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Imagining trauma: Memory amplification and the role of elaborative cognitions

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Abstract

Background and objectives: Trauma victims, such as war veterans, often remember additional traumatic events over time: the “memory amplification effect”. This effect is associated with the re-experiencing symptoms of post-traumatic stress disorder (PTSD), including frequent and intrusive images of the trauma. One explanation for memory amplification is that people gradually incorporate new, imagined information about the trauma with what they actually experienced, leading to an amplified memory for what actually happened. We investigated this proposal here. *Methods:* Participants viewed highly negative and graphic photographs and recorded their intrusions. Critically, we instructed some participants to elaborate on their intrusions—that is, we asked them to imagine details about the trauma beyond what they actually witnessed. We assessed memory for the traumatic photos twice, 24-hours apart. *Results:* The elaboration condition experienced fewer intrusions about the photos compared to the control condition. Furthermore, the elaboration condition were less susceptible to memory amplification compared to controls. *Limitations:* The use of negative photos allowed experimental control, however does not permit generalization of our findings to real-world traumatic experiences. *Conclusions:* Our findings suggest that *effortful* imagination of new trauma-related details leads to a reduction in intrusions and an increased tendency to *not* endorse trauma exposure over time. One explanation for this finding is that elaboration enhanced conceptual processing of the trauma analogue, therefore reducing intrusions. Critically, this reduction in intrusions affected participants’ tendency to endorse trauma exposure, which is consistent with the reality-monitoring explanation for memory amplification.

Keywords: PTSD; memory; intrusions; trauma analogue

1. Introduction

Trauma survivors—such as veterans—can be inconsistent when remembering past events, usually by remembering *additional* traumatic events (civilian death) over time—termed the "memory amplification" effect (Southwick, Morgan, Nicolaou, & Charney, 1997). Memory amplification is associated with the re-experiencing symptoms of post-traumatic stress disorder (PTSD), including intrusive trauma-related images (Roemer, Litz, Orsillo, Ehlich, & Friedman, 1998). People with PTSD also often experience involuntary elaborative non-memories (thoughts or images about non-experienced event details; Reynolds & Brewin, 1998), such as mental imagery from similar events witnessed in the media. Thus, one explanation for amplification is that people gradually incorporate imagined trauma-related information into their memory, causing difficulty in distinguishing experienced and non-experienced events and a tendency to endorse exposure to non-experienced events. Accordingly, enhancing imagination of trauma-related details should also encourage memory amplification. We investigated this proposal.

The memory amplification effect arises in diverse samples, including 9/11 disaster restoration workers (Giosan, Malta, Jayasinghe, Spielman, & Difede, 2009) and witnesses to a school shooting (Schwarz, Kowalski, & McNally, 1993). For example, Giosan and colleagues asked 9/11 restoration workers whether they experienced (yes/no) stressful events (seeing human remains), on two occasions one year apart. Workers answered "yes" more often at the second assessment and this increase was associated with PTSD symptom severity. Other studies have replicated the typically small, but significant relationship between PTSD symptoms and number of no-to-yes changes, including correlation coefficients of 0.26 [0.22, 0.30] (King et al., 2000) and 0.32 [0.17, 0.60] (Southwick et al., 1997). Importantly, this relationship is usually stronger when focusing on re-experiencing symptoms exclusively (Giosan et al., 2009; Roemer et al., 1998).

Although field research suggests PTSD may contribute to memory amplification, these studies cannot test the mechanism(s) underlying this association. Recently, we investigated the memory amplification effect in the laboratory (Oulton, Takarangi, & Strange, 2016). Participants viewed negative photos (e.g., mutilation) and then completed two recognition tests—identifying photos as "old" (previously seen) or "new" (previously unseen)— one week apart. Participants' ability to distinguish old and new photos (i.e., their sensitivity) decreased over time. Further, among participants exhibiting memory amplification—responding "old" to more photos over time—re-experiencing symptoms were associated with memory amplification (r=-.28, *95%* CI [-0.48, -.05]).

One possibility is that re-experiencing symptoms *causally* contribute to memory amplification (King et al., 2000; Strange & Takarangi, 2012). Specifically, people might mistake information they imagine—via re-experiencing symptoms—with what actually occurred. Indeed, people commonly determine a memory's origin using heuristics (familiarity; Johnson, Hashtroudi, & Lindsay, 1993) and if internally-generated information is familiar and vivid, people can mistake this information as a memory of a true experience (Johnson et al., 1993). Memory amplification may reflect an accumulation of these errors. Consider, for example, a veteran who frequently experiences intrusions that include details he did not actually experience during service. These cognitions may encourage an impression that he experienced many distressing experiences during service. Consequently, when asked about his trauma exposure, he might experience difficulty distinguishing experienced and non-experienced events and endorse exposure to non-experienced events that are only vaguely familiar. Put differently, due to reality-monitoring errors, the veteran might lower his response criterion (how much evidence required to endorse trauma exposure) because he assumes the probability of exposure is higher than reality, and his memory accuracy might decline. Indeed, supporting the reality-monitoring explanation, intrusions often contain imagined details. People sometimes experience "worst case scenario" intrusions (Merckelbach, Muris, Horselenberg, & Rassin, 1998) that are exaggerated trauma-related, image-based cognitions and cognitions involving plausible extensions of the trauma (Reynolds & Brewin, 1998).

Yet no research has investigated the reality-monitoring explanation experimentally. Further, intrusions could cause memory amplification via several pathways. For example, intrusions might motivate people to justify their distress, causing a liberal response bias. Alternatively, the internal generation of new details *per se* might cause amplification. We investigated the latter possibility here. Specifically, we examined whether *elaborating* on intrusions about graphic photos—imagining details beyond what was witnessed—would enhance memory amplification. We anticipated this process would increase the opportunity for reality-monitoring errors, thereby encouraging memory amplification.

To test this prediction, following Oulton et al. (2016), participants viewed negative photos and, later completed a recognition test on two occasions, 24 hours apart. However, some participants received instructions encouraging imagination of new, trauma-related information between these memory tests.

