, Steketee, & Rothbaum, 1989; Resick & Schnicke, 1992). For example, according to the cognitive model of Ehlers and Clark (2000) individuals with persistent PTSD appraise the trauma event and/or its consequences in a highly dysfunctional manner. As a result, these individuals experience 'a sense of current serious threat' (p. 320, Ehlers & Clark, 2000), which in turn leads to symptoms such as intrusions, anxiety, or arousal. Various studies have supported the role of dysfunctional appraisals in PTSD. In a seminal study, Foa et al. (1999) developed the Post Traumatic Cognitions Inventory (PTCI) assessing dysfunctional appraisals related to the self, the world, and self-blame, and showed that these appraisals correlated with PTSD severity and discriminated between traumatized individuals with and without PTSD. Prospective studies (e.g., Bryant & Guthrie, 2005, 2007) provided evidence that a tendency to engage in dysfunctional appraisals prior to a traumatic event is predictive of subsequent PTSD symptoms. Similarly, dysfunctional appraisals shortly after the trauma have been found to predict PTSD some months later, even when controlling for initial symptom levels (e.g., Ehring, Ehlers, & Glucksman, 2008; Kleim, Ehlers, & Glucksman, 2007; Kleim et al., 2013).

There is also increasing evidence for a causal role of dysfunctional appraisals in PTSD (cf. Kraemer et al., 1997). For example, Woud et al. (2012, 2013) tested the effects of experimentally-induced positive and negative appraisals on response to an analogue trauma (a distressing film). The experimental manipulation used methods developed within the Cognitive Bias Modification (CBM) literature (Koster, Fox, MacLeod, 2009; Woud & Becker, 2014), namely a computerized training, in this case specifically designed to target dysfunctional, trauma-related appraisals (CBM-Appraisal; CBM-App). Participants were trained to adopt a positive or negative appraisal style towards the distressing film, whereby the training was applied either after (Woud et. al., 2012) or before the film (Woud et. al., 2013). Participants trained to adopt a positive appraisal style reported reduced analogue posttraumatic stress symptoms, such as intrusion frequency and intrusion distress, than those trained to adopt a negative appraisal style (see also Cheung, Bryant, 2017; Schartau, Dunn, & Dalgleish, 2009, and for a review on CBM in PTSD, see Woud, Verwoerd, & Krans, 2017).

To conclude, there is emerging evidence for a potential causal role of dysfunctional appraisals. However, this research is at an early stage and still limited, e.g., limited to analogue experimental studies that did not use distressing real-life events. Hence, from a theoretical perspective, additional research is needed in order to test and refine cognitive models of PTSD. A second argument arises from a clinical perspective. Generally, interventions within the framework of Cognitive Behavioural Therapy (CBT) are moderately effective (Bisson, Roberts, Andrew, Cooper & Lewis, 2013), and interventions with a specific focus on changing dysfunctional appraisals are highly effective, e.g., Cognitive Therapy (Ehlers & Clark, 2000) and Cognitive Processing Therapy (Resick & Schnicke, 1992; and for recent meta-analyses, see e.g., Cusack et al., 2016; Ehring et al., 2014). CBM-App may be a promising and innovative addition to cognitive treatments for PTSD, however, further evidence for its potential effectiveness is warranted.

Therefore, the current study aimed to replicate and extend previous findings in the context of CBM-App. Previous studies using the CBM-App manipulation (Woud et al., 2012; Woud et al. 2013) had used a stressful film as an analogue trauma. Although the trauma film paradigm is a valid laboratory paradigm to investigate analogue posttraumatic stress symptoms (e.g., Holmes & Bourne, 2008; James et al., 2016), the induced analogue trauma is less personally relevant than personal experiences. Further, the situation of observing a trauma happening to others is simulated rather than experiencing a trauma oneself. In the current study, we thus investigated whether CBM-App effects can be replicated using distressing autobiographical events with high personal relevance. As one eventual aim for this line of research is to develop versions of the CBM-App training that might provide therapeutic benefits for patients with PTSD, using participants' own distressing life events and asking them to recall this moves the research a step closer towards this potential application. Additionally, it allowed us to investigate the impact of appraisals some time after the event, rather than those immediately before, during, or immediately after the event's occurrence.

A further aim of the present study was to measure the impact of the CBM-App appraisal training on a broader range of outcomes. Previously, effects had mostly been tested in an explicit manner, e.g., via self-report. However, such explicit measures may not fully capture all relevant aspects of dysfunctional appraisals: It seems likely that dysfunctional appraisals are also activated on an automatic level (e.g., Brewin et al., 1996; Ehlers & Clark, 2000). To illustrate, according to the cognitive model of Ehlers and Clark, PTSD is at least in part underpinned by associative learning processes. A characteristic of such associative systems is that they are cue-driven and triggered automatically. Consequently, an individual suffering from PTSD may experience PTSD symptoms such as dysfunctional appraisals without being aware of the trigger or the source of the appraisals' activation. Research on dysfunctional appraisals may therefore benefit from including not only measures based on explicit self-report of appraisals, but also measures that are able to also capture appraisals' automatic nature. The Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) is a well-established instrument to capture such processes, assessing the associative strength between automatically activated memory associations. During the IAT, participants sort stimuli (e.g., words) into four categories by means of two response keys: two represent a target concept (e.g., me vs. other), and two represent two poles of an attribute dimension (e.g., traumatized vs. healthy). Each target category is paired with both attributes. As such, faster RTs during a particular target-attribute combination suggest a strong association between the two stimuli. The IAT has been applied in various clinical domains (for a review, see Roefs et al., 2011), and has added unique variance to the prediction of outcome behaviors (Greenwald, Poehlman, Uhlmann, & Banaji, 2009). In the context of PTSD, Lindgren, Kaysen, Werntz, Gasser, and Teachman (2013) tested the predictive validity of two IATs, the *traumatized self IAT* (evaluating the self as traumatized vs. healthy) and the *dangerous memory IAT* (evaluating remembering as dangerous vs. safe). Only the traumatized self IAT was associated with PSTD symptoms, and it predicted variance in PTSD symptoms even when controlling for relevant other variables (see also Engelhard, Huijding, van den Hout, & de Jong, 2007). These data thus show that it is also important to assess automatic components of dysfunctional appraisals.

