ORIGINAL ARTICLE

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Decreasing Event Centrality in Undergraduates Using Cognitive Bias Modification of Appraisals

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Abstract

Event centrality refers to the extent to which a personal event in autobiographical memory serves as a reference point for other experiences, as a turning point in the life-story, and is integrated into components of personal identity. Research has shown that event centrality is positively related to symptoms of posttraumatic stress disorder (PTSD). However, limited research is available on the causal relation between event centrality and PTSD symptoms. We examined this causal link in a series of experiments. A pilot test showed that, out of four manipulations, only a cognitive bias modification training of appraisal (CBM-App) decreased event centrality in participants with high event centrality scores. Next, we tested whether the CBM-App training influenced event centrality and PTSD symptoms in a new sample. Participants in the CBM-App condition reported reduced event centrality compared to participants in a non-centrality control condition. No changes in PTSD symptoms were found. The link between event centrality and PTSD symptoms was mediated by posttraumatic cognitions and rumination. Together, these studies suggest that CBM-App training can lower appraisals of event centrality of a distressing autobiographical memory. Long-term effects on PTSD symptoms will need to be tested in future research.

Keywords Autobiographical memory · Centrality of event · Event centrality · PTSD · Posttraumatic stress disorder · Trauma · Trauma appraisals

Introduction

Individual differences in cognitive appraisals following a traumatic event are one of the main factors in the development of posttraumatic stress disorder (PTSD; Cromer and Smyth 2010; DePrince et al. 2011). In the cognitive model of PTSD (Ehlers and Clark 2000) it is proposed that negative appraisals of the trauma and its consequences, along with poor elaboration and contextualization of the event in

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autobiographical memory, lead to a sense of current threat. These processes are thought to prohibit the integration of a traumatic event into one's autobiographical memory, thereby maintaining PTSD.

Berntsen and Rubin (2006, 2007), proposed that a traumatic memory remains vivid and highly accessible because of its distinctiveness and emotional impact. This suggests that it is not poor integration, but rather an over-integration of the trauma memory in the autobiographical knowledge base which explains PTSD symptoms. The traumatic memory may form a reference point for the organization of autobiographical knowledge and can have a continuous impact on the interpretation of other non-traumatic experiences in the personal past and future. This way, the enhanced integration of the traumatic memory can cause other memories to become associated with the traumatic memory, which could lead to rumination, worry, and memory intrusion (Berntsen and Rubin 2007). This 'event centrality' (Berntsen and Rubin 2006, 2007) is defined by whether the event is appraised (1) as a reference point for other experiences (e.g., the individual overestimates the occurrence of similar traumatic events), (2) as a turning point in life-story (e.g.,

the individual feels that the traumatic event has changed his/her life), or (3) as being integrated into components of personal identity (e.g., 'being a trauma victim' has become part of the self).

Although the two theories differ in certain means, such as in their conceptualization of the integration of the traumatic event in memory, both theories (Berntsen and Rubin 2006, 2007; Ehlers and Clark 2000) may converge on the idea that the individual can start to view other life experiences from a trauma-related perspective, and stress the importance of cognitive appraisals[1] related to the trauma in explaining PTSD symptoms. Appraisals such as "Nowhere is safe" and "The next disaster will strike soon" (Ehlers and Clark 2000) align with seeing the traumatic event as a reference point for other experiences (Berntsen and Rubin 2007); appraisals such as "I have changed for the worse" and "I will never be able to lead a normal life again" (Ehlers and Clark 2000) align with experiencing the event as a turning point in the life-story (Berntsen and Rubin 2007); and appraisals such as "I attract disaster" and "Others can see that I am a victim" (Ehlers and Clark 2000) align with the event being integrated into components of personal identity (Berntsen and Rubin 2007). In short, the concept of event centrality appears to include many of the negative appraisals that have been considered to be causal to the development and maintenance of PTSD. In addition, Lancaster et al. (2011) proposed two mediation models in an undergraduate sample. In the first model, event centrality mediated the link between posttraumatic appraisals and PTSD symptom severity; in the second model the pathway was reversed, such that posttraumatic appraisals mediated the link between event centrality and PTSD symptoms. No significant differences were found between the models, which suggest that event centrality may act as a specific subtype of posttraumatic appraisal.

Event centrality is typically assessed with the centrality of event scale (CES; Berntsen and Rubin 2006, 2007). Previous research has found that CES scores are positively correlated with trauma-related psychopathology (Barton et al. 2013; Berntsen and Rubin 2006, 2007; Blix et al. 2014; Brown et al. 2010; Robinaugh and McNally 2011, and many more). In addition, it was found that event centrality predicts the development of PTSD symptoms measured a couple of weeks or months later (Blix et al. 2016; Boals and Ruggero 2016; Boelen 2012a). Furthermore, it was shown that the link between CES scores and PTSD symptoms was partly and fully mediated by different factors. Lancaster

et al. (2011) showed that no significant difference could be found between their two proposed mediation models, which could suggest that event centrality is a type of posttraumatic appraisal. Further studies showed that the effect of event centrality was partially mediated by the violation of beliefs and intrinsic goals (George et al. 2016), or by self-efficacy (Chung et al. 2017). The mediation model in a bereaved sample tested by Boelen (2012b) showed that the relation between event centrality and PTSD symptoms was fully mediated by memory intrusiveness, negative appraisals, rumination, and depressive avoidance. These studies suggest that several maladaptive cognitive appraisal processes are involved in the maintenance of the relation between event centrality and PTSD symptoms.