2. Method

2.1 Participants

We predetermined a target sample size of at least 48 participants per condition, which we rounded to at least 50; a precision analysis (Cumming, 2013) revealed this sample size was sufficient to obtain a target margin of error (the half width of the target confidence interval) of 0.4, based on an estimated medium effect (d=0.50). Overall, 126 participants completed the study. We excluded two participants who completed the second test more than

60 hours after the first test, 13 who did not experience intrusions[1], two who misinterpreted instructions and three who inadvertently received the wrong test or diary. Thus, our final sample consisted of 106 participants (35.8% male); 75 university students, who received course credit or an honorarium and 31 community members who received an honorarium. Participants were aged 18-56 (*M*=24.85, *95% CI* [23.14, 26.56]); most identified as Caucasian (including White; 66.0%); others as Asian (11.3%), mixed ethnic origin (6.6%), European (5.7%), Hispanic (4.7%), African (1.9%) or Other (3.8%).

2.2. Materials

2.2.1. Trauma Analogue.

We selected 70 IAPS photographs (Lang, Bradley, & Cuthbert, 2008) and 10 additional photos (Krans, Langner, Reinecke, & Pearson, 2013) of negative scenes (mutilation) and divided them into four sets of 20 target photos (see Oulton et al., 2016) matched on valence and category membership; how well each photo matched the overall "theme" of the photos (*F*s < 1). Participants saw two sets (40 target photos) at encoding. Photos appeared for 500ms on five, randomly timed, occasions during encoding. Thus, each photo appeared for 2.5 seconds total. An additional 20 negative photos—10 IAPS photos and 10 photos from Krans et al.—acted as primacy and recency buffers (same for every participant), presented only once for 500ms, and never appeared at test. Sets were counterbalanced across participants such that each combination was presented equally.

2.2.2. Trauma History Screen (THS).

We administered the THS (Carlson et al., 2011) to assess exposure to high magnitude stressor (HMS) events (sudden events that cause extreme distress in most people exposed), traumatic stressor (TS) events (HMS events associated with extreme distress) and events associated with persisting posttraumatic distress (PPD events). The THS has excellent

[1] To ensure all participants within the elaboration condition were exposed to the experimental manipulation, across both conditions we included only participants who reported at least one intrusion during either the monitoring period or 24-hour delay.

temporal stability (HMS events: *r*= 0.93; PPD events: *r*=0.73) and strong convergent validity (Carlson et al., 2011). After completing the THS, participants completed the PTSD checklist for DSM-5 (Weathers et al., 2013) in relation to their most distressing event. In the current study, Cronbach's alpha for PCL-5 scores was .93.

2.2.3. Beck Depression Inventory (BDI-II).

We used the 21-item BDI-II (Beck, Steer, & Brown, 1996) to measure depression symptoms experienced during the past two weeks. Participants rated items on a Likert scale (0=*I do not feel like a failure*, 3=*I feel I am a total failure as a person;* range: 0–63). Internal consistency (*a*=0.93; Beck et al., 1996) and construct validity among university students (Oliver & Burkham, 1979) is good. Cronbach's alpha for BDI-II scores was .90 for our study sample.

2.2.4. State-Trait Anxiety Inventory-Trait Scale (STAI-T).

We used the 20-item STAI-T (Spielberger, Gorsuch, & Lushene, 1970) to measure participants' stable propensity to experience anxiety. Participants rate items ("*I feel nervous and restless*") from 1 (*almost never*) to 4 (*almost always*) (range: 20–80). Test-retest reliability (*r*=0.88) (Barnes, Harp, & Jung, 2002) and concurrent validity with other anxiety questionnaires is good (Spielberger, 1983). Internal consistency was high for our study sample (Cronbach's alpha=.91)

2.2.5. Global Rumination Scale (GRS).

The GRS (McIntosh & Martin, 1992) measures a predisposition toward repetitive thought. Because people's trait tendency to ruminate might influence how they elaborate on intrusions, we wanted to ensure our conditions were equivalent. Participants rated 10 statements ("*When I have a problem I tend to think of it a lot of the time*") from 1 (*does not describe me well*) to 7 (*describes me well*). The scale has adequate test-retest reliability (*r*=.78) and correlates significantly with anxiety measures (Segerstrom, Tsao, Alden, &

Craske, 2000). Previous research (Segerstrom et al., 2000) among undergraduate students has revealed a Cronbach's alpha of .66 for GRS scores. For our study sample, Cronbach's alpha was .69.

2.2.6. Positive Affect Negative Affect Schedule (PANAS).

We used the 20-item PANAS (Watson, Clark, & Tellegen, 1988) to measure participants' positive affect (PA) and negative affect (NA). Participants rated each item (e.g., "afraid") according to how they felt at the present moment (1=*Very slightly or not at all*, 5=*Extremely*). The measure has excellent temporal stability (NA: r=0.81, PA: r=0.79) and convergent and divergent validity (Watson et al., 1988). In the current study, Cronbach's alpha for Positive Affect was .89 and .86 before and after photo exposure, respectively. Cronbach's alpha for Negative Affect was .83 and .87, respectively.

2.2.7. Intrusion monitoring task.

We instructed participants to close their eyes and "think about whatever [they] like[d]" for 10 minutes after encoding. We also told participants to press a computer key whenever they experienced an intrusion during this period (Kubota, Nixon, & Chen, 2015). We described intrusions as recollections of the photographs that appeared *involuntarily* in consciousness. Immediately after every key press, we prompted participants to describe the intrusion in a booklet and then close their eyes again. We asked participants to limit their description to one sentence. The time participants spent describing their intrusions was included within the 10-min time limit. Thus, the task terminated after 10-min, regardless of how long participants spent describing their intrusions. At the end, participants rated their intrusions (overall) on: vividness, associated distress and degree of visual detail (1=*not at all*, 5=*extremely*) and how hard they tried to push intrusions out of their mind, how much the experience felt like it was happening "right now", how aware they were of their surroundings, and how much intrusions occurred out of the blue (1=*not at all*, 5=*completely*).

2.2.8. Recognition test.

The recognition tests consisted of three sets of 20 photos: one set of "Old" (previously presented) negative photos and two sets of "New" (previously unseen) photos. One set of New photos were neutrally valenced IAPS photos—to check participants were attending to test items—and the other was a target negative photo set that was never previously shown. Test items appeared in a random order. Participants identified each photo as old or new and indicated their confidence (0=*not at all confident*, 10=*extremely confident*).