To summarize, the present study had two main objectives: To replicate studies testing the effects of induced appraisals on analogue posttraumatic stress symptoms, but using a participants' own negative life events as an analogue traumatic event as opposed to a film, and to extend previous research by also testing the training's effect on automatic appraisals. The study included participants who had experienced a distressing negative life event, which was re-activated in the session via an imagery procedure. After that, participants received either positive or negative CBM-App. In line with previous studies (Woud et al., 2012; Woud et al., 2013), following verification that a differential bias had in fact been established between the groups (via an Encoding Recognition Test, ERT), it was first examined whether effects previously found in relation to film stimuli were also found when the training was applied to a negative autobiographical event. That is, we examined whether the induced bias transferred to appraisals of the negative event (via the Post Traumatic Cognitions Inventory, PTCI), and led to reduced intrusiveness in the positively-trained compared to negatively-trained group of the life event over the subsequent week (as indexed by frequency or distress ratings for intrusions recorded in a diary; Woud et al., 2012, Woud et al., 2013). As an extension of previous research, we administered an Implicit Association Test (IAT) before and after training. Other measures administered during the training session and at one-week follow-up served to investigate duration and generalization of training effects, and to further validate or complement main outcomes.

We hypothesized that, compared to participants receiving negative CBM-App training, participants receiving positive training would show a greater reduction in negative appraisals of their negative autobiographical event from pre to post-training, and lower intrusiveness of the memory over the subsequent week. Further, we hypothesized that participants receiving positive CBM-App training would also show a greater reduction in implicit negative appraisals from pre to post-training than participant receiving negative CBM-App.

2. Methods

2.1 Participants

The tested sample included 66 healthy participants (53 female, M_{age} = 23.2, SD = 4.50). Participants' eligibility was checked via an online screening: Participants were required to have experienced a distressing life event (according to their own report); be fluent in German; to not suffer from a psychological disorder at the time of the study; never had a diagnosis of PTSD or psychosis; never experienced rape or sexual violence; not self-harm; have a score < 19 on the Beck Depression Inventory II (BDI-II; Beck, Steer & Brown, 1996; German translation by Hautzinger, Keller, & Kühner, 2006), and have no suicidal tendencies (item 9 BDI < 2). Further, the screening included the State Trait Anxiety Inventory (STAI-T;

Spielberger, Gorsuch & Lushene, 1970; German translation by Laux, Glanzmann, Schaffner, & Spielberger, 1981) and the Spontaneous Use of Imagery Scale (SUIS; Reisberg, Pearson & Kosslyn, 2003; German translation by Görgen, Hiller, & Witthöft, 2016). Exclusion criteria related to current and past mental health and experience of sexual violence were intended to reduce the likelihood of including people who might be unduly affected by the negative training.

2.2 Distressing autobiographical event

2.2.1 Selection. The online screening was also used to select a distressing autobiographical event that would act as the analogue trauma event during the lab session (for a similar procedure, see Santa Maria, Reichert, Hummel, & Ehring, 2012; Schartau et al., 2009). Participants were first asked if they had ever experienced a distressing or traumatic life event, and only those answering *yes* could proceed with the remainder of the study. Thus the study sample was limited to participants who reported having experienced a distressing autobiographical event. Participants were asked to describe a maximum of three negative events that had happened to them and to indicate their age at the time of the event. They then rated each event in terms of distress felt when the event occurred and event-related distress right now, by means of an 11-point Likert rating (0 = *not at all distressing*, 100 = *very distressing*). Further, participants had to indicate how frequently the event was the object of appraisal, i.e., how often they thought about the event or appraised the event itself or its consequences (0 = *not appraised at all*, 1 = *once per year*, 2 = *once per month*, 3= *once per week*, 4 = *several times per week*, and 5 = *every day*). Finally, participants completed the Posttraumatic Stress Disorder Checklist for DSM 5 (PCL-5; German version Krüger-Gottschalk et al., 2017) for each event. The event that was rated as most distressing on the 'distress now' rating was selected for the lab session. Further, to ensure that the event did not cause severe traumatic stress (given our use of a negative training condition), the PCL-5 scores of that event were inspected, i.e., the PCL total score was required to be < 38 and participants were required not to meet DSM criteria for PTSD based on the PCL.

2.2.2 Re-activation of negative life event in session. An adapted version of the procedure by Santa Maria et al. (2012) was used to re-activate the negative life event at three points during the session.

Participants were first given an instruction sheet that included the selected negative event. This was followed by a brief baseline re-activation, in which participants were asked to think back and to re-live the event for about 15 seconds.

Later in the session and prior to the CBM-App, the first full re-activation took place. Participants were instructed to think back to the most distressing moment of the selected event and to provide a brief, written description of that moment. Next, participants were instructed to imagine themselves in that specific moment for 30 seconds. Participants were asked to close their eyes and to imagine the moment as vividly as possible, as if they were experiencing it again, with all the associated images and emotions. This full re-activation procedure was repeated post CBM-App. However, this time participants did not write a summary of the distressing moment but were asked to read the summary they had written previously before imagining the event for 30 seconds.