In sum, initial studies have shown that event centrality and symptoms of PTSD are correlated, and that this relation is mediated by several factors including posttraumatic cognitions and rumination. Yet, little is known about whether event centrality can be manipulated experimentally, and the causal effect of event centrality on PTSD symptoms. To our knowledge, only three experimental studies tested whether event centrality can be manipulated. Two of these studies also tested the relationship between event centrality and PTSD symptoms. Boals and Murrell (2016) showed that adding an acceptance and commitment therapy (ACT) module (specifically 'self-as-context') to treatment as usual in victims of physical or sexual abuse resulted in a decrease in both PTSD symptoms and event centrality, where the effect on PTSD symptoms was mediated by event centrality. Similar results were found using an expressive writing intervention after listening to a 10 min ACT audio analog (Boals et al. 2015). Students who met criteria for PTSD reported a significant decrease in event centrality 1–4 weeks after the ACT intervention. In addition, an analog of a CBT session was created to test the effect of CBT on event centrality. Students in the CBT condition reported a decrease in centrality 4 weeks after the intervention. The third study examined the effect of increasing event centrality by using a persuasive writing task (Lancaster and Erbes 2016). Students were instructed to convince someone else of the importance and severity of their most negative life experience via writing. Participants in the persuasive writing condition, who reported their event as potentially traumatic according to DSM 5 criterion (Diagnostic and Statistical Manual of Mental Disorders 5; American Psychiatric Association 2013), reported a significant increase of event centrality after the writing task, compared to participants in a factual writing condition. Together, these studies suggest that it is possible to experimentally induce modulations in event centrality, however, no causal relation has yet been found.

Alternatively, cognitive bias modification (CBM) could be used to manipulate appraisals of event centrality, in order to causally modulate event centrality and PTSD

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[1] We are aware that Berntsen and Rubin (2006, 2007) do not use the word 'appraisal' to describe event centrality concepts, however, we want to clarify that the theory of event centrality refers to appraisal-like processes, and that the word 'appraisal' is not solely related to posttraumatic cognitions and the trauma theory of Ehlers and Clark (2000).

symptoms. Biased appraisals can be induced using a CBM-Interpretation procedure (CBM-I; Mathews and Mackintosh 2000). CBM-I provides participants with a computer-based training that modifies their appraisals systematically in a more positive (or negative) way (Koster et al. 2009). CBM-I and CBM-I-based training of appraisals (CBM-App) have shown to successfully reduce depressive intrusions (Lang et al. 2009), intrusive memories (Woud et al. 2012), and posttraumatic cognitions (Woud et al. 2013, 2017; for a review of CBM studies in PTSD and trauma, see). Woud et al. (2012, 2013) used a CBM-App training based on themes of the Self subscale of the Posttraumatic Cognitions Inventory (PTCI; Foa et al. 1999). The scale includes items as "If I think about the event, I will not be able to handle it" and "I can't deal with even the slightest upset." Participants were presented with 80 ambiguous scenarios related to the PTCI self-scale, that ended in a to-be-completed word fragment. The word fragment systematically produced an outcome that was consistent with either an adaptive or a maladaptive appraisal of the scenario. The CBM-App successfully induced appraisal styles congruent to the training condition. In Woud et al. (2012), a significant decrease in posttraumatic cognitions was found directly after the training and 1 week after the training for participants in the adaptive condition. In Woud et al. (2013) no difference on the PTCI was found directly after the training, although participants in the adaptive condition showed a significant decrease in posttraumatic cognitions 1 week after the training. This suggests that it is possible to change trauma-related appraisals with CBM. These two studies (Woud et al. 2012, 2013) focused on posttraumatic appraisals of the self. In the present study, we extended this work to the domain of event centrality. We aimed to directly test the causal link between event centrality and PTSD symptoms using a CBM-App targeting event centrality.

The first goal was to develop a CBM-App training and test its effect on event centrality. We predicted that participants in a centrality focused CBM-App condition aimed at reducing event centrality would report lower CES scores after the training compared to participants in a control condition. Our second goal was to examine whether the CBM-App training would reduce PTSD symptoms. We predicted that participants in the centrality CBM-App condition would report fewer PTSD symptoms 3 days after the training compared to participants in the control condition. Our third goal was to test whether previously supported mediation models would hold in our sample. We expected that the link between event centrality and PTSD symptoms was mediated by rumination, worry, and posttraumatic cognitions. Approval for these studies was obtained from the Social and Societal Ethics Committee of the KU Leuven (SMEC, reference number G-2015 02 164).

Pilot Study: Manipulating Event Centrality

Participants and Procedure

We tested four newly developed manipulations of event centrality in a pilot study in first year psychology students (N = 274): two writing assignments, and implicit association training (IAT) and a CBM-App training of event centrality. All first year psychology students were invited to participate in this experiment during a routine collective testing session at the psychology department. Groups of maximum 16 participants were invited to the lab, and were assigned to one of four different manipulations based on the order of arrival to the lab (first 16 participants completed manipulation 1; second 16 participants completed manipulation 2 etc). Informed consent was obtained from all participants. The CES was administered before and after each manipulation and was completed in regards to the participants' most negative or traumatic autobiographical memory. The experiment was conducted using Inquisit 4.0 web (2015) and took approximately 40 min. Participants were rewarded with course credits.

Centrality of Event Scale

The Dutch version of the centrality of event scale (CES; Berntsen and Rubin 2006; Vermeulen et al. in preparation) measures the centrality of a specific event in the individual's life-story. Items are, for example, "I feel that this event has become a central part of my life-story" and "This event was a turning point in my life". The questionnaire contains 7 self-report items, which participants rated on a 5-point Likert scale from 1 (*totally disagree*) to 5 (*totally agree*). The original 7-item CES was found to have an internal consistency of $\alpha = 0.92$ in a student sample (Berntsen and Rubin 2006). The Dutch version of the CES was found to be reliable and has an internal consistency ranging between $\alpha = 0.85$–0.90 in a student sample (Vermeulen et al. in preparation).