We constructed 12 different versions of the test, counterbalanced so every target photo appeared equally often as 'new' and 'old' across participants. Test items presented at T2 were completely different to test items presented at T1. Therefore, incorrect identifications at T2 could not reflect participants mistaking photos from the first test as originating from encoding.

2.2.9. Elaboration Exercise.

After the T1 test, the experimenter read aloud the elaboration exercise instructions to participants in the elaboration condition who experienced intrusions during the monitoring period. We designed our instructions to encourage internal generation of details beyond what the photos displayed, and concrete thinking (distinct and situationally specific thoughts) rather than abstract thinking (indistinct and cross-situational thoughts; Stöber & Borkovec, 2002) which is associated with rumination and worry (Watkins & Moulds, 2005). Specifically, the experimenter instructed participants to "*imagine that you are present at the scene you have pictured*" and "*form a mental image of the specific events*" that could have occurred beforehand and afterwards. See Appendix A for full instructions.

Participants completed the elaboration task for every recorded intrusion and described what they imagined. However, when participants reported multiple intrusions with the same content, they completed the exercise only once for that specific intrusion. Elaboration participants who experienced no intrusions (*N*=8) received the intrusion diary (which included the elaboration exercise) after completing the first test.

2.3.10. Intrusion diary.

Participants recorded intrusions in a paper diary for 24-hours after leaving the lab. For each intrusion, participants recorded the intrusion's content and indicated the type (image, thought or combination) on a single page. Participants also rated (1=*not at all*, 5=*extremely/completely*) the level of associated distress, vividness, how hard they tried to push it out of their mind, how much it felt as though the experience was happening "right now", awareness of current surroundings, how "out of the blue" the intrusion was, and how much the accompanying emotions reflected the emotions experienced at the time they viewed the photos. Diaries given to elaboration participants also included the elaboration exercise on the back of each page, which they were instructed to fill out immediately after experiencing each intrusion.

2.2.11. PTSD Checklist (PCL).

We used the PCL for DSM-IV (Weathers, Litz, Herman, Huska & Keane, 1993) to assess participants' analogue PTSD symptoms in relation to the photos after completing the first memory test[2] and again, 24 hours after encoding. We used the PCL-IV because we thought the items were more applicable to experiences following a trauma analogue relative to some items in the PCL for DSM-5 ("*blaming yourself or someone for the stressful experience or what happened after it*"). Participants rated how much 17 items ("*feeling jumpy or easily startled*," 1=*not at all*, 5=*extremely*; range: 17-85) bothered them *since viewing the photos*. The PCL has high test-retest reliability (*r*=.96; Weathers et al., 1993) and correlates strongly with the Clinician Administered PTSD Scale (*r*=.93; Blanchard, Jones-

[2] We omitted 5 items, because they are meaningless for a 20-minute delay period (i.e., "*repeated, disturbing dreams or nightmares* ", "*trying to avoid activities, people or places that remind you of the traumatic event*", "*loss of interest in things that you used to enjoy*", "*trouble falling or staying asleep*" and "*feeling distant or cut off from other people*"), thus the revised scale consisted of 12 items (see also Monds, Paterson, Kemp, & Bryant, 2013)

Alexander, Buckley, & Forneris, 1996). For our study sample, Cronbach's alpha was .86 and .90 at Test 1 and Test 2, respectively.

2.2.12. Experience of Intrusions Scale (EIS).

We used the 5-item EIS (Salters-Pedneault, Vine, Mills, Park, & Litz, 2009) to assess the frequency, unwantedness and unpredictability of participants' intrusions over the 24-hour delay. Participants rated items ("*how distressed were you when these thoughts came to mind?*") from 0 (*not at all/almost never*) to 4 (*extremely/very frequently*). The EIS has good test-retest reliability (*r*=.83) and correlates with other intrusion measures, including the re-experiencing subscale of the PCL-C (Weathers et al., 1993; *r*=.22). Cronbach's alpha was .83 for our study sample.

2.2.13. Response to Intrusions Questionnaire (RIQ).

We administered the rumination subscale of the RIQ (Clohessy & Ehlers, 1999) to assess rumination about intrusions. Participants rated how often they engaged in three behavioural and cognitive strategies ("*I dwell on them*") when experiencing intrusions about the photos during the 24-hour delay (1=*not at all*, 7=*very often*). Participants selected '0' if they experienced no intrusions. The rumination subscale of the RIQ correlates significantly with PTSD symptoms (*r*=.51), as measured by the Post-traumatic Stress Symptom Scale (PSS; Foa, Riggs, Dancu & Rothbaum, 1993). Previous research among ambulance service workers has revealed low internal consistency for this short scale (*a* = .31; Clohessy & Ehlers, 1999). Cronbach's alpha was higher for our study sample (*a* = .73).

2.3. Procedure

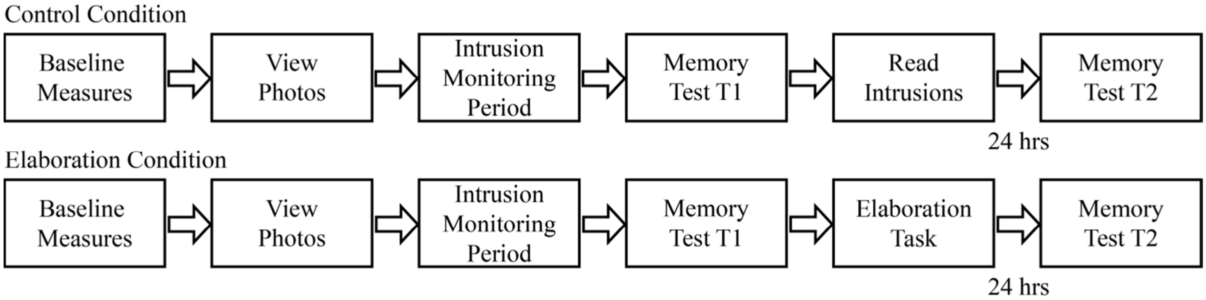
This research was approved by the Flinders University Social and Behavioural Research Ethics Committee and the City University of New York's University Integrated Institutional Review Board, and conducted in accordance with the provisions of the World Medical Association Declaration of Helsinki. We warned potential participants that participation involved viewing graphic photos. To minimize hypothesis guessing, we told participants that the study investigated the effect of self-relevance on responses to emotional material.

