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The effects of computerised metacognitive cognitive bias modification training on the development of adaptive metacognitive beliefs and post-traumatic stress disorder symptoms

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1. Introduction

People are frequently exposed to traumatic events (Benjet et al., 2016) (e.g., sudden death of a loved one), and while the majority will adjust and continue to lead a healthy life, some will go on to develop post-traumatic stress disorder (PTSD). Cognitive theories of PTSD (e.g., Ehlers & Clark, 2000) postulate that negative appraisals surrounding the trauma, heighten one's current sense of threat and lead to PTSD. Consequently, these theories view the *content of these appraisals* (i.e., thoughts) as a key therapeutic target for PTSD recovery (Cognitive Therapy; Ehlers & Clark, 2000 and Cognitive Processing Therapy; Resick & Schnike, 1992). Yet, an understudied model—the metacognitive model of PTSD (Wells, 2000; Wells & Sembi, 2004)—offers a different perspective and suggests that targeting *metacognitive beliefs*—i.e., the beliefs we have about our own thinking/cognition—as opposed to cognitive beliefs, may help reduce the onset of PTSD.

The metacognitive model of PTSD (Wells, 2000; Wells & Sembi, 2004) views the occurrence of symptoms (e.g., intrusions) as a *normal* response following a trauma and suggests that symptoms emerge as part of an individual's in-built reflexive adaptation process (RAP). The RAP runs its course uninterrupted for most people, however, those who develop PTSD will experience a disruption in the RAP due to an extended pattern of thinking known as the cognitive attentional syndrome (CAS). The CAS is driven by a one's metacognitive beliefs, which can include *positive beliefs about the need to engage in aspects of the CAS* (e.g., "worrying helps me cope") and *negative beliefs about thoughts and feelings* (e.g., "my worrying is dangerous for me"). There are also *metamemory beliefs*—a form of metacognition related to how people evaluate the contents of their trauma memory (e.g., "I must have a complete memory to feel normal"). In sum, the metacognitive model suggests that maladaptive metacognitive beliefs, alongside poor coping strategies (e.g., avoidance) maintain a current sense of threat and lead to PTSD.

Research shows that individuals who endorse maladaptive metacognitive beliefs both *pre-* and *post-trauma* are more likely to report PTSD symptoms (e.g., Bennett & Wells, 2010; Roussis & Wells, 2006;Takarangi, Smith, Strange, & Flowe, 2017); key findings which suggest that training individuals to adopt healthier metacognitive beliefs may be a crucial preventative approach to PTSD. Due to the correlational design of these studies, it currently remains unclear whether there is a causal link between metacognitive beliefs and PTSD. We took the first step towards addressing this by manipulating people's metacognitive beliefs in the lab via the cognitive bias modification (CBM) paradigm and tested its effects on metacognitive beliefs and analogue PTSD symptoms. Several studies have utilised CBM to successfully train people to adopt functional or dysfunctional trauma-related appraisals (see Woud, Verwoerd, & Krans, 2017 for a review and for related findings see de Kleine et al., 2019; Woud et al., 2021). Woud, Holmes, Postma, Dalgleish, and Mackintosh (2012) developed a new CBM training protocol that modified negative self-efficacy appraisals associated with the development of PTSD (e.g., "the event happened to me because of the sort of person I am"). The CBM training was comprised of a series of scripted vignettes that appeared to participants as a sentence completion task and authors developed two CBM training groups; a positive CBM-App (i.e., trained participants to adopt a positive appraisal style) and a negative CBM-App (i.e., trained participants to adopt a negative appraisal style). Participants watched a trauma film and completed the CBM training (randomly allocated). Post-training (session 1 and session 2; 7 days later), participants' appraisal style and analogue PTSD symptoms were assessed via questionnaires and an intrusion diary. As predicted, CBM-App training successfully modified appraisal styles congruent to the training participants received and participants who received the positive training also reported significantly fewer intrusions over the week, compared to the negative group. These results suggest that CBM can be employed to successfully modify trauma-related appraisals/beliefs.

In this current study, drawing partly on Woud et al.'s (2012) training protocol, we developed and piloted a bespoke CBM protocol that aimed to train participants to adopt healthy metacognitive beliefs, named $CBM_{Metacog}$ (please see supplementary material for information on our pilot testing).