Writing Assignment 1

As previous research already showed that event centrality is a flexible, rather than static construct (Boals and Murrell 2016; Boals et al. 2015; Lancaster and Erbes 2016), a new writing assignment was designed. This assignment had the intention to change event centrality by writing about the central event from a perspective that makes it less central in relation to other autobiographical events. The writing assignment aimed to decrease event centrality by asking participants to write down their most central negative or traumatic event and four different life events in chronological

order in a figure containing five consecutive blocks: two events that happened before the central negative event, the central negative event, and two events that happened after the central negative event. This resulted in a timeline that visualized the negative event as merely one of several life events.

Writing Assignment 2

In this writing assignment, participants were also asked to write down their most central negative or traumatic event and four other life events, two that happened before, and two that happened after the central negative event. This time, however, participants were instructed to write down explicitly for each of the four events why this event was unaffected by the central negative event. The writing task consisted of a figure containing five blocks; a block in the middle for the central negative event, and blocks in all four corners for each of four events and the corresponding reason why the event was unaffected by the central event.

Implicit Association Training (IAT)

Previous research already showed that it is possible to increase implicit self-esteem through classical condition, using an implicit association training (IAT, Baccus et al. 2004). In this pilot study, it was tested whether an IAT was also suitable to decrease cognitive appraisals. The IAT aimed to decrease event centrality of the negative event, and to increase event centrality of the positive event simultaneously. Before the IAT started, participants provided five words that described a personal, central positive event and five words describing a personal, central negative event. They were instructed to enter one unique word at a time, and that they should not enter a word which they already listed. Participants were then trained to link event centrality-related words (e.g., 'important', 'reference point') to their positive words (e.g., 'joyful', 'relaxed'), and non-central words (e.g., 'unimportant', 'normal') to their negative words (e.g., 'fight', 'pain'). Words from the four categories appear in random order in the middle of a computer screen. Participants were instructed to assign each word to the category on the left (positive and central) or right (negative and non-central) of the screen by pressing a left or right response key.

Cognitive Bias Modification of Appraisal (CBM-App)

We based our event centrality CBM-App on the procedure described by Woud et al. (2012, 2013). Themes from the CES (e.g., connection to identity, changes caused by the event in life-story, connection to other events) were used to develop CBM-App materials. Our centrality CBM-App training required participants to read ambiguous scenarios

about hypothetical situations in a student's life, that ended in a to be-completed word fragment. Participants were instructed to complete the word fragments which disambiguated the scenario. All scenarios started with a title, followed by three sentences, with the last sentence ending in a word fragment which the participants completed in order to disambiguate the meaning of the scenario, for example: *Talking to your mother. You're having a conversation with your mother about the negative event. Your mother asks you how important the negative event was to you. You answer the event was unim_ortant to you.* The training consisted of 30 ambiguous event centrality-related scenarios and 10 neutral filler scenarios unrelated to centrality and which were included to mask the purpose of the manipulation. To ensure that participants read and paid attention to the scenarios, each sentence remained on the computer screen for at least 1sec. After 1sec, participants pressed the spacebar to continue to the next sentence. After the last sentence, participants pressed the spacebar to reveal the word fragment. Once they identified the missing letter, they pressed the spacebar again and typed the missing letter as fast as possible. If the response was correct, the completed word appeared. If the response was incorrect, a large red X appeared on screen until the correct letter was pressed. Each scenario was followed by a comprehension question (e.g. *Were you having a conversation with your father?*) in order to ensure that the participants processed the meaning of the scenario. If the response was incorrect, a large red X appeared on screen. After the feedback, or when the question was answered correctly, the next scenario appeared.

Results and Conclusion

Means, standard deviations, and within-condition differences of the CES are shown in Table 1. A mixed model repeated measure ANOVA was performed with Time (pre- and post-manipulation) as the within-subject factor, Condition (writing assignment 1, writing assignment 2, IAT, CBM-App) as the between-subjects factor, and CES scores as the dependent variable. There was no significant main effect of Time, $F(1, 270) = 0.03$, $p = .86$, $\eta_p^2 = 0.00$, or Condition, $F(1, 270) = 0.09$, $p = .97$, $\eta_p^2 = 0.00$, nor was there a significant time × condition interaction, $F(1, 270) = 1.23$, $p = .30$, $\eta_p^2 = 0.01$. We reran these analyses for participants with a CES score above the median (CES score ≥ 22; $N = 147$). The main effects of time and condition remained non-significant, $F(1, 143) = 0.31$, $p = .59$, $\eta_p^2 = 0.00$, and $F(1, 143) = 2.10$, $p = .10$, $\eta_p^2 = 0.04$, respectively. However, there was a significant time × condition interaction, $F(1, 143) = 3.30$, $p = .02$, $\eta_p^2 = 0.07$. Further within condition t-tests showed no significant change in CES scores for both

Table 1 Means and standard deviations of event centrality in the four conditions of the pilot over time

	CES scores				CES scores ≥ 22			
	Pre	Post	*t*	*p*	Pre	Post	*t*	*p*
WA 1	21.46 (8.18)	20.86 (8.03)	− 1.22	0.22	27.77 (2.20)	27.91 (2.78)	− 0.42	0.68
WA 2	21.73 (8.29)	21.98 (7.75)	0.86	0.40	28.67 (3.81)	28.59 (4.26)	0.18	0.86
IAT	21.83 (7.25)	21.66 (6.69)	− 0.66	0.51	26.55 (4.10)	27.09 (4.35)	− 1.76	0.09
CBM	21.32 (7.55)	21.70 (7.38)	0.92	0.36	27.12 (3.44)	26.00 (5.17)	2.19	0.03

Standard deviations are noted between brackets

CES centrality of event scale, *WA* writing assignment, *IAT* implicit association training, *CBM* cognitive bias modification

writing assignments or the IAT. However, CES scores were significantly reduced after the CBM-App condition.