Participants first completed measures of trauma history, PTSD, depression, trait anxiety, rumination and mood, respectively. Next, they viewed the buffer and target photographs on a computer. We then asked participants "*how closely did you pay attention to the photos presented?*" (1=*not at all*, 7=*extremely closely).* Participants also rated how disgusting, distressing and unpleasant the photos were (1=*not at all*, 7=*extremely*) and completed the mood measure again. Next, participants completed the intrusion monitoring task, followed by the recognition test and the modified PCL. If participants from either condition reported no intrusions during the monitoring period, we then gave them the paper diary and accompanying instructions. Alternatively, if the participant experienced intrusions and was in the elaboration condition, they completed the elaboration exercise. To control for additional exposure to intrusion descriptions, we asked participants in the control condition who experienced intrusions to read their monitoring period booklet and alert the experimenter once they had finished. After completing this exercise, participants received the diary and accompanying instructions.

We emailed participants a survey link that contained the PANAS, the delayed recognition test, the EIS, PCL and RIQ, respectively, 24-hours after the lab session. We also asked participants whether they had voluntarily thought or spoken about the photos over the 24-hour period. If they responded yes, participants indicated frequency (1=not at all, 5=nearly all the time). We then debriefed participants.

Our data can be found on the Open Science Framework (OSF) at https://osf.io/vtdx8/.

Figure 1. Illustration of procedure for the control condition and the elaboration condition.



3. Results & Discussion

3.1 Sample Characteristics

We first compared conditions on demographics, existing symptomology and trauma history. Age, gender and ethnicity did not significantly differ between conditions (*ps*>.05). Table 1 displays descriptive and inferential statistics for existing symptomology measures and trauma history[3]. Again, there were no significant differences.

[3] Because some participants who endorsed exposure to repeated stressors (e.g., childhood abuse) reported extremely high HMS levels we transformed this data using Winsorization. We used a 95th percentile Winsorization in which outliers beyond the 95th percentile in a set of scores are replaced by the score for the 95th percentile (see Carlson et al., 2011).

Table 1.

Baseline measures administered before manipulation by experimental condition, including means (with 95% confidence intervals), and inferential statistics.

	Control	Elaboration	Statistic
HMS (t)	5.35[3.23, 7.47]	6.25[3.97, 8.52]	*t*(103)=.58, *p*=.56, *d*=0.14 [-0.27, 0.50]
TS	1.51[1.26, 1.76]	1.88[1.57, 2.19]	*t*(103)=1.88, *p*=.063, *d*=0.37 [-0.02, 0.75]
PPD	0.73[.50, .95]	0.72[.48, .96]	*t*(103)=0.05, *p*=.96, *d*=0.01 [-0.37, 0.39]
PCL-5	23.07[19.07, 27.08]	24.82[20.21, 29.44]	*t*(104)=0.58, *p*=.57, *d*=0.11 [-0.27, 0.49]
STAI-T	46.67[44.20, 49.14]	50.24[47.13, 53.34]	*t*(104)=1.82, *p*=.072, *d*=0.35 [-0.03,0.74]
BDI-II	13.96[11.68, 16.25]	16.12[13.08, 19.15]	*t*(94.73)=1.14, *p*=.26, *d*=0.22 [-0.16,0.61]
GRS	49.87[47.83, 51.92]	51.06[48.62, 53.49]	*t*(104)=0.75, *p*=.45, *d*=0.15 [-0.24,0.53]

Note. HMS (t) =High Magnitude Stressor Exposure (scores transformed using Winsorization), TS=Traumatic Stressor Exposure, PPD=Persisting Posttraumatic Distress Events Exposure, PCL-5= PTSD checklist for DSM-5 (in relation to most distressing event), STAI-T=Trait Subscale of State Trait Anxiety Inventory, BDI-II=Beck Depression Inventory, GRS= Global Rumination Scale

3.2 Emotional Impact of Photos

To determine whether the images were an effective trauma analogue, we analyzed participants' photo ratings, change in affect after photo exposure and analogue PTSD symptoms (see Table 2). Participants rated the photos as very unpleasant, disgusting, and moderately distressing, and reported paying close attention. There were no differences between conditions (*p*s>.05).

Next, we compared positive and negative affect scores before and after encoding, using 2 (Elaboration, Control) x 2 (Time 1, Time 2) mixed ANOVAs. Main effects of condition and interactions between condition and time were not significant (*p*s>.05). However, there were significant main effects of time for positive (F(1, 104)=117.90, p<.001, η_p^2= .53, 95% *CI* [.40, .63]) and negative (F(1, 104)=124.30, p<.001, η_p^2=.54 [.41, .64]) affect. Positive affect significantly decreased (*d*=1.00 [0.78, 1.23]), and negative affect significantly increased following encoding, *d*=1.11 [0.86, 1.35].

Table 2.

Means (with 95% confidence intervals) for photo ratings, affect and analogue PTSD symptoms by experimental condition

	Control	Elaboration
Photo Ratings (before manipulation)		
Unpleasant	5.80 [5.43, 6.17]	5.65 [5.22, 6.07]
Distress	4.73 [4.32, 5.14]	4.41 [3.92, 4.91]
Disgust	5.71 [5.27, 6.15]	5.47 [5.03, 5.91]
Attention	5.64 [5.34, 5.94]	5.82 [5.47, 6.17]
Affect (before manipulation)		
PA before photos	29.13 [27.16, 31.09]	27.57 [25.36, 29.78]
PA after photos	20.58 [18.56, 22.60]	21.51 [19.65, 23.37]
NA before photos	16.16 [14.73, 17.59]	16.16 [14.58, 17.73]
NA after photos	24.67 [22.71, 26.64]	22.33 [20.07, 24.60]
PCL Time 1 (before manipulation)		
Total	25.69 [23.61, 27.77]	25.00 [22.39, 27.61]
Intrusions	9.84 [8.83, 10.85]	9.61 [8.41, 10.80]
Arousal	7.89 [7.09, 8.69]	7.49 [6.50, 8.47]
Avoidance	7.96 [7.21, 8.72]	7.90 [7.13, 8.67]
PCL Time 2 (after manipulation)		
Total	27.03 [24.95, 29.11]	27.89 [24.56, 31.22]
Intrusions	8.49 [7.60, 9.39]	8.53 [7.41, 9.65]
Arousal	7.61 [6.85, 8.37]	8.10 [6.80, 9.40]
Avoidance	10.93 [10.04, 11.81]	11.26 [9.90, 12.63]

Note. PA: positive affect, NA: negative affect, PCL: PTSD Checklist for DSM-IV

Finally, we compared PCL scores after T1 and T2[4], using a 2 (Elaboration, Control) x 2 (Time 1, Time 2) mixed ANOVA. There was a significant main effect of time: PCL scores were higher at T1 (*M*=25.36, *95% CI* [23.73, 26.99]) compared to T2[5] (*M*=20.72 [19.26, 22.18]), $F(1, 104)=48.82$, $p<.001$, $\eta_p^2=.32$ [.18, .44]. It is likely the first PCL captured initial symptoms and reactions, which later subsided. There was no significant main effect of

[4] Three participants had missing data for one PCL item at T2. We substituted these missing values with the mean of all valid items on the PCL subscale for that participant.