2.3 Cognitive Bias Modification – Appraisal training

The training was translated and adapted from an earlier study (Woud et al., 2012, 2013). Participants were presented with a series of ambiguous, appraisal-related scripts that ended with a word fragment. Participants were instructed to complete the word fragments by typing in the first missing letter. This produced an outcome consistent with a functional or dysfunctional appraisal of the script. Scripts were based on items of the Posttraumatic Cognitions Inventory Self subscale (PTCI; Foa et al., 1999), e.g., "Trusting oneself to act appropriately in future" was adapted into: '*In a crisis, I predict my responses will be h-lpf-l /*

u-el-ss' (positive CBM-App: '*helpful*', negative CBM-App: '*useless*'). The CBM-App training comprised 72 training and 8 neutral filler scripts (presented in blocks of 10). Thirty-two scripts were followed by a question to test ongoing comprehension by means of a simple yes/no question.

2.4 Assessment of Trained Bias

2.4.1. Encoding Recognition Task. To test whether the CBM training induced the corresponding appraisal style a two-phase Encoding-Recognition Task (ERT; see Woud et al., 2012; 2013; Mathews & Mackintosh, 2000) was administered. During encoding, participants read 10 novel ambiguous, appraisal-related scripts. All scripts started with a title. As in the training phase, participants were asked to complete a word fragment at the end of each script. However, completing the word fragment did not resolve the script's ambiguity. After each script, participants were asked to imagine themselves vividly in the described situation. In the recognition-phase, the 10 encoding-phase titles were presented again, followed by a set of 4 related sentences. It was participants task to rate how close in meaning each sentence was to the original script of that title using a 4-point Likert scale (1= *not at all similar* to 4 = *very similar*). There were two target sentences, representing a positive and negative interpretation of the original script, and two foil sentences, representing a general positive and negative meaning that did not resolve the script's ambiguity. A bias index was calculated by subtracting the mean ratings for negative targets from those of positive targets, with positive scores indicating a relative bias for endorsing positive over negative interpretations. As participants completed the ERT twice, there were two sets (order counterbalanced). The ERT and CBM-App training were programmed in Inquisit 3.0 (2011)

2.4.2. Posttraumatic Cognitions Inventory. The Posttraumatic Cognitions Inventory (PTCI; Foa et al., 1999; German translation by Ehlers, 1999) is a self-report measure comprising 36 statements reflecting appraisals surrounding traumatic experiences. It contains three subscales: negative cognitions about the self, the world, and self-blame. The instructions of the PTCIs administered during the session asked participants to link their thoughts to the event they just re-activated. The PTCI at follow-up asked participants to link their thoughts to the event they re-activated in the session the week before. The PTCI therefore acted to test whether the induced appraisal bias generalized to appraisals of the selected distressing autobiographical event.

2.5 Intrusiveness of Distressing Autobiographical Event in the Week Post-Training

2.5.1. Intrusion diary. Intrusions were defined to participants as any memory of the negative life event that appeared automatically and unintentionally in the participant's mind. It was also explained that there are different types of intrusions, i.e., mental images, verbal thoughts, or a combination of both. Participants were asked to keep an intrusion diary (similar to that used in Woud et al., 2012, 2013), comprising a structured record sheet on which they had to note each intrusion they experienced, for each intrusion specifying the type and contents of the intrusion, and the level of distress the intrusion caused (0 = *not all distressing*, 100 = *very distressing*).

2.5.2. Posttraumatic Stress Disorder Checklist for DSM 5. The Posttraumatic Stress Disorder Checklist for DSM 5 (PCL-5; German version Krüger-Gottschalk et al., 2017) is a 20-item self-report measure assessing the DSM-5 symptoms of PTSD, i.e., intrusions, avoidance, changes in negative thoughts and mood, and trauma-related arousal. The PCL's instructions were adapted and required participants to indicate how often each listed problem generated distress for them during the past week. The intrusion subscale of the PCL-5 provided complemented the intrusion diary, providing a convergent measure of intrusiveness of the negative life event in the week post-training.

2.9 Implicit Associations

As a measure of implicit trauma-relevant appraisals, we administered a translated version of the Implicit Association Test (IAT) developed by Lindgren et al. (2013) assessing the associative strength between the target concepts ‘self versus others’ and the attributes ‘traumatized versus healthy’. Word stimuli were as follows: self: self, me, my, mine; others: not me, other, they, them; traumatized: traumatized, damaged, broken, distressed; healthy: healthy, adjusted, capable, whole. There were two critical assignments: i) words belonging to the categories trauma and self shared a response key and words belonging to the categories healthy and not me shared a response key; ii) words belonging to the categories trauma and not me shared a response key and words belonging to the categories healthy and me shared a response key. As such, participants who associate the self as traumatized should have faster RTs in the trauma & me (and healthy & not me) assignment compared to the trauma & not me (and healthy & me) assignment. The present IAT had the standard structure, i.e., it included seven blocks with 20 or 40 trials depending on the type of block (for details, see Lane, Banaji, Nosek, & Greenwald, 2007). The D600 score was used for analyses (Greenwald, Nosek, & Banaji, 2003).

2.6 Response to Memory Re-activation during Session

While the memory re-activation during the session primarily served to make sure that participants completed the training and outcome measures with the relevant memory in mind, having the re-activation procedure both pre and post-training also provided the opportunity to assess whether effects of training on responses to reactivation of the distressing event were observable within the training session itself (as in previous studies using a similar paradigm, e.g. Santa-Maria et al., 2012). Reponses were indexed by change in state positive and negative affect, report of PTSD-like experiences, and intrusions within the session.

2.6.1. Positive and Negative Affect. The brief 20-item Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988; German translation by Grühn et al., 2010) was used as a measure of state positive and negative affect, to provide an index of mood response to the memory re-activation. At pre-training this served to verify that the re-activation had the intended effect on mood (as a manipulation check) and that this was balanced across groups at pre-training. At post-training, it provided an index of whether the effect of the re-activation on mood differed between groups following training. The PANAS comprises 10 positive and 10 negative words, which participants are required to rate on a 5-point scale from ‘1’ (very slightly or not at all) to ‘5’ extremely.