This pilot study showed that event centrality was reduced after a CBM-App training, but only in participants with CES scores above the median at baseline. Based on these findings, we conducted a second experiment to further test the effect of this CBM-App.

Experiment: The Effect of CBM-App Training on Event Centrality and PTSD Symptoms, and the Mediating Effect of Posttraumatic Cognition, Worry and Rumination

Participants

At KU Leuven, 650 Dutch speaking first year psychology students completed the 7-item Dutch version of the CES for screening purposes during one of the collective testing sessions. Students who scored above 22 (the median score in the pilot study; $N = 303$) were invited to participate in the experiment. In total, 101 students (33%) responded (89 women), with an average age of 18.80 years ($SD = 1.90$), ranging from 17 to 31 years. Participants received course credits for their participation.

Materials

The 7-item Dutch version of the CES was used to assess event centrality. Please see the description in the pilot study for details.

PTSD Symptoms

The Dutch version of the impact of event scale (IES; Horowitz et al. 1979) was used to measure intrusions and avoidance related to a distressing event. This self-report questionnaire consists of 15 items: 8 items in the intrusion subscale and 7 in the avoidance subscale. The items are rated on a 4 point Likert scale ranging from 0 (*not at all*), 1 (*rarely*), 3 (*sometimes*), to 5 (*often*). The Dutch version of the IES has an

acceptable to good reliability ranging from $\alpha = 0.80–0.87$ for the intrusion subscale and $\alpha = 0.77–0.86$ for the avoidance subscale (Brom and Kleber 1985).

Posttraumatic Cognitions

The Dutch version of the posttraumatic cognition inventory (PTCI; Foa et al. 1999; Van Emmerik et al. 2006) was used to assess posttraumatic cognitions. Participants rate 36 self-report items on a 7-point Likert scale ranging from 1 (*totally disagree*) to 7 (*totally agree*). The PTCI has three subscales: negative cognitions about the self (Self), negative cognitions about the world (World), and self-blame (Blame). The Dutch version of the PTCI is reliable with high internal consistency in both patient and student samples and has an internal consistency ranging between $\alpha = 0.78–0.82$ (Self; $\alpha = 0.93–0.94$, World; $\alpha = 0.92–0.93$, Blame; $\alpha = 0.82–0.88$; Van Emmerik et al. 2006).

Worry

The Dutch version of the Penn state worry questionnaire (PSWQ; Meyer et al. 1990; Van Rijsoort et al. 1999) was used to assess pathological worry. Participants rate 16 self-report items on a 5-point Likert scale, ranging from 1 (*not at all*) to 5 (*very*). The Dutch version of the PSWQ is reliable, with good temporal stability, moderate predictive validity, and high internal consistency of $\alpha = 0.88$ (Verkuil and Brosschot 2012).

Rumination

The abbreviated version of the Dutch ruminative response scale (RRS; Raes and Hermans 2007; Treynor et al. 2003) was used to assess trait rumination. Participants indicate how they typically respond to negative mood. The questionnaire consists of 22 self-report items rated on a 4-point Likert scale ranging from 0 (*almost never*) to 3 (*almost always*). A total score can be calculated. The brooding and reflection subscales of the RRS, as identified by Treynor et al. (2003), consist of five items each. The Dutch RRS has acceptable

to good reliability and internal consistency of $\alpha = 0.75$ ($\alpha = 0.78$–0.92 for the subscales; Schoofs et al. 2010).

Trait Anxiety

The Dutch version of the state trait anxiety inventory (STAI-T; Spielberger et al. 1970; Van der Ploeg 1980) was used to assess trait anxiety, to ensure baseline randomization over the two conditions, and was included as a covariate. The STAI-T consists of 20 items which the participants rate on a 4-point Likert scale, ranging from 1 (*almost never*) to 4 (*almost always*). The Dutch version of the STAI-T has a test–retest reliability of 0.75 and internal consistency of $\alpha = 0.85$, indicating acceptable to good reliability (Van Der Ploeg 1980).

Depressive Symptoms

The Dutch version of the beck depression inventory-II (BDI-II; Beck et al. 1996, 2002), assesses severity of depressive symptoms. It was used to ensure baseline randomization over two conditions and was included as a covariate. The questionnaire contains 21 self-report items, where each item consists of four statements (ranging 0–3 in severity). Participants select the statement which describes best how they felt within the past 2 weeks. The Dutch translation of de BDI-II is a reliable and valid measure with an internal consistency ranging between $\alpha = 0.73$–0.85 (Evers et al. 2005).

Additional Measures

For purposes beyond the goal of this study (i.e., master thesis research) the Rosenberg self-esteem scale (Rosenberg 1979) and the posttraumatic growth inventory (Jaarsma et al. 2006; Tedeschi and Calhoun 1996) were administered but will not be analyzed here.

Experimental Manipulation: CBM-App of Event Centrality

Training Phase

An adapted version of the CBM-App from the pilot study was used to decrease event centrality in the experimental condition. A control condition was added, and additional scenarios were included to further boost the effect of the training. The training consisted of 80 ambiguous training scenarios related to event centrality and 10 neutral filler scenarios that were unrelated to event centrality. Training scenarios systematically ended in a word fragment that resulted in a non-central interpretation of the scenario. The control condition consisted of 90 neutral scenarios that were unrelated to event centrality and that referred to events in daily student life, for example: *New Shoes. Your old shoes are all worn. You decide it is time to buy new shoes. You go to the city to do some shop_ing*.