[5] Note, however, that the PCL we administered at T2 contained 5 more items than the modified PCL administered at T1. We therefore excluded these additional items when computing total PCL scores at T2 for this analysis.

condition or interaction between condition and time, suggesting elaboration did not affect overall analogue PTSD symptoms (*ps*>.05).

3.3 Intrusions

We measured intrusions in three ways: during the 10-minute monitoring period (prior to our manipulation), during the 24-hour delay period and after T2 using the EIS. We wondered whether elaboration would encourage intrusions about the photos, and/or alter intrusion characteristics at the two later time points. We therefore compared our conditions on intrusion frequency and characteristics at each time point.

There was large variation in intrusion frequency during the monitoring period (*M*=3.23 *95% CI* [2.71, 3.74], *range:* 0-14); some participants (Elaboration: *N*=8; Control: *N*=4) experienced no intrusions[6]. Of those who experienced intrusions, many (48.9%) indicated that most were images, 4.3% said primarily thoughts and 45.7% indicated they were mainly a combination of images and thoughts. Table 3 displays intrusion frequency and characteristic ratings by condition. Importantly, intrusion frequency and characteristics did not significantly differ between conditions prior to the manipulation (*p*s >.05). However, there was a non-significant trend for the elaboration condition to report fewer intrusions during the monitoring period compared to the control condition.

Next, we examined whether elaboration encouraged participants to ruminate on their intrusions and/or voluntarily think or talk about the photos. But conditions were comparable on the Response to Intrusions Questionnaire scores (*p*=.64) and the percentage of participants who indicated voluntarily thinking or talking about the photos did not significantly differ between the control (59.3%) and elaboration conditions (62.7%), χ^2 (1)=0.13, *p*=0.71, φ= 0.04.

[6] Although 8 participants from the elaboration condition did not experience any intrusions during the monitoring period—and therefore did not complete the elaboration exercise in the lab—recall the experimenter still instructed *all* participants from the elaboration condition to complete the exercise for intrusions experienced during the 24-hour delay.

Finally, we examined intrusions experienced during the 24-hour delay, following exposure to the elaboration manipulation. Mean intrusion frequency was 2.12, *95% CI* [1.75, 2.49], *range*: 0-10). Nineteen participants did not experience intrusions (Control: *N*=9, Elaboration: *N*=10). Interestingly, although intrusion characteristics were comparable across conditions, the elaboration condition reported significantly *fewer* intrusions and scored significantly lower on the EIS—which measures the frequency, unwantedness and unpredictability of participants' intrusions—relative to control participants (see Table 3). To ensure the intrusion frequency difference was not driven by pre-existing group differences on factors predisposing people to intrusions, we examined the effect of condition on diary intrusion frequency after statistically controlling for monitoring period intrusion frequency, trait anxiety and trauma exposure. An ANCOVA showed the effect of condition on intrusion frequency remained statistically significant, $F(1, 100)=4.13$, $p=.045$, $\eta_p^2=.04$ [.00, .14]. Taken together, these findings suggest elaboration caused a significant—albeit small—reduction in intrusion frequency.

Table 3

Comparison of mean involuntary cognition frequency, involuntary cognition characteristic ratings, and EIS scores between the control and elaboration condition.

	Elaboration	Control	Statistic
Before Manipulation			
Frequency (MP)	2.75 [2.05, 3.44]	3.67 [2.91, 4.44]	*t*(104)=1.79, *p*=.08, *d*=0.35 [-.04, 0.73]
Characteristics (MP)			
Distress	3.05 [2.67, 3.43]	2.84 [2.53, 3.15]	*t*(92)=0.84, *p*=.40, *d*=0.18 [-0.23, 0.58]
Vividness	3.19 [2.88, 3.50]	3.29 [3.01, 3.58]	*t*(92)=0.52, *p*=.61, *d*=0.11 [-0.30, 0.51]
Suppression	3.70 [3.33, 4.06]	3.80 [3.43, 4.18]	*t*(92)=0.41, *p*=.69, *d*=0.08 [-0.32, 0.49]
Here and Now	1.81 [1.50, 2.13]	2.04 [1.73, 2.35]	*t*(92)=1.01, *p*=.31, *d*=0.21 [-0.20, 0.62]
Aware	3.26 [2.83, 3.68]	3.22 [2.83, 3.60]	*t*(92)=0.14, *p*=.89, *d*=0.03 [-0.38, 0.44]
Out of the Blue	3.33 [3.02, 3.63]	3.27 [2.99, 3.56]	*t*(92)=0.25, *p*=.81, *d*=0.05 [-0.36, 0.46]
Visual Detail	3.42 [3.07, 3.76]	3.57 [3.27, 3.86]	*t*(92)=0.67, *p*=.50, *d*=0.14 [-0.27, 0.55]
After Manipulation			
Frequency (D)	1.67 [1.25, 2.09]	2.55 [1.96, 3.13]	*t*(104)=2.45, *p*=.016, *d*=0.47 [0.08, 0.85]
Characteristics (D)			
Distress	2.74 [2.39, 3.08]	2.92 [2.58, 3.26]	*t*(85)=0.76, *p*=.45, *d*=0.16 [-0.26, 0.58]
Vividness	3.15 [2.85, 3.44]	3.21 [2.89, 3.52]	*t*(85)=0.28, *p*=.78, *d*=0.06 [-0.36, 0.48]
Suppression	3.21 [2.82, 3.61]	3.56 [3.20, 3.92]	*t*(85)=1.33, *p*=.19, *d*=0.29 [-.14, 0.71]
Here and Now	1.84 [1.57, 2.10]	1.88 [1.59, 2.16]	*t*(85)=0.20, *p*=.84, *d*=0.04 [-0.38, 0.47]
Aware	4.12 [3.84, 4.41]	3.71 [3.41, 4.02]	*t*(85)=1.97, *p*=.052, *d*=0.42 [-0.003, 0.85]
Out of the blue	3.35 [2.98, 3.72]	3.15 [2.81, 3.49]	*t*(85)=0.81, *p*=.42, *d*=0.17 [-0.25, 0.59]
Emotional	3.02 [2.70, 3.34]	2.96 [2.63, 3.28]	*t*(85)=0.27, *p*=.79, *d*=0.05 [-0.36, 0.48]
EIS score	5.80 [4.78, 6.82]	7.18 [6.24, 8.13]	*t*(104)=1.99, *p*=.049, *d*=0.39 [0.001, 0.77]
RIQ score	8.13 [6.85, 9.40]	8.53 [7.33, 9.73]	*t*(82)=0.47, *p*=0.64, *d*=0.10 [-0.33, 0.53]

