Investigating the Memory Amplification Effect: Understanding the Role of Reality-Monitoring Errors

by

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Thesis
Submitted to Flinders University
for the degree of

Doctor of Philosophy

College of Psychology, Education & Social Work

6th March 2018

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Summary

Victims of traumatic experiences—such as war veterans—are often inconsistent when remembering stressful past events. Interestingly, field research suggests that these inconsistencies typically follow a particular pattern, whereby victims remember being exposed to *additional* events (e.g., experiencing sniper fire, sitting with the dying) over time. This pattern of findings—termed the "memory amplification effect"—is positively associated with the re-experiencing symptoms of post-traumatic stress disorder (PTSD), such as involuntary memories, thoughts or images about the trauma. Given the relationship between re-experiencing symptoms and memory amplification, one possibility is that memory amplification reflects a failure in reality monitoring. More specifically, as memory traces fade over time, trauma victims may erroneously incorporate *imagined* details about the trauma—that are introduced via re-experiencing symptoms—with what actually happened. Indeed, supporting this explanation, we know that trauma victims sometimes experience involuntary cognitions that are not accurate depictions of the trauma as it actually happened. Importantly, however, no research to date has investigated this explanation for memory amplification. Thus, the broad objective of this thesis was to empirically examine whether reality-monitoring errors contribute to the memory amplification effect. To this end, across several investigations in this thesis, I tested the key assumptions underlying the reality-monitoring proposal. Specifically, I investigated whether (1) re-experiencing symptoms are associated with changes in memory distortion and/or response biases, (2) victims of real-life traumatic experiences with heightened PTSD symptoms experience involuntary cognitions that include imagined details and are experienced similarity to involuntary memories, and (3) experimentally manipulating the imagination of new (non-experienced) trauma details has a causal effect on memory amplification. Consistent with reality-monitoring proposal, my findings suggest that the re-experiencing symptoms of

PTSD are associated with an increased tendency to endorse trauma exposure over time, and an increase in false traumatic memories. Further, my results show that victims of trauma with heightened PTSD symptomology are more susceptible to involuntary cognitions that included imagined details—"involuntary elaborative cognitions"—relative to trauma victims with minimal PTSD symptoms. Importantly however, because we were unsuccessful in manipulating involuntary elaborative cognitions specifically, we observed no direct evidence for the reality-monitoring account. But, taken together, the findings from this thesis provide some preliminary support for the reality-monitoring proposal and suggest that future investigation of the precise mechanism underlying the memory amplification and intrusions relationship is certainly warranted. In particular, these findings suggest that examination of the strategies participants adopt when determining whether an event is experienced or non-experienced would be useful, as well as investigating the role of individual difference factors, including trait ability to internally generate vivid mental imagery and meta-cognitive beliefs about memory.

Declaration

I certify that this thesis does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed.....

Date:

Acknowledgements

First and foremost I would like to express my sincerest gratitude to my supervisor **Dr Melanie Takarangi**. I am incredibly thankful for the enormous amount of encouragement, support, enthusiasm and time you have invested in me over the past four years. Thank you for genuinely caring about my various projects and for the countless hours you have spent reading drafts, discussing research ideas with me, providing feedback, listening to practice talks, preparing me to give lectures, reviewing conference posters… the list goes on and on! You have been all the support I could ever ask for and I am incredibly fortunate to have been able to work with and learn from you. Most of all, I would like to thank you for encouraging me to go outside of my comfort zone and teaching me to trust in my abilities. I feel like I have grown a lot of confidence from this experience and that is undoubtedly thanks to you. Thank you so much for entrusting me with this project.

I would also like to thank my fantastic collaborators. **Professor Deryn Strange**, thank you for all your great insights and for turning work around so (unbelievably) fast. It has been an absolute pleasure working with you and I have no doubt that your helpful feedback over the years has enormously improved the calibre of this work. **Professor Reginald Nixon,** thank you so much for all of your invaluable advice and feedback over the years. Thank you also to the **reviewers** who were involved in the publication process of each chapter and the **Australian Research Council** for making this research possible.