Bias Assessment

To examine the effect of the CBM-app, a bias assessment was included pre- and post-training. Event centrality bias was assessed before and after the experimental manipulation. The bias assessment consisted of two phases, an encoding phase, and a recognition phase. In the encoding phase, participants were presented with 10 novel ambiguous scenarios related to event centrality. The procedure was the same as in the training phase except that the word fragment did not disambiguate the meaning of the scenario. After each scenario, participants rated how well they could imagine themselves in the situation (10-point Likert scale). In the recognition phase, the titles of the scenarios were presented again followed by four statements about the scenario, representing either a high central, a low central, a generally positive or generally negative appraisal. Participants rated on a 4-point Likert scale how close the meaning of the statement fitted resembled the meaning of the scenario. For example, in the encoding phase: *Daydreaming on the couch. You are lying on your couch and your mind wanders off. You're thinking about all the things you've experienced in your life so far. You also think about the negative event and whether the event had an impa_t on your life*. Recognition phase: *You think about the negative event and it makes you sad* (negative); *You think about the negative event and how little impact it has on your life* (low central); *You think about the negative event and how great your life has been so far* (positive); *You think about the negative event and how much impact it has on your life* (high central).

An event centrality appraisal bias index was calculated by computing a mean difference score for the pre-training and post-training assessments separately. For each item, a difference score was calculated by subtracting the ratings on the low centrality statements from the ratings on the high centrality statements. Lower index scores indicate a bias in favor of low central appraisals.

Procedure

Tasks were completed on a testing computer using Inquisit 4.0 (2015). Informed consent was obtained from all participants. Participants were randomly assigned to one of two conditions. Participants completed a demographic questionnaire, the STAI-T, BDI-II, PSWQ, RRS, and the RSES. Then, participants were asked to recall their most stressful negative or even traumatic memory, to briefly write down this memory, and to keep this specific memory actively in mind during the rest of the experiment. Participants then

completed the PTGI, IES, PTCI, and CES based on this memory. Next, participants completed the pre-training bias assessment, the centrality CBM-App training or control condition, and the post-training bias assessment. Finally, participants completed the CES and PTCI again and left the lab. 3 days after the first session, participants received an email with an invitation to an online assessment (follow-up). Participants completed the CES, IES, PTCI, BDI-II, PWSQ, RRS, and RSES online and were asked two additional questions regarding social desirability and demand effects (what they thought the experiment was about, and whether they had participated in a similar study before). Following completion of the online questionnaires, participants were debriefed and assigned course credits. Participants finished the first session within approximately 45 min. The online questionnaire took about 15 min.

Statistical Analyses

Mixed model repeated measures ANCOVAs were utilized to examine the effect of the experimental manipulation on event centrality and PTSD symptoms. Condition (centrality, control) was the between-subjects factor, Time (pre-training, post-training, follow-up) the within-subject factor, trait anxiety (STAI-T) and depression (BDI-II) were added as covariates. Process (Hayes 2017) was used to examine the mediating effect of posttraumatic cognitions, rumination and worry on the relation between event centrality and PTSD symptoms at follow-up. A probability of $\alpha = 0.05$ was used to determine statistical significance. Partial eta-squared and Cohen's d are reported as effect sizes. All analyses were conducted using SPSS 24 (IBM Analytics 2016).

Results

Randomization Check

There were no significant differences between the conditions in sex, $\chi^2(1) = 1.43$, $p = .23$, age, $F(1, 100) = 1.07$, $p = .30$, trait anxiety (STAI-T), $F(1, 100) = 0.33$, $p = .57$, or depressive symptoms (BDI-II), $F(1, 100) = 0.01$, $p = .95$. In addition, for the dependent and mediation variables, no differences were found at baseline: intrusions (IES), $F(1, 100) = 3.40$, $p = .07$, avoidance (IES), $F(1, 100) = 0.09$, $p = .77$, posttraumatic cognitions (PTCI), $F(1, 100) = 0.05$, $p = .83$, rumination (RRS), $F(1, 100) = 0.00$, $p = .95$, and worry (PSWQ), $F(1, 100) = 0.28$, $p = .60$. Table 2 presents the descriptive statistics of the demographic and randomization check variables. Table 3 presents descriptive statistics of the dependent and mediating variables for the two conditions and different time points.

Table 2 Numbers, means, and standard deviations of the demographic and randomization variables over the two conditions of study 2

	Experimental condition	Control condition
Sex	43 W/8 M	46 W/4 M
Age	18.61 (1.17)	19.00 (2.43)
STAI-T	46.25 (7.94)	47.28 (9.90)
BDI-II	14.88 (9.06)	14.74 (11.70)

Standard deviations are noted between brackets

W women, *M* men, *STAI-T* state trait anxiety inventory-trait, *BDI-II* beck depression inventory-II

Control Analyses

Across the two conditions, a mean score of $M = 6.44$ was found for how well participants could relate to the scenarios (scores could range from 0 to 10). Between conditions, no significant difference was found, $F(1, 99) = 0.85$, $p = .56$, indicating that the scenarios from both conditions were comparable in how relatable they were.