According to the metacognitive model of PTSD (Wells, 2000; Wells & Sembi, 2004), healthy metacognitive beliefs are associated with an increase in one's meta-awareness—a skill that is deemed to be beneficial to recovery—and refers to "the mental state that arises when attention is directed towards explicitly noting the current contents of consciousness" (Smallwood & Schooler, 2015, p. 495). The metacognitive model proposes that meta-awareness of symptoms allows people to notice intrusions, as well as when they are engaging in unhelpful coping strategies (e.g., worry, rumination, threat monitoring) that may maintain their symptoms. Yet, a growing body of research demonstrates that people often lack meta-awareness of their intrusions (Baird, Smallwood, Fishman, Mrazek, & Schooler, 2013; Takarangi, Strange, & Lindsay, 2014; Takarangi, Nayda, Strange, & Nixon, 2017). Across these studies, meta-awareness of intrusions was measured using self-caught versus probe-caught techniques adopted from the mind-wandering literature (e.g., Schooler, Reichle, & Halpern, 2005). These techniques typically require participants to engage in a low-level cognitive task (e.g., a reading task) and they are instructed to self-report (i.e., by pressing a computer key) whenever they noticed themselves experiencing an intrusion (i.e., *self-caught intrusion*s). Additionally, participants are periodically probed to ask whether their attention was off-task, and these probes are found to often capture intrusions that are experienced without awareness (i.e., *probe-caught intrusions*). Furthermore, recent work shows that meta-awareness is associated with one's metacognitive beliefs (Takarangi, Nayda et al., 2017), however, it is unclear whether training people to adopt healthy metacognitive beliefs also increases their meta-awareness of PTSD; a finding that would have strong implications for both theory and clinical practice. To our knowledge, our study will be the first to examine these links.

The present study used the trauma film paradigm, with participants randomly assigned to receive either $CBM_{Metacog}$ or $CBM_{control}$ training immediately before watching a trauma film. We predicted that participants receiving the $CBM_{Metacog}$ training would have healthier metacognitive appraisals and beliefs (*hypothesis 1*) and fewer analogue PTSD symptoms (*hypothesis 2*), compared to the $CBM_{control}$ group. Finally, we tested whether the $CBM_{Metacog}$ training enhances meta-awareness of PTSD symptoms, particularly memory intrusions. Here, we predicted that participants in the $CBM_{Control}$ group would experience more self-caught intrusions, compared to the $CBM_{Control}$ group (*hypothesis 3*).

2. Materials and Method

2.1. Design

A 2 CBM training ($CBM_{Metacog}$ versus $CBM_{Control}$) x 2 monitoring condition (self-caught only condition versus self-caught-plus-probes condition) x 2 session (session 1 and session 2) mixed experimental design was employed. Both CBM training and monitoring condition were the between-subjects factors, and session was the within-subjects factor.

2.2. Participants

One hundred and fifty-six participants signed up to the study and completed the pre-screen questionnaire. Twenty-one participants then dropped out either prior to, or immediately after session 1, leaving 135 participants completing the study in exchange for money and/or course credits. Participants (*n* = 126 female) (age *M* = 19.27; *SD* = 1.56) mostly identified as Caucasian (British). Previous studies using the self-caught versus probe-caught methods to assess meta-awareness of intrusions in analogue trauma studies (e.g., Takarangi, Nayda, et al., 2017) reported a medium effect size of *d* = .49 for probe-caught intrusions. Thus, based on this previous work, we used G*Power software (Faul, Erdfelder, Lang, & Buchner, 2007) to calculate an a priori sample size, with alpha set to .05. This calculation revealed that a sample size of 134 participants would be sufficient to detect differences between groups at 80% power. Ethical approval was obtained from the University of XXXXX in line with the Declaration of Helsinki and informed consent was obtained from all participants.

2.3. Measures & Materials

2.3.1. CBM training

The $CBM_{Metacog}$ training was delivered online using Qualtrics software (lab-based), and like previous CBM studies, it involved participants processing a series of vignettes that appeared to them as a sentence completion task (Woud et al., 2012). In our training, when complete, the sentence was consistent with a healthy metacognitive belief: “gaps in my memory for a negative event show that I am a d - u s t - n g” (adjusting). The $CBM_{Metacog}$ condition was based around four types of maladaptive metacognitive beliefs: 1) positive beliefs about worry and rumination; 2) the uncontrollability/danger of thoughts; 3) positive and negative beliefs about the need to have a complete memory; and 4) beliefs about the meaning of intrusions. The $CBM_{Control}$ used emotionally neutral training sentences related to normal everyday activities [e.g., “your morning routine involves you having a coffee and reading the n_wspa_er” (resolved as newspaper)]. As the $CBM_{Metacog}$ training was delivered prior to the trauma film, the training sentences were structured to refer to a negative event generally, and not the film specifically.