A huge thank you must also go to my fellow lab buddies: **Deanne, Di, Ella, Sasha** and **Tori.** Your feedback and ideas when I was faced with all kinds of tricky research hurdles throughout this journey were invaluable. Thank you for giving your time so generously and, more than anything, thank you for your friendship. Our cheeky lab meetings at the pub, writing (wine drinking) retreats, and often hilarious adventures overseas at various conferences are memories I will cherish. Without each and every one of you, this PhD thing would have been nowhere near as fun!

Adam, thank you for believing in me from the very beginning and always encouraging me to achieve my goals. Despite being physically apart for a lot of this adventure, you have always found a way to be there for me during both the highs and lows, and I love you so much for that. Finally, thank you to my incredible **Mum and Dad** for encouraging me to take on this challenge and not once doubting my ability to make it to the end. Without your love and support over the years none of this would have been possible. This thesis is testament to your belief in me.

1. (Mis)remembering Negative Emotional Experiences[1]

Author Contributions

JO collated all relevant literature and drafted the chapter. MT provided critical revisions.

In this chapter we consider the malleability of memories for emotional and traumatic events. We begin by overviewing contrasting theoretical accounts of traumatic memory. In the following sections we review research on how emotional events are remembered compared to neutral events, as well as evidence for the "specialness" of traumatic memory. To conclude, we discuss current developments and applied issues relating to traumatic memory distortion.

1.1. The "memory wars"

The 1980s saw a flurry of recovered memory cases arise in the United States (Colaneri & Johnson, 1992). These cases involved adults who previously never remembered experiencing childhood sexual abuse remembering that they had, in fact, been abused. In a typical scenario, the accuser claimed that memories of this abuse had been 'repressed' for years until he or she sought therapeutic help and subsequently recovered the memory. Broadly speaking, 'repression' refers to warding off any conscious experience of a frightening memory or fantasy (Singer, 1990). Many clinicians, legal scholars and the public at large have long considered repression of sexual abuse a real phenomenon (e.g., Fredrickson, 1992). Such memories are believed to be inaccessible, yet affect experience by encouraging intrusions, nightmares, and other behavioural symptoms that can only be alleviated when the memory is recovered. Central to this argument is the claim that recovered memories brought about in therapy are retrieved *accurately*.

Given that therapeutic intervention was involved in many recovered memory cases, a natural, although contentious, question that arose was just how authentic these 'recovered' memories were. Indeed, this question occupied centre stage in scientific, clinical and popular

[1] Oulton, J. M., & Takarangi, M. K. T. (2017). (Mis)remembering negative emotional experiences In R. Nash & J. Ost (Eds.), *False and distorted memories* (pp. 9-22). New York, NY: Routledge.

discussions throughout the 1990s (see, for review, Lindsay & Read, 1995) and is still a matter of debate among some researchers today (e.g., Brewin & Andrews, 2014; Patihis, Ho, Tingen, Lilienfeld, & Loftus, 2014). The emotionally charged controversy polarised the academic and psychological health communities into camps that either supported the reality of repressed memories or argued that some recovered memories might be false.

Although critics acknowledged the tragic prevalence of child sexual abuse, they pointed to the constructive nature of memory and the ease with which fabricated memories could be implanted (e.g., Loftus, 1997). According to these critics, "memory work" – therapeutic techniques used to recover suspected histories of abuse – could lead clients into falsely believing they were sexually abused. Other skeptics emphasised the sheer lack of experimental evidence for "special" memory mechanisms for trauma, including repression.

Although the recovered memories controversy is a complex dispute that touches on the subjects of incest, family, public policy and the law, at its core, it is a debate about how people remember and *misremember* traumatic experiences. Can people be led to believe they experienced a harrowing event, which in reality never occurred? Or are traumatic memories permanently engraved in the mind, even if inaccessible?