Manipulation Check

To test the effect of the CBM-App training on the event centrality bias, a mixed model repeated measures ANCOVA was performed with time (pre-training, post-training) as the within-subject factor, condition (experimental, control) as the between subjects factor, the centrality bias index as the dependent variable, and STAI-T and BDI-II scores as covariates. There was a significant main effect of Time, $F(1, 96) = 22.02$, $p < .001$, $\eta_p^2 = 0.18$, indicating an overall decrease in centrality bias. There was a significant main effect of Condition, $F(1, 96) = 6.41$, $p = .01$, $\eta_p^2 = 0.06$, indicating an overall smaller centrality bias in the experimental condition. Importantly, there was a significant Time x Condition interaction, $F(1, 96) = 21.93$; $p < .001$, $\eta_p^2 = 0.18$, see Fig. 1. Paired samples t tests showed that there was a significant decrease in the event centrality bias index in the experimental condition, $t(50) = 5.04$, $p < .001$, $d = 0.93$, but no change in the control condition, $t(49) = 0.02$, $p = .99$, $d = 0.00$. This confirmed that the centrality CBM-App training worked as intended.

Experimental Effects

Event Centrality

To test the effect of the CBM-App training on event centrality (CES scores), a mixed model repeated measures ANCOVA was conducted with time (pre-, post-training, follow-up) as the within-subject factor, condition (experimental, control) as the between-subjects factor, CES

Table 3 Means and standard deviations of the different dependent variables in the different conditions over time of study 2

	Experimental condition			Control condition		
	Pre	Post	Follow-up	Pre	Post	Follow-up
Bias index	1.31 (0.67)	0.38 (1.27)	–	1.15 (0.90)	1.29 (0.91)	–
CES	26.26 (6.03)	25.83 (6.00)	24.33 (6.14)	25.56 (6.02)	25.88 (6.46)	25.98(6.02)
IES intrusions	10.96 (9.79)	–	11.71 (9.59)	14.10 (8.93)	–	14.00 (10.01)
IES avoidance	13.33 (11.01)	–	12.73 (10.48)	13.92 (8.92)	–	11.56 (9.74)
PTCI	97.18 (35.89)	90.69 (37.20)	90.08 (36.63)	98.80 (39.02)	95.08 (40.95)	95.28 (38.66)
RRS	24.98 (11.44)	–	22.53 (12.98)	25.14 (12.94)	–	24.16 (13.48)
PSWQ	54.31 (10.85)	–	55.11 (10.81)	55.44 (10.42)	–	57.46 (10.02)

Standard deviations are noted between brackets

CES centrality of event scale, *IES* impact of event scale, *PTCI* posttraumatic cognitions inventory, *RRS* ruminative response scale, *PSWQ* penn state worry questionnaire
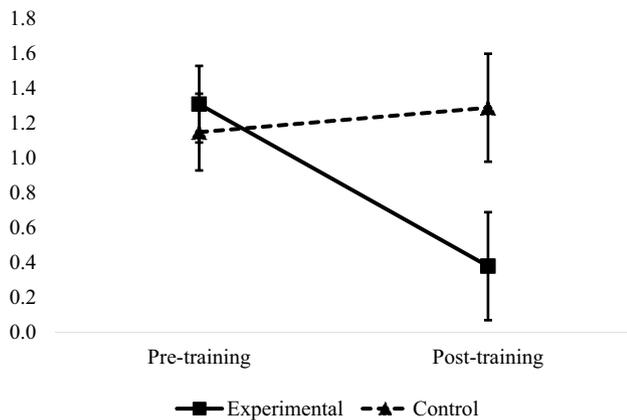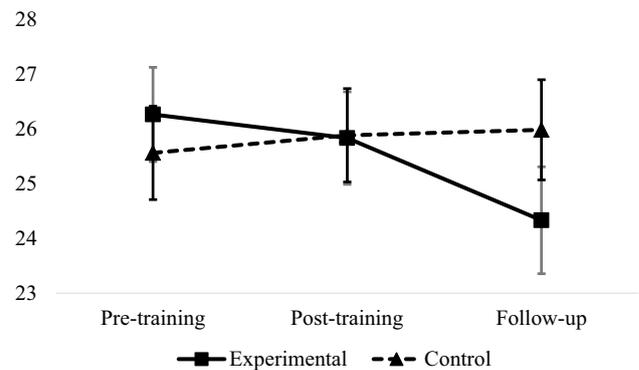

Fig. 1 Centrality bias assessment scores per condition over time. A lower score indicates lower event centrality. Error bars represent standard deviations

Fig. 2 Event centrality scores (CES) per condition over time. Error bars represent standard deviations

scores as the dependent variable, and STAI-T and BDI-II scores as covariates. There was no significant main effect of time, $F_{(2,96)} = 2.05$, $p = .13$, $\eta_p^2 = 0.04$, or condition, $F(1, 96) = 0.08$, $p = .78$, $\eta_p^2 = 0.00$. There was a significant time × condition interaction, $F(2, 96) = 9.57$; $p = .003$, $\eta_p^2 = 0.09$, see Fig. 2. For the experimental condition, paired samples *t*-tests showed no change in CES scores from pre- to post-training, $t(50) = 0.74$, $p = .46$, $d = 0.06$, but there was a significant decrease in event centrality from pre-training to follow-up, $t(50) = 3.32$, $p = .002$, $d = 0.32$, and from post-training to follow-up, $t(50) = 2.57$, $p = .01$, $d = 0.24$. No significant changes in CES scores were found in the control condition, all $t < 0.96$, all $p > .34$. This shows that the centrality CBM-App training significantly reduced event centrality as assessed with the CES but only after 3 days.

PTSD Symptoms

Two mixed model repeated measures ANCOVAs were conducted with Time (pre-training, follow-up) as the within-subject factor, condition (experimental, control) as the between-subjects factor, the IES subscales (intrusion and avoidance) as the dependent variables, and STAI-T and BDI-II as covariates. No significant effects were found for either subscale, all $F < 3.02$, all $p > .08$. This indicates that the centrality CBM-App training did not affect short-term intrusion or avoidance symptoms.