2.6.2. Responses to Script-Driven Imagery Scale. The Responses to Script-Driven Imagery Scale (RSDI; Hopper et al., 2007; German translation by Sack, 2005) assesses state PTSD and dissociative symptoms elicited by script-driven imagery. It includes 11 items assessing state reexperiencing, avoidance, and dissociative symptoms, and participants have to rate the occurrence of these symptoms. Participants completed the RSDI following each full re-activation of the negative life event during the session. At pre-training this served to check that the activation had an equal effect across both training groups, and at post-training as an index of whether effects of the activation differed between groups.

2.6.3. Intrusion assessment. The intrusion assessment during the session was similar to that during the week post-training, except that for each intrusion participants were also asked to rate the intrusion’s overall vividness (0 = *not at all vivid* 100 = *very vivid*).

2.4 Trauma History

As a brief measure of trauma history, a shortened version of the Trauma History Checklist (THC; Holmes et al., 2004) was used. It included 9 traumatic events (e.g., serious accidents, life-threatening illness) and participants had to indicate whether or not they lived through or saw such an event. The THC was included to check that prior trauma history did not differ between groups.

2.5 Procedure

During the first lab session, participants gave informed consent and completed the PANAS and THC. After that, participants received the instruction sheet about the selected negative life event, followed by a brief re-activation of the event in order to have a baseline assessment for the trauma-related questionnaires. Accordingly, the first PTCI and intrusion questionnaire were administered after this brief re-activation. This was followed by the first full re-activation of the negative life event which served as a reference for completing the CBM-App training. After that, the second PANAS and the first RSDI were administered. Further, participants completed the second PTCI and intrusion questionnaire, and the trauma IAT was administered. After that, participants did the pre-training ERT, the positive or negative CBM-App training, the third PANAS, and the post-training ERT. This was followed by the second full re-activation of the negative life event in order to test the training's effect following the re-activation, the fourth PANAS, and the second RSDI. Participants then completed the third PTCI and intrusion questionnaire, and the second trauma IAT. The first lab session ended with an explanation of the intrusion diary. One week later participants, returned to the lab with their diary and completed the fourth PTCI and the PCL (see Figure 1 for a diagrammatic overview of the procedure). The study was approved by the ethics committee of the department of psychology at Ruhr-Universität Bochum.

2.6 Statistical Analyses

Repeated-measures ANOVAs were conducted to examine changes in appraisal (i.e., ERT and PTCI), intrusions and associations (i.e., IAT) during the session, with Time x CBM-App interactions as effects of main interest. If significant, paired sample t-tests were conducted to further decompose the interaction. Intrusions at follow-up and the PCL were analysed via independent t-tests.

3. Results

3.1 Participant Characteristics

One participant was excluded from analyses due to their age (44)[1]. Hence, the final sample included N = 65 participants. There were no group differences in gender: $\chi 2(1) = .25$, $p = .62$ (positive CBM-App: 28 females, 6 males; negative CBM-App: 24 females, 7 males). Further, groups did not differ on the following variables prior to the CBM training: age, BDI, STAI-T, SUIS, state mood (PANAS POS and PANAS NEG), THC, appraisals (first ERT), distress when the event occurred and distress right now, how frequently the event was the object of appraisal, and the PCL scores for negative event. However, the two groups differed on age at time of chosen event ($p = .05$), with those trained positively being younger when the stressful event happened than those trained negatively (positive CBM-App: $M = 16.62$, $SD = 4.94$, negative CBM-App: $M = 18.90$, $SD = 4.21$). There were no group differences on PTCI scores and intrusions (i.e., frequency and distress) after the first brief baseline re-activation. Regarding PTCI scores, intrusions (55 participants reported intrusions), and trauma associations (IAT) post first full re-activation, results also showed no group differences, indicating that the task did not affect the two CBM groups differently (see Table 1 for an overview of all means, standard deviations, and exact statistics).

3.2 Effects of CBM-App on Bias: ERT and PTCI

3.2.1 ERT (Manipulation check). The Encoding Recognition Task (ERT) was analysed via a Time (pre CBM, post CBM) x CBM (positive, negative) x Scenario Set (AB, BA) repeated measures ANOVA. Results showed a significant Time x CBM interaction, $F_{1,61} = 29.87$, $p < .001$, $\eta^2 = .33$, indicating that appraisals changed over time between the two CBM groups. Two paired sample t-tests, i.e., one per CBM group, showed that those trained positively reported more functional appraisals post-training, $t(33) = 6.13$, $p < .001$, $d = 1.06$. Appraisals of those trained negatively did not change pre-post: $t(30) = 1.49$, $p = .149$, $d = .28$. An independent t-test showed that appraisals of those trained positively were more positive than those trained negatively at post-training, $t(63) = 4.90$, $p < .001$, $d = 1.22$. Hence, the CBM training was successful in inducing a differential bias across the two groups.

3.2.2 PTCI. Changes in appraisal on the Posttraumatic Cognitions Inventory (PTCI) were analysed via a Time (pre CBM, post CBM) x CBM (positive, negative) repeated measures ANOVA. We found a significant Time x CBM interaction, $F_{1,63} = 4.72$, $p = .034$, $\eta^2 = .07$, indicating that appraisals related to the distressing autobiographical event changed differently over time between the two groups. Paired sample t-tests showed that those trained positively reported more functional appraisals post-training, $t(33) = 4.37$, $p < .001$, $d = .73$ (pre: $M = 80.29$, $SD = 32.39$; post: $M = 68.09$, $SD = 26.37$). Appraisals of those trained negatively did not change from pre to post: $t(30) = 1.93$, $p = .063$, $d = .33$ (pre: $M = 80.55$, $SD = 25.65$; post: $M = 76.23$, $SD = 25.03$). Post-training PTCI scores did not differ between groups, $t(63) = 1.27$, $p = .208$, $d = .32$.