1.2. Theoretical perspectives on traumatic memory: special or basic?

Many clinicians and theorists believe that our memories for trauma are 'special' – processed and retrieved differently from everyday experiences (for review, see e.g., Shobe & Kihlstrom, 1997). Rooted in early psychodynamic tradition (e.g., Breuer & Freud, 1893–1895), this perspective, referred to as the *trauma-memory argument*, maintains that horrific memories are frequently buried in the unconscious by special processes – such as repression – and can later be recovered with minimal distortion.

Modern advocates of this argument emphasise that people encode trauma memories in ways that make them difficult to retrieve coherently, such that they are "fractured" in nature (Shobe & Kihlstrom, 1997). For example, Van der Kolk (1994) proposes that traumatic stress interferes with

people's ability to form a conscious, verbal narrative of the traumatic event, but leads to unconscious remembering in the form of sensory-motor and emotional fragments (e.g., bodily sensations which occurred during the event, images of the trauma). These unconscious representations are deeply engraved in memory and can manifest in behaviour.

Current models of posttraumatic stress disorder (PTSD) also reflect an underlying assumption that traumatic memory is special: some authors conceptualise PTSD as an autobiographical memory disorder, in which the trauma memory is fragmented and difficult to integrate with the person's life story. For example, Brewin, Dalgleish, & Joseph's (1996) dual processing model of PTSD argues that traumatic memories are often represented nonverbally. This information is not consciously retrieved and is only accessible when a person encounters situational reminders of the trauma. Overall, there are strong connections between current theoretical conceptions of traumatic memory and the trauma-memory argument.

1.3. Remembering emotional versus neutral events

The century-old trauma-memory argument has embedded itself deeply into clinical practices and popular culture. Indeed, many of us share an intuition that some moments in our lives are indelibly preserved due to their emotional significance (Talarico & Rubin, 2006). But just how objectively accurate are these memories? Are emotional events remembered differently compared to neutral ones, or do people simply *believe* they have retained detailed memories of emotional events?

Field studies provide the primary support for the assumption that memories for emotional events are fixed over time (e.g., Brown & Kulik, 1977; Peterson & Bell, 1996). According to Brown and Kulik (1977), when a highly shocking event occurs (e.g., the assassination of one's president), a special memory mechanism takes over, causing the moment to be recorded with almost perfect accuracy. These "flashbulb" memories resemble a "photographic print" and are immune to decay and distortion. As an example, Brown and Kulik examined memories for John F. Kennedy's assassination. Fourteen years after the assassination, nearly all participants recalled contextual event

information – such as their location when they heard the news – confidently and vividly. Later studies have replicated these findings: people vividly recall natural disasters (Bahrick, Parker, Fivush, & Levitt, 1998), injuries (Peterson & Bell, 1996) and space shuttle explosions (Neisser & Harsch, 1992).

However, these studies have several limitations. First, they do not include a baseline measure, a comparable, emotionally neutral event. Thus, one cannot infer whether a "special" memory mechanism exists for emotionally significant events *alone*, as Brown and Kulik (1977) propose. Second, people tend to mull over and discuss emotional events, and this rehearsal process can aid memory (e.g., Rimé, Mesquita, Philippot, & Boca, 1991). Thus, *ordinary* memory mechanisms like rehearsal might explain enhanced memory for emotional events. Finally, because the reported event details often cannot be corroborated, it is impossible to know whether participants' reports are accurate or simply *misremembered*. Importantly, there is now substantial evidence suggesting that, in fact, flashbulb events tend to be remembered inconsistently over time (e.g., Neisser & Harsch, 1992).

Although real-life studies show that emotional events are *subjectively* well preserved in memory, many laboratory studies show, paradoxically, that emotional events are poorly retained (e.g., Clifford & Hollin, 1981; Loftus & Burns, 1982). In an early example, Clifford and Hollin (1981) measured participants' memory for either a violent film – depicting a man aggressively mugging a woman – or a nonviolent film – where the male asks the woman for directions. Witnesses to the violent incident were significantly poorer at identifying the man in the film compared to witnesses to the nonviolent event. These results deviate from field studies and Brown and Kulik's flashbulb memory hypothesis (1977) because they suggest emotion *impairs* memory rather than facilitates it.