2.3.2. Metacognitive/metamemory appraisals and beliefs

Metacognitive appraisal style induced from the CBM training was assessed using the encoding recognition task (ERT) (Mathews & Mackintosh, 2000). Immediately following the training, participants in both training conditions were presented with 10 novel ambiguous sentences, based around items on the MCQ, BAMQ and RIQ (Table 1). Each sentence was introduced with a specific title and unlike the training sentences, remained ambiguous. After each ambiguous sentence, we asked participants to rate the extent to which the sentence "describes them now" using a 5-point scale, 1 (*does not describe me at all*) to 5 (*describes me perfectly*). In the surprise recognition phase, only the original 10 ambiguous encoding titles (e.g., "incomplete memories") were presented, along with a set of four related sentences. Participants were asked to read each of the four sentences and rate how similar they were in meaning to the original encoding sentence that was presented with that title previously, using a 5-point scale, 1 (*not similar at all*) to 5 (*extremely similar*). Two of the four sentences were congruent with either a positive or negative interpretation of the original sentence and all participants were instructed to interpret the "event" in these sentences to refer to a negative event. The raw data from the recognition phase was converted into an index bias score, which is the degree to which the ambiguous sentences had been interpreted in either a positive or negative way. The bias score was calculated by subtracting the mean ratings for the negative targets from the positive targets. We assessed metacognitive appraisal style at post-training session 1 and session 2.

Table 1
Example of encoding and recognition stimuli used to determine index bias scores

Title	"Memory Beliefs"
Encoding Sentence	"My beliefs about what it means to have gaps in my memory have changed since taking part in this study session"

Recognition Sentences	
Negative Target	"As a result of this study session, I now understand that having gaps in my memory shows I am psychologically unhealthy"
Positive Target	"As a result of this study session, I now understand that having gaps in my memory shows I am psychologically healthy"
Negative Foil	"As a result of this study session, I now understand that I can remember less if I am tired"
Positive Foil	"As a result of this study session, I now understand that I can remember better if I try harder"

Metacognitive/metamemory beliefs were also assessed using self-report questionnaires, which included the Beliefs about Memory Questionnaire (BAMQ; Bennett & Wells, 2010), three subscales from the Metacognitions Questionnaire–30 (MCQ-30; Wells & Cartwright-Hatton, 2004) (18 items in total) and an adapted version of the Responses to Intrusions Questionnaire (RIQ; Clohessy & Ehlers, 1999). The BAMQ is comprised of 15 items that measure positive beliefs about the need to have a complete memory for a specific event (e.g., "I must try to remember all the details of the event so that I can understand why it happened") and negative beliefs about the consequences of not having a complete memory for an event (e.g., "gaps in my memory for the event are preventing me from getting over it"). The BAMQ was administered at baseline —as part of the pre-screen questionnaires administered prior to the CBM session—in relation to participants' self-nominated life event, and at session 1 (i.e., post CBM training in relation to the film) and session 2 (i.e., in relation to the film). Participants rated the extent to which they agreed with each item using a 4-point scale (1 – *do not agree* to 4 – *agree very much*), with lower scores representing healthier metamemory beliefs.

The three MCQ–30 subscales were positive beliefs about worry (i.e., “I need to worry in order to work well”) (MCQ1), beliefs about the uncontrollability/danger of thoughts (i.e., “my worrying could make me go mad”) (MCQ 2) and beliefs about the need to control thoughts (i.e., “not being able to control my thoughts is a sign of weakness”) (MCQ 3). These three MCQ subscales were chosen due to their association with PTSD (Takarangi, Smith et al., 2017). Participants rated their agreement with each statement using a 4-point scale, 1 (*do not agree)* to 4 (*agree very much*), with higher scores representing higher agreement with maladaptive thinking. The MCQ subscales were administered at pre-screen (in relation to a historic event) and at session 1 and at session 2 (in relation to the trauma film).

The adapted RIQ measured negative inferences about the meaning of intrusions (i.e., “something is wrong with me”) on a 7-point scale, 1 (*totally disagree*) to 7 (*totally agree*).. Only participants who reported experiencing intrusions (i.e., either in relation to their self-nominated worst event at pre-screen, or in relation to the film at post-training session 1 and session 2) completed the RIQ.