Mediation of the Relation Between Event Centrality and PTSD Symptoms

Multiple regression analysis was used to investigate whether posttraumatic cognitions (PTCI), rumination (RRS) and worry (PSWQ) mediated the link between event centrality (CES) and symptoms of PTSD (IES) at follow-up. The mediation analysis was conducted using Process described by Hayes (2017). Results are shown in Fig. 3. Event centrality was a significant predictor of posttraumatic cognitions, rumination, worry, and PTSD symptoms. Posttraumatic cognitions and rumination, however not worry, were a significant predictor of PTSD symptoms. These results support the mediational hypothesis The significance of the

Fig. 3 Mediation analysis of the effect of event centrality on PTSD symptoms through post-traumatic cognitions, rumination and worry at follow-up. This figure displays that the link between event centrality and PTSD symptoms is fully mediated by posttraumatic cognitions and rumination. Standardized regression coefficients are displayed for each relation specifically *p < .05; **p < .01; ***p < .001
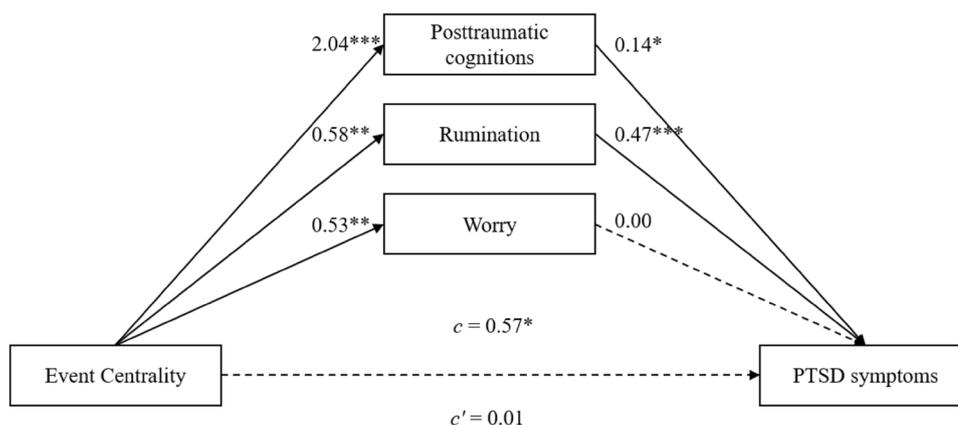
indirect effect was tested using bootstrapping procedures. Unstandardized indirect effects were computed for each of 5000 bootstrapped samples. Figure 3 shows that the indirect effect between event centrality and PTSD symptoms (c') almost disappeared when posttraumatic cognitions, rumination and worry were included as mediators, $R^2 = 0.35$, $F(1, 99) = 13.13$, $p < .001$. Posttraumatic cognitions and rumination, but not worry, emerged as unique mediators. This indicates that the link between event centrality and symptoms of PTSD was mediated by rumination and posttraumatic cognitions, but not by worry.

Discussion

This study directly tested whether it is possible to experimentally decrease appraisals of event centrality using a centrality CBM-App. We examined the hypothesized causal relation between appraisals of event centrality and PTSD symptoms. Our first aim was to test whether a new centrality CBM-App training was successful in decreasing event centrality. In line with our prediction, participants in the CBM-App condition showed a significant decrease in the event centrality bias index scores. That is, they indicated low central meanings to be more appropriate for the ambiguous scenarios than participants in the control condition. In addition, there was a significant decrease in event centrality scores (CES) in the experimental group 3 days after the training, whereas the control group reported no significant change. These results are not in line with the results of Woud et al. (2012), where a decrease in posttraumatic cognitions was found directly after the training and 1 week later. However, the delay in the effect of the training is similar to that reported by Woud et al. (2013). Their results showed that the CBM-App was able to decrease posttraumatic cognitions but this effect was only visible 1 week after the training. This indicates that the effects of induced cognitive biases only manifest themselves in other measures over time, perhaps

because the participant needs practice in daily life before change occurs. The delay in training effect is different than the results of other studies that aimed to manipulate event centrality. For example, Boals et al. (2015) found a decrease in event centrality only 4 weeks after the writing intervention, however no effect was found 1 week after the training. Boals and Murrell (2016) were able to find an effect of their intervention directly after treatment, however not after 6 weeks. Lancaster and Erbes (2016) found an intended increase directly after the training. The differences in timespan might show that these various manipulations may have distinct effects on event centrality. For now, it becomes clear that event centrality is indeed susceptible to manipulation, and might therefore have clinical potential. Whether effects are short- or long-term appears to depend on the manipulation used.

Our second aim was to examine whether the CBM-App training would also affect PTSD symptoms. This was not confirmed, as participants in the CBM-App condition did not show a decrease in symptoms of avoidance or intrusions compared to both control group and to pre-training scores. These results are in line with the research of Boals et al. (2015), where an expressive writing manipulation after listening to either an ACT or CBT analog showed a decrease in centrality, however no effect of training on PTSD symptoms was found. Our results are in contrast to the results of Woud et al. (2012), where fewer intrusions were reported in participants trained in an adaptive way by the CBM-App. In Woud et al. (2013), the positive trained group reported only less distress, however no difference in intrusion frequency compared to a negative CMB-App control group. One difference between the studies of Wouds and colleagues and ours, which may explain this discrepancy, is that Woud et al. (2012, 2013) assessed intrusions of a trauma film rather than intrusions of the most distressing autobiographical memory of the participant. The trauma film is unlikely to be central to the individual and, as such, perhaps caused less distress than more negative and central memories. Second, our CBM-App

training focused on appraisals of event centrality whereas the training by Woud and colleagues focused on items of the self-scale of the PTCI. These items include appraisals about intrusions specifically (e.g., having intrusions means I am going mad), whereas the event centrality training focuses on appraisals of the traumatic event in a broader context of the life-story and personal identity.