Subsequent research, however, suggests that this conclusion might be oversimplified because it fails to consider that emotion may enhance memory for some event details, whereas impairing memory for others. A more complete picture of emotion's effects on memory may

therefore depend on the *type* of information participants are asked to recall. Hence, researchers have frequently divided to-be-remembered details into central and peripheral information (see, for review, Levine & Edelstein, 2009). Broadly speaking, central details are items that are spatially, conceptually or temporally associated with an emotional stimulus (e.g., the weapon a perpetrator used), whereas peripheral details are items unrelated to emotional details (e.g., what a background bystander was wearing). Central details are often better retained in memory for emotional events compared to neutral events, whereas memory for peripheral details is worse for emotional events compared to neutral events. Researchers frequently refer to this phenomenon as memory narrowing (e.g., Reisberg & Heuer, 2004).

Laboratory data support memory narrowing using slides (e.g., Safer, Christianson, Autry, & Osterlund, 1998), films (e.g., Clifford & Hollin, 1981), narratives (e.g., Levine & Burgess, 1997) and even simple stimuli, such as words (e.g., MacKay & Ahmetzanov, 2005). In one example, Christianson and Loftus (1991) presented participants with slides depicting a story. In the neutral condition, one critical slide showed a woman cycling; in the emotional condition the critical slide showed a woman beside her bike bleeding from a head injury. Participants were better at remembering the central detail (the colour of the woman's coat) in the emotional condition compared to the neutral condition. By contrast, memory for a peripheral detail (colour of a background vehicle) was poorer in the emotional condition compared to the neutral condition. Findings from real-world contexts parallel laboratory research: people typically show accurate memory for central features of traumatic experiences, including natural disasters (Bahrick et al., 1998) and medical emergencies (Peterson & Whalen, 2001).

Importantly, however, emotion sometimes *enhances* memory for peripheral information (Heuer & Reisberg, 1992; Laney, Campbell, Heuer, & Reisberg, 2004) and/or impairs memory for central details (e.g., Morgan et al., 2004). Understanding these seemingly paradoxical findings relies on the mechanism underlying memory narrowing. Researchers have typically attributed memory narrowing to arousal; specifically, Easterbrook's (1959) cue utilisation hypothesis.

According to this account, the more arousal a person experiences, the less information he or she can consciously attend to. Because arousal typically accompanies emotion, emotion is also accompanied by attentional narrowing. This narrowing leads people to use more mental resources in processing the arousing event details. Hence, an increase in emotional arousal facilitates the encoding of central information and impoverishes the encoding of peripheral information.

Recently, however, Mather and Sutherland (2011) advocated their Arousal- Biased Competition (ABC) theory to account for the contradictions in the literature. According to this theory, arousal enhances selective attention towards high-priority information, leading to a "winner-takes-more" and "loser-takes-less" effect. Priority is determined by (1) bottom-up sensory factors (e.g., how much the stimulus "pops" out) and (2) top-down cognitive factors, including how goal relevant the stimulus is, such as its importance in maintaining survival (e.g., presence of a weapon). The ABC theory conflicts with Easterbrook's hypothesis (1959) in that it proposes that emotion does not "narrow" attention, but simply exaggerates a pre-existing bias of attention towards high-priority information – which is frequently central information, *but not always.* The ABC theory is well supported by vision research and reconciles some puzzling research findings, including instances where central details are *not* better remembered; for example, when people are told they will be tested on *all* aspects of a scene later (Kensinger, Piguet, Krendl, & Corkin, 2005) or to direct their attention towards all visual details of a scene (e.g., describing the scene so that an artist could reproduce it; Kensinger, Garoff-Eaton, & Schacter, 2007). That is, when participants' goals are manipulated, their attention may move away from central information.