Note. EIS: Experience of Intrusions Scale, RIQ: Response to Intrusions Questionnaire, MP: Monitoring Period, D: Diary

How do we explain elaboration causing a small *reduction* in intrusions? Information-processing theories argue that when people fail to integrate sensory-based trauma representations (the sights) with their conceptual event representations (the event's meaning), intrusions occur. According to Ehlers and Clark (2000), persistent PTSD occurs when a trauma memory is poorly contextualized, and intrusions will reduce when the trauma's meaning is processed in an organized way. The elaboration task may have encouraged conceptual processing, therefore reducing intrusions. Indeed, some manipulations designed to interfere with conceptual processing—a concurrent verbal task when watching a trauma analogue—enhance intrusions (Bourne, Frasquilho, Roth, & Holmes, 2010; Holmes, Brewin, & Hennessey, 2004). However, several studies have found no effect or a decrease in intrusions following similar conceptual processing manipulations (Krans, Naring, & Becker, 2009; Pearson, Ross, & Webster, 2012), casting doubt on this explanation.

Alternatively, some PTSD theories argue perceptual priming and fear conditioning cause intrusions (Michael, Ehlers, & Halligan, 2005; Rothbaum & Davis, 2003). According to the fear conditioning account, a trauma (the unconditioned stimulus) triggers an unconditioned fear response. This unconditioned response becomes associated with cues related to the unconditioned stimulus, such as objects present during the trauma. Consequently, these cues can cause similar responses to the unconditioned response (the conditioned response), including intrusions. Thus, one possibility is that elaborating caused more specific—and easily distinguished—memory traces for the photos. The range of associations between the photos and certain cues may have been narrower, relative to control participants who may have had quite general memories of the photos. Indeed, this outcome would mean elaboration participants were less sensitive to intrusions when encountering cues compared to controls.

Importantly, although we cannot determine the precise mechanism from these data, we can use this unintended intrusion manipulation to test the reality-monitoring explanation: fewer intrusions should cause less memory amplification and memory distortion due to less opportunity for reality-monitoring errors. Thus, the elaboration condition should show less memory amplification and memory distortion, relative to control participants. Next, we test this assumption.

3.4 Memory Test Performance

We aimed to test whether elaboration of intrusions would affect participants' tendency to respond "old" to test items over time (memory amplification) and their ability to distinguish between old and new photos over time (sensitivity). To separate sensitivity from response bias, we used a signal detection method (Stainslaw & Todorov, 1999). We classified old photos as signal events and new, negative photos as noise events: identifying an old photo as "old" was coded as a hit, and identifying a new negative photo as "old" was coded as a false alarm. We calculated signal detection measures *d'* and *c*, where *d'* denotes sensitivity and *c* denotes response bias. Note that $c < 0$ represents a response bias toward responding "old," and $c > 0$ indicates a response bias toward responding "new". Increasing *d'* values indicate a greater ability to distinguish old test items from new test items. We compared sensitivity and response bias before and after the elaboration manipulation, using 2 (Elaboration, Control) x 2 (Time 1, Time 2) mixed ANOVAs.

For sensitivity, there was a significant main effect of time; participants were worse at distinguishing between old and new photos at T2 (M=1.27, *95% C*I [1.16, 1.37]) compared to T1 (M=1.87, [1.71, 2.02]]), $F(1, 104)=69.09$, $p<.001$, $\eta_p^2=.40$ [.26, .51]. However, there was no significant main effect of condition ($F(1, 104)=.13$, $p=.72$, $\eta_p^2=.001$ [.00, .05]), or interaction between condition and time ($F(1, 104)=0.92$, $p=.34$, $\eta_p^2=.009$ [.00, .07]), suggesting that elaboration did not affect sensitivity.

For response bias, there was a significant main effect of time, $F(1, 104)=27.74$, $p<.001$, $\eta_p^2=.21$, *95% CI* [.09, .34]. Like previous research (Oulton et al., 2016), participants became *less* biased to respond "old" to the photos at T2 (M=-0.02 [-.13, .10]) compared to T1 (M=-0.25 [-.35, -.15]). Although there was no significant main effect of condition ($F(1, 104)=0.26$, $p=.61$, $\eta_p^2=.002$ [.00, .05]), there was a significant interaction[7] between condition

[7] Note that when we excluded participants who completed Test 2 more than 36 hours after Test 1 the interaction effect was stronger $F(1, 92)=7.63$, $p=.007$, $\eta_p^2=.08$ [.01, .19]. Similarly, when we excluded participants who did not experience any intrusions during the monitoring period, the interaction effect was also slightly stronger, $F(1, 92)=4.69$, $p=.033$, $\eta_p^2=.05$ [.00, .15].

and time, $F(1, 104)=4.48$, $p=.037$, $\eta_p^2=.04$ [.00, .14]. Specifically, elaboration participants showed a greater change in response bias towards saying "new" to the items over time (T1: *M*=-.33[-.48, -.18]] T2; *M*=.01 [-.17, .19]; $t(50)=4.97$, $p<.001$, $d=0.57$ [0.32, 0.83]) compared to control participants (T1: *M*= -.18[-.31, -.05] T2; *M*=-.04 [-.20, .12]; $t(54)=2.34$, $p=.023$, $d=0.27$ [0.04, 0.50].