At one-week follow-up, an independent t-test showed no significant differences between the two groups, $t(63) = 1.11$, $p = .27$, $d = .28$ (positive CBM: $M = 63.82$, $SD = 22.19$, negative CBM: $M = 69.55$, $SD = 19.14$). Thus, CBM-App successfully induced a differential change in appraisals related to the distressing autobiographical event from pre to immediately post-training between the two groups, although the two groups did not differ on absolute level of negative appraisal either at post-training or one-week follow-up.

3.3 Intrusive Memories over the Week Post-Training

3.3.1 Intrusion Diary. Fifty-six participants reported intrusions in the week after the first session. An independent t-test on intrusion frequency showed no significant differences between the two groups, $t(63) = .98$, $p = .330$, $d = .24$ (positive CBM: $M = 4.15$, $SD = 3.39$, negative CBM: *M* = 5.19, *SD* = 5.11). However, there was a significant difference for intrusion distress, *t*(54) = 2.97, *p* = .004, *d* = .80, with those trained positively reporting less intrusion distress than those trained negatively (positive CBM: *M* = 31.51, *SD* = 19.39, negative CBM: *M* = 46.72, *SD* = 18.69).

3.3.2 PCL. An independent t-test on the PCL total score revealed that those trained positively reported less posttraumatic stress symptoms than those trained negatively, *t*(63) = 2.81, *p* = .007, *d* = .70 (positive CBM: *M* = 7.24 *SD* = 6.13, negative CBM: *M* = 12.13, *SD* = 7.89). Analyses of the 4 subscales revealed significant differences for the following scales, with those trained positively scoring lower than those trained negatively: intrusions: *t*(63) = 2.24, *p* = .03, *d* = .56 (positive CBM: *M* = 2.41, *SD* = 1.92, negative CBM: *M* = 4.03, *SD* = 3.72); arousal: *t*(63) = 2.75, *p* = .008, *d* = .68 (positive CBM: *M* = 1.53, *SD* = 1.50, negative CBM: *M* = 3.19, *SD* = 3.16). All other scales (i.e., avoidance and changes in negative thoughts and mood) were non-significant (all *p*s > .050).

3.4 Changes in Implicit Appraisals

3.4.1 Correlations. To validate the IAT, we correlated pre-training IAT scores with the following measures: PCL negative event: *r* = .37, *p* = .002; pre-training bias index (i.e., ERT scores): *r* = -.14, *p* = .287; PTCI after first re-activation: *r* = .37, *p* = .003. Results showed that the higher the posttraumatic stress symptoms and the higher levels of explicit dysfunctional appraisals, the stronger participants' 'trauma - me' associations.

3.4.2 IAT. Scores were analyzed with a Time (pre CBM, post CBM) x CBM (positive, negative) repeated measures ANOVA. Results showed a non-significant Time x CBM interaction, $F_{1,61}$ = 1.30, *p* = .26, η^2 = .02, indicating that automatic trauma associations did not differentially change over time between the two groups (main effects Time and CBM: *p*s > .05) .

3.5 Response to Memory Re-activation during Session

3.5.1 Mood. Mood responses were analysed via an Order (first re-activation, second re-activation) x Time (pre re-activation, post re-activation) x CBM (positive, negative) repeated measures ANOVA. PANAS POS: There was a significant Order x Time interaction ($F_{1, 63}$ = 21.60, p < .001, η^2 = .26), indicating that for the first and second re-activation, mood changed pre-post re-activation. This was true for both CBM groups (Order x Time x CBM interaction: $F_{1, 63}$ = .21, p = .65, η^2 = .003). The 2-way interaction was decomposed by 2 paired sample t-tests, showing that participants' mood became less positive pre-post the first and second re-activation: first re-activation: t(64) = 10.17, p < .001, d = 1.50; second re-activation: t(64) = 5.21, p < .001, d = .65. PANAS NEG: There was a significant Order x Time interaction ($F_{1, 63}$ = 30.53, p < .001, η^2 = .33) (Order x Time x CBM interaction: $F_{1, 63}$ = .33, p = .57, η^2 = .01). T-tests revealed that participants' mood became more negative pre-post the first and second re-activation: first re-activation: t(64) = 8.29, p < .001, d = 1.34; second re-activation: t(64) = 4.56, p < .001, d = .65 (see Table 2 for means and standard deviations). Overall, results showed that the re-activation procedure changed participants' mood in the intended direction, and the extent of this change did not differ between groups.

3.5.2 RSDI. Participants RSDI scores were examined with two independent sample t-tests. There were no group differences after either re-activation: first re-activation: t(63) = .78, p = .44, d = .19 (positive CBM: M = 27.50, SD = 9.75; negative CBM: M = 29.29 SD = 8.64); second re-activation: t(64) = .52, p = .61, d = .13 (positive CBM: M = 22.59, SD = 10.98; negative CBM: M = 23.94, SD = 9.96).

3.5.3 Intrusion assessment during the session. Forty-eight participants reported intrusions after the first re-activation (pre CBM), and 39 participants reported intrusions after the second re-activation (post CBM). Results of our Time (pre CBM, post CBM) x CBM (positive, negative) repeated measures ANOVA on intrusion frequency showed no significant Time x CBM interaction, $F_{1,63}$ = 2.75, p = .10, η^2 = .04 (positive CBM: pre: M = 1.19, SD =

1.94, post: M = 1.00, SD = 1.33; negative CBM: pre: M = 1.55, SD =1.67, post: M = 1.35, SD = 1.25). The ANOVA for intrusion distress also revealed no Time x CBM interaction, $F_{1,29}$ =.27, p = .61, η^2 = .01 (positive CBM: pre: M = 60.10, SD = 16.67, post: M = 47.37, SD = 25.95; negative CBM: pre: M = 51.36, SD = 29.00, post: M =43.40, SD = 28.71). Finally, the Time x CBM interaction for intrusion vividness was also not significant, $F_{1,55}$ =.60, p = .44, η^2 = .01 (positive CBM: pre: M = 5.50, SD = 3.36, post: M = 3.39, SD = 3.58; negative CBM: pre: M = 4.38, SD = 3.33, post: M =3.00, SD = 3.15). Hence, there were no immediate training effects on intrusions within the session.