2.3.3. PTSD symptoms

At the end of session 1, all participants were given instructions on how to keep a 7-day intrusion diary in relation to the film they watched in session 1. Intrusions were defined based on previous research (see Holmes, James, Coode-Bate, & Deeprose, 2009) and participants were asked to: 1) record all intrusions as soon as they occurred; 2) report what type of intrusion it was (i.e., thought, image, or combination of both); and 3) rate the distress associated with each reported intrusion, using a scale of 0 (*no distress*) to 10 (*extremely distressing*). Participants handed in their intrusion diaries at session 2 and were asked to rate on a scale of 0 (*not at all*) to 10 (*extremely*), how accurate they were at completing the intrusion diary. Similar to previous work (e.g., Ehlers, Hackmann, & Michael, 2004), only intrusions that were experienced as being somewhat distressing (i.e., distress rating > 0) were considered intrusive—akin to real-life PTSD intrusions—and included in the final analysis. Participants completed the Impact of Event Scale-Revised (IES-R; Weiss & Marmar, 1997), which was administered at session 2 in relation to the film they watched at session 1. Higher scores for the total IES-R represent greater analogue PTSD symptoms in relation to the film. All measures demonstrated strong internal reliability (i.e., > α = .70), except for the BAMQ negative, which at session 2 demonstrated poor reliability (α = .52) and was subsequently removed from the analysis (see supplementary material for secondary measures).

2.3.4. Trauma film

A 4-minute film depicting a multi-fatality car accident was used as analogue trauma. This film has been used in past research (e.g., Takarangi, et al., 2014) with no reported long-term adverse effects. Participants rated their current mood (happiness, anxiety, anger and depression) using an 11-point scale of 0 (*not at all*) to 10 (*extremely*) (Davies & Clark, 1998), both immediately prior to and following the film. Using the same scale, they also rated how much attention they paid to the film and how distressing and unpleasant it was.

2.3.5. Meta-awareness task

Meta-awareness was assessed during a monitoring phase reading task based on previous meta-awareness studies (e.g., see Takarangi, Nayda et al., 2017). All participants were instructed to press the space bar key every time they noticed themselves having an intrusion about the film (i.e., capturing intrusions that occurred *with meta-awareness*), and were then instructed to refocus back on the article. Additionally, for participants in the *self-caught-plus-probes condition*, they were also periodically probed while reading the article. Written probes would appear on the screen (i.e., “Just now what were you thinking about?”)

and participants were instructed to press: respond in one of three ways: (1) “Press 1 if you were thinking about the film”; (2) “Press 2 if you were thinking about the article you were reading”; (3) “Press 3 if you were thinking about something else”. Based on previous studies (e.g., Takarangi, Nayda et al., 2017), the probe-caught intrusions were referred to as intrusions *without meta-awareness* (i.e., otherwise if participants were meta-aware of them, they would have self-caught them). The number of self-caught only intrusions was summed to give a total self-caught only intrusion frequency score. For participants exposed to probes, the proportion of probes that were about the film was calculated for each CBM group.

2.4. Procedure

Prior to session 1, participants’ informed consent, demographic information, baseline mood, trauma history (Traumatic Experiences Questionnaire; TEQ; adapted from Foa, Ehlers, Clark, Tolin, & Orsillo, 1999) and pre-existing metacognitive/metamemory beliefs were measured via an online pre-screen survey. Next, based on previous studies (Takarangi, Smith et al., 2017) participants were asked to nominate the worst event that they had experienced within their lifetime (e.g., physical assault). Then, participants pre-existing metacognitive/metamemory beliefs were completed here in relation to the nominated event (e.g., unexpected death of a family member, family member diagnosed with a serious illness, personal physical assault).

In session 1 (lab-based), study information and informed consent was verified once more, as well as participants’ understanding of intrusions. Participants were randomly allocated to a CBM training group ($CBM_{Metacog}$ or $CBM_{Control}$) and completed the CBM training, which was immediately followed by the ERT. Next, participants were asked to watch the trauma film followed by the reading task and then complete ratings on their mood and metacognitive beliefs. Participants were then given the 7-day intrusion diary to complete over the week. In session 2 (lab-based), participants submitted their intrusion diaries and self-completed follow-up measures, including intrusion diary compliance ratings, metacognitive beliefs, mood and analogue PTSD symptoms and were then debriefed.

2.5. Data analysis strategy

All data were analysed with the General Linear Model, with alpha set to .05. We pre-registered our hypotheses, via the Open Science Framework (OSF) prior to data collection (https://osf.io/gqdsp/?view_only=91a26df4f19a477288a890a119b782de). Post-hoc comparisons were Holm-Bonferroni corrected (Holm, 1979) to control family-wise error rates.