One possible explanation for the absence of effect on PTSD symptoms is that there might be no direct causal relation between appraisals of event centrality and symptoms of PTSD. Boals and Murrell (2016) previously demonstrated that treatment as usual for PTSD, without a specific focus on event centrality, resulted in a decrease in PTSD symptoms, however no changes in event centrality. In addition, Boals et al. (2015) showed that specific ACT and CBT centrality interventions were able to decrease event centrality, however not symptoms of PTSD. This indicates that temporarily modifying cognitions may not be sufficient to induce changes on symptom level. The assumption that there is no direct relation between event centrality and PTSD symptoms would be in contrast to the model of Berntsen and Rubin (2006, 2007), and would indicate that important appraisals in the Ehlers and Clark model (2000) do not encompass event centrality related themes. Nevertheless, the large amount of correlational research has shown that there is a strong correlation between event centrality and symptoms of PTSD (Barton et al. 2013; Berntsen and Rubin 2006, 2007; Blix et al. 2014, 2016; Brown et al. 2010; Robinaugh and McNally 2011, and many others). Another possibility is that the relation might be the other way around, where experiencing emotional arousal and intrusions related to the trauma can influence how central the traumatic event becomes. This could indicate that having appraisals of event centrality might be part of suffering from PTSD, and that simply trying to modify these cognitions may not do enough to change these symptoms. Yet another possibility is that the effects of the CBM-App were too small to affect PTSD symptoms. The reported results of the CBM-App on the CES were statistically significant, but in terms of effect size rather small, which might also explain the null findings in regard to changes in PTSD symptoms.

Our final aim was to examine whether the relation between event centrality and PTSD symptoms was mediated by posttraumatic cognitions, worry, and rumination, as has been found in previous research in clinical populations (Boelen 2012b). The mediation analyses showed that the relation between event centrality and PTSD symptoms was indeed mediated by posttraumatic cognitions, rumination, but not worry. This is largely in line with the results of Boelen (2012b), who found that the link between event centrality and PTSD symptoms was mediated by intrusiveness, negative cognitions, and rumination and depressive avoidance. A recent study Brooks et al. (2017), however, suggested that

event centrality could influence the relation between rumination and symptoms of PTSD instead. Herewith, rumination could lead to the event becoming part of the individuals identity, which thereafter triggers maladaptive cognitive processes related to the development of PTSD symptoms. Taken together, these results could suggest a bi-directional relation between rumination and event centrality, where both processes might intensify one another in the development and maintenance of PTSD symptoms. Our results are also in line with Lancaster et al. (2011), who stated that the link between event centrality and PTSD symptoms was mediated by posttraumatic cognitions. However, one problem that may arise here is that Lancaster et al. (2011) also found that the link between posttraumatic cognitions and PTSD symptoms was fully mediated by event centrality. This indicates that both appraisals of event centrality and posttraumatic cognitions are strongly related, and perhaps, as already suggested by Brown et al. (2010), it could be that both theories might cover the same subjects as both questionnaires include a number of overlapping concepts.

There are some limitations regarding both studies. First, our first (pilot) study did not include a general control condition without manipulation. This was due to reasons of feasibility of the sample sizes. It might be that the changes in event centrality were the result of regression towards the mean. Second, the IAT was not optimally designed. First, non-central words were linked to words related to negative events, and simultaneously central words were linked to words related to positive events. This made it difficult to examine whether one of these methods (connection positive to central vs. connection negative to non-central) worked, and if so, which method would be preferred. In addition, because participants entered words themselves, we had no control over these words, and whether they were in line with our intentions. Future research could test an improved version of this IAT training. Third, there was a rather short time period of only three days between post-training and follow-up. This was long enough to detect changes on the CES, but if it is indeed true that changes in PTSD symptoms would need more time to manifest themselves after the training, this might have been too short. Future studies should include a longer follow-up period, at least a week or preferably even longer. Another limitation is that the study sample consisted almost exclusively of Caucasian female psychology students, which limits the generalization of the results to a more heterogeneous community or patient. Although we did select only students with heightened levels of event centrality, their scores did not reach levels that have been found in PTSD patients. However, our highly intellectual sample could also have caused small effect sizes, because it might have vanished any variance in response. Future studies should determine whether larger effect sizes could be obtained in a clinical sample. As this was a first attempt to test causality

with a new training, we used healthy participants instead of clinical participants. When longer-term beneficial effects can be found in future studies, it will be worth testing whether this causal relationship could also be found in a clinical or subclinical population.

To conclude, this is the first study, to our knowledge, that tested the effect of a new CBM-App training to change appraisals of event centrality and to test the causal relation with PTSD symptoms. The centrality CBM-App training was successful in decreasing appraisals of event centrality as measured with the CES. However, no effects were found on PTSD symptoms in this short-term follow-up period. Future studies should lengthen the follow-up time and possibly repeat the training in intervals. In line with results from studies with clinical populations, the relation between event centrality and PTSD symptoms was mediated by negative cognitions and rumination (but not worry). This gives validity to studying event centrality in a student population as a first step towards research in a clinical population.

Compliance with Ethical Standards

Conflict of Interest Mirjam Vermeulen, Adam D. Brown, Filip Raes and Julie Krans have stated that they have no potential conflict of interest pertaining to this submission to Cognitive Therapy and Research.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

Animal Rights This article does not contain any studies with animals performed by any of the authors.

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