3.5 Memory Confidence

We compared mean confidence scores for Old and New test items before and after the elaboration manipulation, using a 2 (Elaboration, Control) x 2 (Time 1, Time 2) mixed ANOVAs. There was a significant main effect of time for old photos; confidence significantly reduced over time (T1: *M*=8.85 [8.69, 9.01], T2: *M*=8.24 [7.99, 8.49]), $F(1, 104)=35.36$, $p<.001$, $\eta_p^2=.25$; but not for new photos (T1: *M*=7.55 [7.25, 7.86], T2: *M*=7.68 [7.39, 7.96]), $p>.05$. Indeed, false alarm rates did not significantly differ across time ($t(105)=1.18$, $p=.24$), which may explain this finding. Critically there were no significant main effects of condition or interactions between condition and time for both old and new photos (*ps*>.05).

3.6 Memory Amplification and Analogue Symptoms

We examined whether PTSD symptoms and intrusions were positively related to memory amplification and whether the presence and/or strength of these relationships would depend on whether intrusions were elaborated on. We calculated a change in response bias (or memory amplification) score by subtracting c scores at T2 from scores at T1. Positive values represented becoming more biased to respond "new", and negative values represented becoming more biased to respond "old" (memory amplification). We then correlated this variable with symptom measures and baseline characteristics for both conditions separately. Table 4[8] shows the results.

Table 4.

Correlations (and 95% CIs) between memory amplification and baseline characteristics, analogue symptoms, involuntary cognitions and voluntary thinking in the control and elaboration condition.

	Memory Amplification		
	Control	Elaboration	Total Sample
Baseline Characteristics			
HMS	-.04 (*N*=55)	-.17 (*N*=50)	-.09 (*N*=105)
TS	-.27* (*N*=55)	-.20 (*N*=50)	-.19 (*N*=105)
PPD	-.08 (*N*=55)	-.09 (*N*=50)	-.08 (*N*=105)
PCL-5	-.31*(*N*=55)	-.23 (*N*=51)	-.25**(*N*=106)
STAI-T	-.19 (*N*=55)	-.14 (*N*=51)	-.10 (*N*=106)
BDI-II	-.18 (*N*=55)	-.10 (*N*=51)	-.13 (*N*=106)
GRS	.06 (*N*=55)	-.16 (*N*=51)	-.04 (*N*=106)
Analogue PTSD Symptoms (Time 2)			
PCL Total	-.33* (*N*=55)	.05 (*N*=51)	-.09 (*N*=106)
PCL Intrusions	-.37** (*N*=55)	.04 (*N*=51)	-.14 (*N*=106)
PCL Avoidance	-.18 (*N*=55)	.06 (*N*=51)	-.03 (*N*=106)
PCL Arousal	-.26 (*N*=55)	.02 (*N*=51)	-.07 (*N*=106)
Intrusions			
Monitoring Period Frequency	-.16 (*N*=55)	.05 (*N*=51)	-.10 (*N*=106)
Diary Frequency	-.26 (*N*=55)	.06 (*N*=51)	-.17 (*N*=106)
EIS	-.33* (*N*=55)	.01 (*N*=51)	-.19 (*N*=106)
Voluntary Thinking			
RIQ	-.31*(*N*=45)	.07 (*N*=39)	-.14 (*N*=84)
Voluntary Thoughts Frequency	.05 (*N*=32)	-.07 (*N*=32)	-.01 (*N*=64)

*Note.***p*<.05, ***p*<.01

Among elaboration participants, there were no significant relationships. Among control participants, memory amplification was associated with PTSD symptoms (in relation to the photos *and* their most traumatic event) and intrusion experience. That is, the more

[8] The number of participants are not consistent for some analyses due to the following reasons: (1) one participant within the elaboration condition did not complete the THS, (2) participants only rated how frequently they voluntarily thought/spoke about the photos if they responded “yes” to the question asking whether they had voluntarily thought or spoke about the photos and (3) the RIQ was only filled out by participants who indicated they experienced intrusions during the delay period.

severe participants' PTSD symptoms, the more biased participants became to respond "old" to photos over time. These correlations were medium in strength, according to Cohen's (1988) benchmarks, and are comparable to correlation coefficients previously observed (King et al., 2000, Southwick et al., 1997). There was also a small relationship between intrusion frequency and memory amplification, but it did not reach statistical significance, r=-.26, p=.052.

Taken together, elaboration did not affect sensitivity, but it eradicated the relationship between PTSD symptoms and memory amplification. Elaboration participants may have easily differentiated experienced and imagined details because the imagined details were less vivid and/or participants could remember the *experience* of imagining these details. Consequently, memory distortion was comparable across conditions and intrusion frequency did not affect memory amplification among the elaboration condition. Conversely, among control participants who did not reflect on their intrusions' content, an overall sense that the trauma analogue was particularly graphic might arise. Therefore, the more these participants re-experienced the photos, the less evidence they might have required to respond "old" to negative photos.

Our findings also suggest *effortful* imagination of new trauma-related details slightly reduces intrusions and encourages a tendency to *not* endorse trauma exposure. Perhaps, the spontaneous and non-deliberate nature of involuntary elaborative cognitions—and, particularly, their lack of context—is essential for amplification to occur; these qualities may prohibit conceptual processing, maintaining intrusions. Alternatively, elaboration perhaps encouraged more specific memories, causing less sensitivity to trauma-related cues and therefore fewer intrusions. Indeed, greater memory specificity may also explain why the elaboration condition showed less memory amplification than controls. Compared to control participants, elaboration participants may have been reluctant to endorse photos that were only vaguely related to the themes depicted in the photos.