3. Results

3.1. Participants' baseline, film and mood measures

To assess for differences in baseline measures and film-related ratings, separate two-way ANOVAs were conducted, using CBM group and monitoring condition group as the between-subjects factors. Participants—across all groups—did not differ in age (*F*s < 2.13, *p*s > .15), trauma history or pre-existing metacognitive beliefs. Similarly, there were no significant group differences on ratings of attention paid to the film or distress ratings for the film (*F*s < 2.49, *p*s > .12). However, participants in the $CBM_{Metacog}$ training group rated the film as being significantly more unpleasant compared to the $CBM_{Control}$ condition, a significant main effect for CBM group $F(1,131) = 4.23$, $p = .04$, $\eta_p^2 = .03$ ($CBM_{Metacog}$ $M = 8.42$, $SEM = .23$; $CBM_{Control}$ $M = 7.76$, $SEM = .23$) (Table 2).

We analysed participants' mood change throughout the experiment with a 2 CBM x 2 monitoring condition x 3 time (pre-film, post-film, post-reading task) mixed ANOVA, using the combined mood scores as the within-subjects factor. The ANOVA revealed a significant main effect for time, $F(1.58, 206.66) = .225.63$, $p < .001$, $\eta_p^2 = .63$. Post-hoc paired *t* tests revealed that participants reported feeling worse in mood after watching the trauma film (M = 3.98, SD = 1.54), compared to before the film (M = 2.27, SD = 1.40), $t(134) = 15.31$, $p < .001$, d =1.32. Following the reading task, participants' mood also continued to worsen compared to post-film, $t(134) = 9.43$, $p < .001$. $d = .82$ (M = 5.97, SD = 2.33 versus M = 3.98, SD = 1.54 respectively) and pre-film, $t(134) = 18.29$, $p < .001$, $d = 1.58$ (M = 5.97, SD = 2.33 versus M = 2.27, SD = 1.40, respectively).

The ANOVA revealed a significant time x CBM group interaction, $F(1.58, 206.66) = 5.60$, $p = .01$, $\eta_p^2 = .008$. Post-hoc independent *t*-tests showed that the interaction was driven by CBM group differences in mood at post-reading task, with the $CBM_{Metacog}$ group (M = 6.10, SD = 2.30) reporting worse mood compared to the $CBM_{Control}$ (M = 5.29, SD = 2.32), $t(133) = 2.04$, $p = .04$, $d = .35$. No significant differences in mood were found at either pre- (p = .37, $CBM_{Metacog}$ M = 2.16, SD = 1.28; $CBM_{Control}$ M = 2.38, SD = 1.52) or post-film (p = .89, $CBM_{Metacog}$ M = 4.00, SD = 1.42; $CBM_{Control}$ M = 3.96, SD = 1.66).

Table 2

Participants' demographic and baseline measures by CBM and monitoring condition

	Self-caught-only		Self-caught-plus-probes			Monitoring	
	$CBM_{Metacog}$	$CBM_{Control}$	$CBM_{Metacog}$	$CBM_{Control}$	CBM group	condition	Interaction
Measure	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*	$F(1,131)$	$F(1,131)$	$F(1,131)$
TEQ	0.61 (1.02)	0.77 (1.37)	0.74 (1.14)	0.61 (.83)	<1	<1	<1
MCQ-1	10.73 (4.02)	10.37 (3.80)	10.26 (3.61)	10.12 (3.93)	<1	<1	<1
MCQ-2	12.15 (3.91)	13.37 (5.83)	11.79 (4.80)	11.12 (4.34)	<1	2.50	1.32
MCQ-3	10.52 (2.36)	11.31 (3.68)	11.56 (3.82)	10.97 (3.53)	<1	<1	1.40
BAMQ-Positive	12.36 (3.67)	13.60 (5.21)	11.88 (4.36)	11.76 (3.79)	<1	2.44	<1
BAMQ-Negative	11.61 (5.24)	11.06 (4.78)	9.74 (2.77)	10.79 (3.76)	<1	2.14	1.20
Film attention	8.91 (1.16)	9.06 (.97)	9.15 (1.42)	8.70 (1.13)	<1	<1	2.17
Film distress	7.15(1.92)	6.57 (1.63)	7.32 (1.57)	6.94 (1.95)	2.49	<1	<1
Film unpleasantness	8.42 (1.94)	7.86 (1.59)	8.41 (1.67)	7.67 (2.17)	4.23*	<1	<1