4. Discussion

The present study built on previous research investigating CBM-App effects in the context of (analogue) posttraumatic stress. There were two main aims: Replicating the effects of earlier training studies in analogue trauma, but using participants' own distressing life event as the traumatic event analogue, and extending present outcomes measures by testing the training's effect on an implicit measure of dysfunctional appraisals. Results of our manipulation check (the encoding recognition test, ERT) showed that the experimental manipulation was successful in inducing training-congruent appraisals: Participants trained positively, compared to those trained negatively, appraised novel ambiguous scripts in a more functional manner post-training. Thus, we can interpret between-group differences on outcome measures as potentially being a result of the induced appraisal style (cf. Clarke, Notebaert, & MacLeod, 2014). This training effect generalized to another measure of appraisals, the Posttraumatic Cognitions Inventory (PTCI), with participants trained positively showing a change towards making more functional appraisals from pre to post-training compared to those trained negatively, albeit without there being a difference between groups in terms of absolute score on the PTCI at post-training or at one-week follow-up. On the main outcome measure, the one-week intrusion diary, we found that positive CBM-App, compared to negative CBM-App, led to less intrusion distress. Consistent with this, at one week post-training, participants trained positively had lower overall scores on the Posttraumatic Stress Disorder Checklist for DSM 5 (PCL-5), including on the intrusion subscale, than those trained negatively. However, the two training groups did not differ in terms of number of intrusions recorded in the diary. Contrary to our hypotheses, implicit appraisals, measured via the Implicit Association test (IAT) were not affected by the CBM-App training. Finally, reactivity to the memory re-activation within the training session, as indexed by change in mood, PTSD-like experiences, or intrusions within the session, did not change differentially between the groups from pre to post-training.

To summarize, our data generally showed that the CBM-App training, when applied to a distressing autobiographical event, was successful in inducing training congruent appraisals. Further, our findings regarding the main outcome measure as used in previous studies, the one-week intrusion diary, were partially in line with our hypotheses. When looking at the additional measures, however, results are more nuanced, i.e., the effects depended on the type of analogue symptom and assessment time point. To illustrate, results on the intrusion diary at one-week follow-up showed the expected effect on intrusion distress whereas intrusions assessed during the session were not affected by the CBM training. Further, we did not find changes in implicit associations during the session but lower levels of PTSD symptoms at one week follow-up. This pattern, however, can be interpreted in line with cognitive theories of PTSD (e.g., Ehlers & Clark, 2000). That is, the CBM-App training targeted appraisals including those relating to posttraumatic stress symptoms. However, such symptoms would need to have occurred frequently and over time in order for appraisals to affect subsequent expression of these symptoms. That is, once posttraumatic stress symptoms have occurred and are consistently appraised in either a functional or dysfunctional manner, their subsequent occurrence may then be modulated in an appraisal-congruent manner. In relation to the study's timeline, during Session 1, training-congruent appraisals were induced, as reflected in the manipulation check. However, a larger number of instances over time in which symptoms were triggered may have been needed before the induced functional/dysfunctional appraisal style could affect posttraumatic stress symptoms. In our set-up, the week following the training could be regarded as the crucial time window for symptoms to occur. These symptoms could then be regarded as the trigger for participants to 'apply' their induced appraisal style, and applying this appraisal style in turn could have affected further occurrences of posttraumatic stress symptoms during the course of the week. As a result, at follow-up those trained positively ended up with lower levels of posttraumatic stress symptoms than those trained negatively. However, it needs to be acknowledged that this is a post-hoc explanation. Hence, it may be useful to consider these potential time-dependent effects of appraisal and symptom experience further in future research.

Generally, our results are in line with those obtained in previous appraisal training studies. Hence, we achieved our first aim of replicating previous findings. Further, our results provide additional support for the prediction of the cognitive model of PTSD that appraisals have a causal effect on posttraumatic stress symptoms. When comparing our results to the studies of Woud et al., (2012, 2013), results consistently showed that appraisals of analogue posttraumatic stress symptoms can be trained via CBM-App, and that they affect intrusion distress accordingly (see Woud et al., 2013). Interestingly, Woud et al. (2013) first applied CBM-App training and then the analogue stressful event followed. In contrast, the present study applied the CBM-App training to an event that had taken place in the past. Hence, one could argue that previous studies were set up as preventive analogue, whereas the present study was set up as analogue for a therapeutic context. However, consistent effects were found regardless of the study's design, providing many follow-up routes for research to further advance our understanding of the temporal interplay of training and (analogue) posttraumatic stress symptoms. It is worth noting that unlike the study by Woud et al. (2012), we did not find an effect of training on number of intrusions in the one-week intrusion diary. Thus our results do not support a role for appraisals on intrusion frequency, but this must be interpreted with caution due to analogue nature of the study (see limitations section below).