Given these possibilities, perhaps the specificity of elaboration is critical in determining whether amplification will occur. We designed our elaboration instructions to discourage abstract thinking—specifically, over-general rumination about the trauma and its consequences—because we wanted to determine the effect of imagination exclusively. But abstract thinking may be critical, because it enhances both the internal generation of new details, encourages less memory specificity *and* maintains intrusions. Relatedly, the valence of elaboration may determine whether intrusions and subsequent memory amplification will occur. Indeed, participants who viewed negative pictures with moderate outcome contextual statements ("there were many survivors") experienced fewer intrusions than participants who viewed pictures paired with severe outcome statements ("there were few survivors"; Krans, Pearson, Maier, & Moulds, 2016). It also possible that elaboration worked similarly to imagery modification techniques used in cognitive therapy for PTSD. For example, we know that when people visualize a past trauma, "fast-forwarding" from the most distressing moment to the time when the person felt safe can help change negative appraisals (e.g., "I will never be well again") and reduce subsequent re-experiencing (Ehlers, Clark, Hackmann, McManus, & Fennell, 2005). Given we did not tell participants to elaborate in a way that made the memory more or less negative, it is possible that participants were inclined to elaborate in a more adaptive way that emulated imagery modification techniques in cognitive therapy. Future studies could try instructions priming more negative-oriented thinking or give more generic instructions, such as asking participants to think about the trauma's meaning and consequences.

Although elaboration participants presumably imagined more trauma-related details, this behavior did not increase memory distortion. One explanation is that elaboration participants could easily differentiate between imagined and witnessed details because memories for imagined details were experienced differently (less vivid and emotional). Alternatively, perhaps the delay between elaboration and the second memory test was too short for traces of cognitive operations—a characteristic associated with imagined information (Johnson et al., 1993)—to decay. Finally, elaboration may have not affected sensitivity simply because the elaboration condition experienced fewer intrusions. Put differently, although elaboration participants imagined more details—which should enhance reality-monitoring errors—the trauma analogue also intruded less frequently—which should reduce reality-monitoring errors. Determining a manipulation that does not confound imagination with intrusion frequency should be a research priority.

Our study has limitations. First, our trauma analogue does not provoke the same fear evoked by real-life traumas. Second, unlike the field studies, participants never viewed the same test items twice—because this would have introduced additional source confusion. Consequently, our findings do not tell us how memory changed over time for specific photos, only how memory sensitivity and bias changed *overall.* Third, because we included the time participants spent describing their intrusions within the 10 min monitoring period time limit, we may have underestimated intrusion frequency for participants with many intrusions. Note, however, participants on average spent less than one minute to describe an intrusion (M=48.10 s, *95% CI* [45.02, 51.18]). Finally, our elaboration task was necessarily artificial. Nevertheless, trauma survivors might engage in similar processes (e.g., imagining the scene, contextualizing the event) in real-world settings, including police interviews.

Overall, elaboration caused fewer intrusions and an increased bias to *not* endorse trauma exposure. While these findings are partly consistent with a reality-monitoring explanation for amplification, our findings might also reflect elaboration causing greater memory specificity, and thus fewer intrusions and a more conservative response bias.

Nevertheless, our results also suggest that intrusions may contribute to memory amplification, as evidenced by the correlations we observed in the control condition. Determining the mechanisms that drive this relationship should be a priority for future research.

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Appendix A

"Recall that the photos you viewed were of real events that happened throughout the world. With the intrusion that you have described in mind, we would like you to now imagine that you are present at that scene you have pictured, or at the scene your thought relates to. Take some time to form a mental image of the specific events that could have occurred beforehand and led to the events occurring in the scene. In other words, try to visualize what would have happened leading up to the event. Specifically, what were you doing beforehand? Who was present? We would also like you to imagine what would happen after the events occurring in the scene, as a result of these events: both in the immediate future and after some time has elapsed. Imagine how you would react or what you would do in response to the event. Imagine what might happen to the victim(s) as a result of this event.

In a few sentences, please describe what you imagined in the space provided under your description of the intrusion."

Appendix B

The guy on the train tracks was dead. He must have jumped in front of the train in order to kill himself. I imagine there were people on the train and certainly the driver who witnessed the event & the result. They probably will have difficulty understanding why he did it and they won't be able to forget about what happened. Maybe they will have nightmares. I think the guy was alone at the time but maybe he had loved ones who will be upset. If I were there, I would try to cover him up with something to preserve his dignity & so that other people are not traumatized.
The intrusion was of the three bodies that were lying on the ground with their heads blown/shot off in what looked like a war zone. / / We were all hiding from the enemy. A group of people were hiding when the enemy stormed in and shot the three armed men. / / Led to further hiding and mourning. Having to inform families of victims. / / Bodies sent back to home country.

I imagined I was at the office when I got called to investigate the crime scene. I'm walking up the driveway with numerous cops standing around - I get a strong feeling of unease. I make my way to the bedroom where the crime happened and feel a lump in my throat, like something trying to stop the vomit from coming out of my mouth. I get a sick feeling like I need to use the bathroom as I get closer to take photos. There are various forensic people doing their job as I was doing mine. / / I go home later that night unable to sleep. Dreading going to the office to look over the pictures I've taken with my colleagues. The victims family decided to cremate the body once investigation is complete.

i am at university when the fire alarm goes off. i follow the fire protocol, but make a wrong turn and end up walking through an area where the fire has been. that's when i see the child on the ground covered in 3rd degree burns. i call the campus emergency line. likely i will experience some sort of counseling to deal with what have seen. moreover the child likely did not survive.

I imagined as if i was in my home town and there was a severe earth quake that shattered buildings. My immediate response was to run to an open area and then call up for emergency services. I imagine there would be loss of lives due to the incident

Beforehand they could've been using corrosive chemicals maybe in a lab by themselves. After spilling the chemicals on themself they may have tried to wash away the chemical and call for help. In the future, it would have both psychological and physical impacts for the victim.

It was in an area where there is civil unrest and or war. The village was attacked and everyone was killed. The man was disposing of the body e.g. taking the child to a mass grave. I was a visitor to the area. I can't, I would like to think I would bury them properly and do my best to help the authorities find who was responsible but I have difficulty imagining myself in that situation.

I'm walking past and see a man fall onto the tracks of an oncoming train. As he hits the tracks, his shoulder/head is severed off and the train driver hits the brakes, filling the Autumn air with fumes from the brakes and fresh blood. The police come, the man is identified and I am taken in for questioning. AS it is established the man fell I am only there to explain the scene. The train driver takes the accident to heart and can't cope. Having no-one to talk to he confides in a bottle until he ultimately suffers the same fate as the man he killed.

Highlights

- We tested whether imagining new details about trauma causes memory amplification
- Subjects who elaborated had fewer intrusions than controls.
- Subjects who elaborated showed less memory amplification than controls.