Note: $*p < 0.05$, $**\ p < 0.001$, $***p < 0.001$

3.2. *Hypothesis 1: Metacognitive appraisals and beliefs*

Index bias scores were calculated from the ERT at post-training session 1 and session 2. A 2 session (session 1 and session 2) x 2 CBM ($CBM_{Metacog}$ versus $CBM_{Control}$) mixed AVOVA revealed a significant main effect for CBM group (group means collapsed across session 1 and 2), $F(1,133) = 7.38$, $p = .007$, $\eta_p^2 = .05$, with the $CBM_{Metacog}$ group demonstrating a significantly higher positive appraisal bias ($M = 1.72$, $SEM = .09$) compared to the $CBM_{Control}$ ($M = 1.36$, $SEM = .09$), as predicted. The ANOVA also revealed a significant session x CBM interaction effect, $F(1,133) = 18.58$, $p < .001$, $\eta_p^2 = .12$. Post-hoc independent *t*-tests (Bonferroni-Holm corrected) found that this interaction was driven by CBM group differences at session 1, $t(133) = 5.22$, $p < .001$, $d = .90$ ($CBM_{Metacog}$ $M = 2.01$, $SD = 1.27$; $CBM_{Control}$ $M = 1.06$, $SD = .80$), but not session 2, $t(133) = 1.14$, $p = .256$, $d = .20$ ($CBM_{Metacog}$ $M = 1.42$, $SD = 1.10$; $CBM_{Control}$ $M = 1.65$, $SD = 1.22$). One-sample *t* tests revealed that index bias scores at session 1, from both CBM groups, were significantly different from zero ($CBM_{Control}$ $M = 1.06$, $SD = .80$, $t(67) = 10.95$, $p < .001$; $CBM_{Metacog}$ $M = 2.01$, $SD = 1.27$, $p < .001$, $t(66) = 12.96$, $p < .001$).

To determine whether the CBM training modified participants' metamemory beliefs, a 2 session x 2 CBM group mixed ANOVA was conducted. The $CBM_{Metacog}$ group ($M = 11.16$, $SEM = .47$) reported healthier meta-memory beliefs compared to the $CBM_{Control}$ group ($M = 13.62$, $SEM = .47$); a significant main effect for CBM group, $F(1,133) = 13.79$, $p < .001$, $\eta_p^2 = .09$, as predicted[1]. No other main or interaction effects were significant (*F*s < 2.56, *p*s > .11). MCQ scores were analysed with a MANOVA at post-training session 1 and session 2. At session 1, no significant differences were found on the MCQ subscales between CBM

[1] Participants' baseline (i.e., pre-existing metamemory/metacognitive beliefs, about a historic event) scores were also entered as a covariate in the model and the results remained the same.

groups, $F(3, 131) = .58$, $p = .63$; Wilk's $\Lambda = .99$, $\eta_p^2 = .01$. Similarly, there were no significant differences found at session 2, $F(3, 131) = 1.55$, $p=.21$; Wilk's $\Lambda = ..97$, $\eta_p^2 = .03$. Lastly, we analysed participants' beliefs about the meaning of intrusions, however at both sessions, no significant differences between CBM groups were found (p's >.05).

3.3. Hypothesis 2: PTSD symptoms

In line with the pre-registration, the IES-R total score and the IES-R intrusion subscale were analysed separately using independent *t*-tests. There were no significant differences between groups (ps > .20). Next, we examined the frequency and distress ratings from the intrusion diaries. In total, 113 participants reported experiencing intrusions during the 7-day intrusion diary. $CBM_{Metacog}$ participants reported significantly fewer intrusions compared to those in the $CBM_{Control}$ group, $t(133) = 2.24$, $p = .03$, $d = .40$ (Figure 1). $CBM_{Metacog}$ participants ($M = 3.92$, $SD = 1.74$) also found their intrusions less distressing compared to $CBM_{Control}$ participants ($M = 4.60$, $SD = 1.82$), $t(111) = 2.05$, $p = .04$, $d = .33$).