Regarding our second aim, testing the effects of appraisal training on implicit appraisals, we did not find training-congruent changes on the traumatized self IAT. This could be explained by a mismatch between the trained appraisals and IAT stimuli. The former included cognitions of the PTCI self-subscale, which are rather heterogeneous. The latter, however, included associations related to the self, which is more homogenous. As such, a CBM-App training that specifically targeted appraisals of the perception and interpretation of the self might have been more successful in also affecting IAT scores. When broadening the range to other CBM studies, there are at least two other studies that applied a similar approach. In Wiers, Eberl, Rinck, Becker, and Lindenmeyer (2011, and see also Wiers et al., 2010), hazardously drinking students were trained to avoid or to approach alcohol by means of the Approach Avoidance Test (AAT; Rinck & Becker, 2007). Results showed that those who were trained to avoid alcohol showed stronger associations between alcohol and avoidance post-training, which likely mediated the training's effect (Gladwin et al., 2015). Woud, Hutschemaekers, Rinck, and Becker (2015) applied a Cognitive Bias Modification – Interpretation (CBM-I) to test whether such training can manipulate alcohol-related interpretations, however, there were no between-group differences in alcohol-related associations post-training. To conclude, CBM training can affect automatic associations, although the effect might be accompanied by subtle boundary conditions.

The present study is not without limitations. First, despite our screening to select the most distressing negative life event, the degree to which this event was indeed distressing is difficult to tell, i.e., participants' present distress was around 50 (with a scale ranging from 0-

100). Second, and in line with the previous limitation: although we found the expected mood changes pre-post re-activation, mood ratings were still rather positive. Hence, we do not know how distressing our re-activation procedure actually was. Further, events might get more de-emotionalized after repeated re-activation and thus might make the event less intrusive, representing a caveat. In turn, both these issues might partly explain the low numbers of intrusions assessed during the session. Regarding the intrusion diary, the groups' means on intrusion frequency mirror those of previous studies using CBM-App in combination with the trauma-film paradigm as analog trauma, and the same is true for the means on intrusion distress (e.g., Woud et al., 2012, 2013). However, and despite the significant difference on intrusion distress in the present study, means are relatively low. Hence, additional research is warranted to improve the selection and re-activation of the negative life event in order to create a more optimized setting to trigger (distressing) intrusions. Third, because we included a negative training condition, we did not include participants who had experienced rape or sexual violence, or were experiencing high levels of post-traumatic distress or depression. While a relatively healthy and homogeneous sample is suitable for an experimental investigation such as the current study, it limits generalizability of the results. If we wished to investigate potential benefits of the positive CBM-app, for example in comparison to a sham training control condition, it would be preferable to recruit a more heterogeneous sample with a wider range of clinical symptoms and distressing events. Fourth, although cognitive models of PTSD are supportive of our findings, the absence of PTCI effects at one week follow-up are puzzling and cannot be interpreted adequately, since we do not have a baseline comparison for this assessment. Fifth, our study had sufficient participant numbers only to find between-group differences corresponding to approximately $d > 0.7$ (at 80% power). While the effect sizes found for the significant between-group differences on change in appraisal and intrusion distress indicate sufficient power for these main outcomes, larger samples would of course increase our confidence where statistically non-significant effects were found for other measures. Finally, while our positive versus negative training comparison is suitable for testing questions of causality, in the absence of a neutral control group we cannot draw conclusions about the positive condition being ‘beneficial’, for which future studies would need an alternative control condition (see Blackwell, Woud, & MacLeod, 2017).

To summarize, we aimed to replicate earlier findings on appraisal training in the context of analogue posttraumatic stress symptoms, and to extend previous studies. Results showed that training in a positive or negative appraisal style did affect analogue posttraumatic stress symptoms. These results further support the causal role of dysfunctional appraisal in (analogue) posttraumatic stress symptoms, and raise interesting questions about how the potential interplay of appraisals and posttraumatic stress symptoms over time. Further, they indicate that the appraisal training used can be applied to distressing events that have taken place some years before, suggesting that it would be worthwhile to start testing therapeutic effects of the training in patients with PTSD.

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Declaration of interest

None.

Footnote

1. We had intended to recruit a relatively homogenous young adult sample, and assuming that our recruitment methods would only reach this population had not set formal age inclusion/exclusion criteria. Having been tested, the participant was excluded from analyses as they were not part of the intended population from which we had aimed to sample. We repeated all analyses with the excluded participant, however, results did not change.

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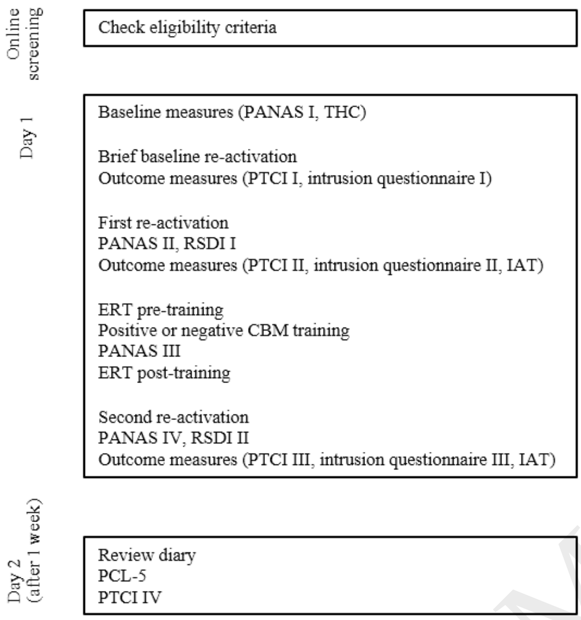
Figures

Figure 1

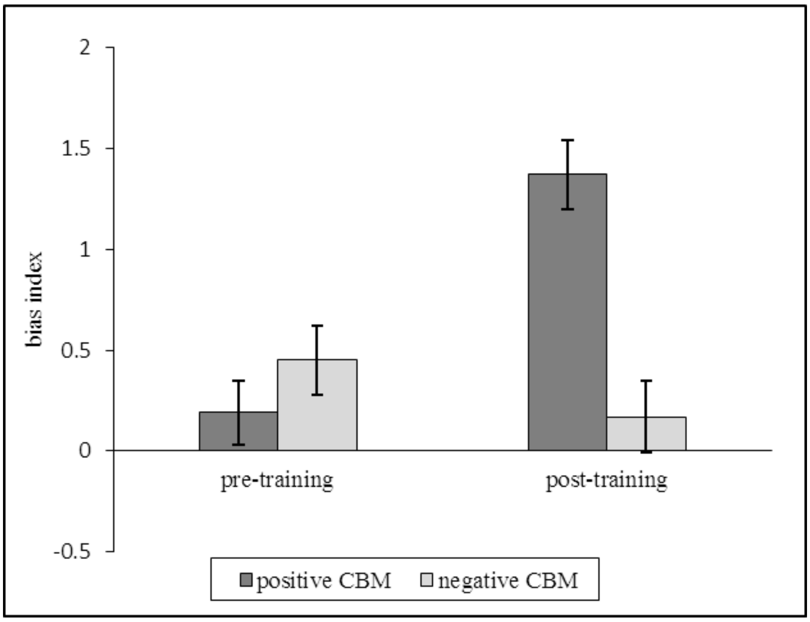
Overview procedure



Note. PANAS =Positive and Negative Affect Schedule; PTCI=Posttraumatic Cognitions Inventory; THC=Trauma history checklist; RSDI=Responses to Script-Driven Imagery Scale; IAT=Implicit Association Test; ERT= Encoding Recognition Task; CBM = Cognitive Bias Modification; PCL-5=Posttraumatic Stress Disorder Checklist for DSM 5.

Figure 2

Manipulation check ERT



Note. Error bars represent standard errors. Calculation bias index: positive targets – minus negative targets. Exact means and standard deviations are as follows: positive CBM: pre-training: M = .19, SD = .95, post-training: M = 1.37, SD = .97; negative CBM: pre-training: M = .45, SD = .94; post-training: M = .17, SD = 1.00. *** p < .001

Table 1

Baseline characteristics and data after baseline and first full re-activation

	Positive CBM-Appp	Negative CBM-App	Statistics
Measure	*M (SD)*	*M (SD)*	
Age	22.26 *(2.92)*	23.48 *(4.37)*	t(63) = 1.34, p = .19
BDI-II	5.21 *(5.14)*	5.61 *(5.08)*	t(63) = .32, p = .75
STAI-T	36.04 *(8.67)*	34.81 *(8.65)*	t(63) = .58, p = .57
SUIS	59.88 (11.13)	59.29 *(10.48)*	t(63) = .22, p = .83
PANAS pos	31.18 *(5.78)*	31.04 *(5.31)*	t(63) = .10, p = .92
PANAS neg	12.73 *(3.51)*	13.32 *(4.79)*	t(63) = .57, p = .57
THC	1.00 *(.92)*	1.01 *(1.08)*	t(63) = .39, p = .70
First ERT	.19 *(.95)*	.45 *(.95)*	t(63) = 1.01, p = .27
Age NLE*	16.62 *(4.94)*	18.90 *(4.21)*	t(63) = 2.00, p =.05
Past distress NLE	88.18 *(19.11)*	87.10 *(10.39)*	t(62) = .28, p = .78

Current distress NLE	46.18 *(21.88)*	52.58 *(26.20)*	*t*(63) = 1.01, *p* = .29
Appraisal frequency NLE	2.56 *(1.08)*	2.65 *(1.17)*	*t*(63) = .31, *p* = .76
PCL 5 NLE	10.49 *(7.03)*	13.73 *(7.58)*	*t*(63) = 1.79, *p* = .08
Baseline re-activation			
PTCI	78.03 *(30.01)*	76.33 *(22.50)*	*t*(63) = .26, *p* = .80
Intrusion frequency lab questionnaire	2.18 *(1.66)*	2.84 *(2.93)*	*t*(63) = 1.13, *p* = .26
Intrusion distress lab questionnaire	45.06 *(24.26)*	54.68 *(22.87)*	*t*(53) = 1.51, *p* = .14
Intrusion vividness lab questionnaire	5.58 (2.98)	5.13 (2.91)	*t*(62) = .61, *p* = .55
After 1st re-activation			
PTCI	80.29 *(32.39)*	80.55 *(25.65)*	*t*(63) = .04, *p* = .97
Intrusion frequency lab questionnaire	1.91 *(1.94)*	1.54 *(1.67)*	*t*(63) = .81, *p* = .42
Intrusion distress lab questionnare	51.62 *(22.56)*	46.44 *(27.07)*	*t*(46) = .72, *p* = .48
Intrusion vividness lab questionnaire	5.50 (3.36)	4.53 (3.38)	*t*(56) = 1.09, *p* = .28
IAT	-.47 *(.34)*	-.42 *(.32)*	*t*(61) = -70, *p* = .49

Note. BDI-II=Beck Depression Inventory-II; STAI-T=Spielberger State-Trait Anxiety Inventory-Trait version; SUIS= Sponaneous Use of Imagery Scale; PANAS pos/neg=Positive and Negative Affect Schedule - positive/negative affect scale; THC=Trauma history checklist; First ERT=First Encoding Recognition Task – Measure of Appraisal Style; NLE=Negative Life Event; PCL-5=Posttraumatic Stress Disorder Checklist for DSM 5; PTCI=Posttraumatic Cognitions Inventory; IAT=Implicit Association Test. * Range age of event: Positive CBM-App: 5-23 years, Negative CBM-App: 11-27 years.

Table 2

Mood pre – post re-activation negative life event

	PANAS POS	PANAS NEG
Assessment point	*M (SD)*	*M (SD)*
PANAS I	31.11 (5.52)	13.02 (4.15)
PANAS II	23.85 (7.17)	19.31 (6.24)
PANAS III	26.28 (7.85)	13.31 (3.65)
PANAS IV	22.70 (7.89)	15.88 (5.49)

Note. PANAS I: After brief baseline re-activation negative life event / pre first full re-activation. PANAS II: post first full re-activation. PANAS III: pre second full re-activation. PANAS IV: post second full re-activation.