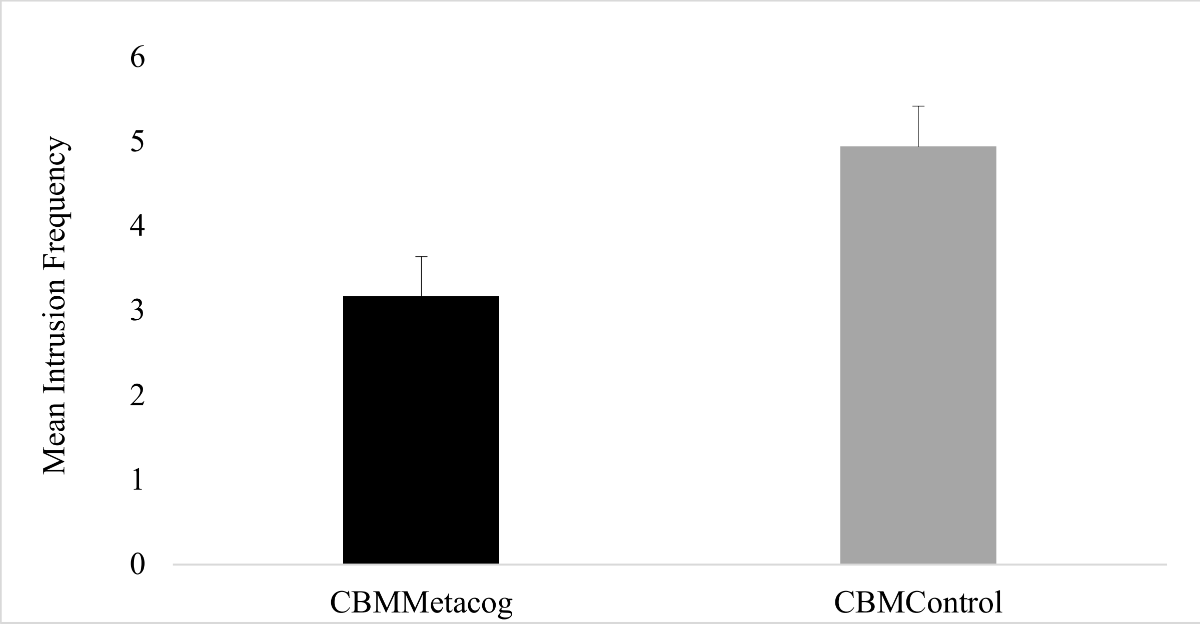

Figure 1. Intrusion diary frequency by CBM group (+1 SEM). $CBM_{Metacog}$ group *(M* = 3.17, *SEM* = .47) vs $CBM_{Control}$ (*M* = 4.94, *SEM* = .48)

3.4. Hypothesis 3: Meta-awareness of intrusions

The frequency of participants' self-caught intrusions using a 2 CBM group x 2 monitoring condition (self-caught-only versus self-caught-plus-probes) between groups ANOVA. Contrary to prediction, CBM group did not affect the frequency of self-caught intrusions, $F(1, 128) = .11$, $p = .74$, $\eta_p^2 = .00$ ($CBM_{Metacog}$ *M* =9.05, *SEM* = 1.12 ; $CBM_{Control}$ *M* = 8.53, *SEM* = 1.10). Further, the main effect for monitoring condition and CBM group x monitoring condition interaction, were non-significant (*F*s <1, *p*s > .42).

Next, we analysed the proportion of participants' probe-caught thoughts that were about the film. On average, participants were exposed to 7.89 probes (*SD* = 4.71, *R* = 1-27) throughout the reading task, with no difference in probe frequency between CBM training groups, $t(62) = .18$, $p = .85$, $d = .05$ ($CBM_{Control}$ *M* = 8.00, *SD* = 5.12; $CBM_{Metacog}$ *M* = 7.78, *SD* = 4.35). Overall, participants reported that they were thinking about the article on 56.43% of the probes, and "other" things on 15.45% of the probes. Thus, participants reported (i.e., were caught thinking about the film and had intrusions about the film that *lacked meta-*

awareness)on 28.12% of the probes. However, contrary to our meta-awareness hypothesis, there were no significant differences in the percentage of probe-caught film intrusions between CBM training groups, $t(62) = .70$, $p > .05$, $d = .18$ (CBM$_{\text{Metacog}}$ $M = 38.32$, $SD = 33.27$; CBM$_{\text{Control}}$ $M = 33.03$, $SD = 26.56$).

4. Discussion

The main aim of this study was to determine whether training people to adopt healthy metacognitive beliefs prior to analogue trauma, would also lead to healthier metacognitive beliefs and fewer analogue PTSD symptoms, compared to a control group. The CBM training in this study is based on past CBM trainings which targeted self-efficacy (Woud et al., 2012) and event-centrality (Vermeulen et al., 2018) appraisals linked to PTSD, however our training differs by instead targeting *metacognitive beliefs* linked to PTSD. An additional research question was whether training people to adopt healthier metacognitive beliefs also increased participants' meta-awareness of their intrusions. Firstly, it appears that the CBM$_{\text{Metacog}}$ training worked to bias participants' thinking in the intended direction compared to the control group. Notably, group differences in index bias scores were found, with higher index bias scores found in the CBM$_{\text{Metacog}}$ group versus CBM$_{\text{Control}}$, as predicted. Results showed that the control group also yielded a positive bias, which may be due to the healthy participant sample used within this study who likely hold pre-existing healthy metacognitive beliefs. Additionally, we found that the effects of CBM$_{\text{Metacog}}$ training transferred over to participants' *meta-memory beliefs*, as participants in the CBM$_{\text{Metacog}}$ training reported healthier metamemory beliefs post-training, compared to the CBM$_{\text{Control}}$ group. Perhaps, metamemory beliefs are more easily manipulated via CBM compared to other types of metacognitive beliefs (e.g., those as measured via the MCQ). It may be that the CBM$_{\text{Metacog}}$ training more easily transfers over to metacognitive beliefs that are assessed in relation to a specific event (i.e., film), as opposed to general metacognitive beliefs (as measured by the MCQ). This study suggests that $CBM_{Metacog}$ training can reliably bias participants thinking in the intended direction—in line with previous work (Woud et al., 2017)—and this has some effect at increasing healthy metacognition.

Our second main outcome variable was analogue PTSD symptoms. Here, we found that participants in the $CBM_{Metacog}$ group reported significantly fewer film intrusions, and overall, experienced less distress from their intrusions compared to $CBM_{Control}$ group. These results support our hypothesis that training people to adopt healthy metacognitive beliefs prior to trauma exposure may help to reduce the development of trauma-related intrusions. These data offer a first proof-of-principle study demonstrating that training people to adopt healthy metacognitive beliefs may serve to protect against the development of analogue PTSD symptoms. However, further research is needed before claims of causality can be firmly established.

Next, we turn to our meta-awareness hypothesis. Here, we found no significant differences in the number of self-caught intrusions or the proportion of probe-caught film intrusions between CBM groups. These data suggest that contrary to our meta-awareness hypothesis, receiving CBM training to increase healthy metacognition may not increase meta-awareness of one's intrusions. One possible explanation for this finding is that the impact of the $CBM_{Metacog}$ training on meta-awareness of intrusions may need more time to take effect to allow for consolidation of the training. Future work could expand on this by including a meta-awareness task at follow-up session 2. Alternatively, it may be the case that increasing one's healthy metacognitive beliefs does not affect meta-awareness levels, which would have implications for the metacognitive model of PTSD.

There are several limitations to note. First, for ethical reasons this first proof-of-principle study employed the trauma film paradigm, which is not a real-life trauma, nor is it a personally experienced distressing event which arguably holds greater emotional intensity/relevance, compared to witnessing stimulated trauma happening to others (i.e., trauma film). Thus, perhaps further replication studies could examine the effects of $CBM_{Metacog}$ against a different type of analogue trauma, such as people's negative/traumatic autobiographical memories. Secondly, we also tested the $CBM_{Metacog}$ training on a non-clinical student sample, thus, it is unknown whether training clinical samples with $CBM_{Metacog}$ would lead to a reduction in PTSD symptoms. Future work could also test the efficacy of $CBM_{Metacog}$ training among healthy samples who report higher pre-existing maladaptive beliefs (i.e., in relation to a historic event), or to prospectively test the training in trauma exposed populations (e.g., first responders). Third, again for ethical reasons, in this first study we tested out a positive CBM condition, relative to a control group. To better determine the causal role of metacognitive beliefs in PTSD, an essential next step is to explore the effects of a negative CBM condition (i.e., adopting unhealthy metacognitive beliefs) on participants' metacognitive beliefs and PTSD symptoms. For instance, a study which included a positive, negative CBM condition as well as a control group would be better equipped to examine causality claims. Fourth, as the control group did not include any reference to intrusions/symptoms, it may be possible that any form of psychoeducation which talks about these symptoms would prove beneficial to reducing intrusions. Further work could employ a different CBM control, whereby people are exposed to information about intrusions, without steering them to interpret their meaning in a specific way.

5. Conclusions

This is the first proof-of-principle study to demonstrate that training people to adopt healthy metacognitive beliefs, prior to trauma exposure, may help to guard against the development of subsequent analogue PTSD symptoms. Should the current findings be replicated via additional experimental and clinical research, they may have implications for the *primary prevention* of PTSD, whereby training first responder communities to adopt healthier metacognitive beliefs may possibly help to reduce their vulnerability to developing PTSD following trauma exposure.

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Author Contributions

The study concept was developed by XXX and XXX.

XXX and XXX designed the study and XXX provided the necessary materials. XXX performed data collection and analysis. XXX and XXX drafted the manuscript and XXX provided critical revisions. All authors approved the final version of the manuscript before submission.

Declaration of Conflicting Interests

The authors declare that they have no conflicts of interest in respect to their authorship or publication of this article.

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