In summary, research suggests that emotional memories are not protected from the general memory distortion that occurs for everyday events. However, there is some consensus that emotional events are remembered somewhat differently than their neutral counterparts. Although this pattern was previously explained by attentional narrowing towards central details, recent research suggests that it results from an increased bias in attention towards high-priority information.

1.4. False memories and emotional events: current developments

Many people share the belief that memory operates like a video recorder (Simons & Chabris, 2011): the mind records experiences and then, on cue, plays back a perfect reproduction of the event. However, as we have shown, memory for both emotional and everyday events is malleable. Interestingly, a separate line of research shows people can come to remember not only *additional details* of events that never actually occurred (e.g., Bartlett, 1932), but also *wholly* false memories, or "rich false memories" (Loftus & Bernstein, 2005), such as going for a hot-air balloon ride (Wade, Garry, Read, & Lindsay, 2002). Importantly, this pattern of memory distortion extends to memories for emotional, and even traumatic, events such as witnessing terrorist bombings on television (Nourkova, Bernstein, & Loftus, 2004) or being attacked by an animal (Porter, Yuille, & Lehman, 1999). In the following section we discuss factors responsible for memory distortion that are either external or internal to the individual.

1.4.1. External factors. People can be led to falsely remember details of an event – often a crime – via external post event information. Typically, participants witness an event and later receive additional information via some source, such as leading questions (e.g., Loftus, 1979) or an event statement attributed to someone else (e.g., Foster, Huthwaite, Yesberg, Garry, & Loftus, 2012). This external source conveys inaccurate information about critical details in the event (e.g., colour of a vehicle) and accurate information about other details. Memory accuracy for the critical details is later tested. An overwhelming number of studies have shown that people are less accurate for details about which they are misled, compared to non-misled details (see, for review, Loftus, 2005).

Importantly, the distorting effects of external post-event information extend to highly emotional events. For example, following a tragic accident when a jet flew into an Amsterdam apartment building, Crombag, Wagenaar, and Van Koppen (1996) *suggestively* questioned participants about whether they had seen non-existent footage of the crash. Ten months after the accident, participants answered the question, "Did you see the television film of the moment the

plane hit the apartment building?" which was embedded among factual questions. Over 60 percent of participants claimed they had witnessed the nonexistent film. Researchers have replicated this effect for the car crash that killed Princess Diana (Ost, Vrij, Costall, & Bull, 2002), the assassination of politician Pim Fortuyn (Jelicic et al., 2006) and the first plane crashing into the World Trade Center (Pezdek, 2003).

In another example, participants completed a questionnaire in the presence of a confederate about their memory for (non-existent) footage of the sinking of the Estonia Ferry in 1994, which resulted in over 900 fatalities (Granhag, Stromwall, & Billings, 2003). For some participants, the confederate stated aloud that he or she did not remember the footage; for some, the confederate said he or she had seen the footage, and for other participants, the confederate was silent. Critically, participants modified their false reports to fit with what the confederate said: 76 per cent of participants claimed to have seen the film when the confederate had, compared to 52 per cent in the control condition, and just 36 per cent when the confederate claimed no memory.

Interestingly, misinformation may be more readily accepted when the event is highly negative compared to positive or neutral (Porter, Spencer, & Birt, 2003). According to Porter and colleagues' Paradoxical Negative Emotion (PNE) hypothesis (Porter, Taylor, & ten Brinke, 2008), although negative emotion may enhance memory accuracy overall, it also encourages a heightened susceptibility to misinformation, relative to neutral and positive emotion. This hypothesis fits with the evolutionary idea that it is *adaptive* for people to incorporate relevant information about a negative event from seemingly reliable sources to prepare for any future occurrences of a similar event. Major event details are the most likely to result in a greater advantage in terms of avoiding or dealing with occurrences of threatening events later on, which could explain why research tends to show greater memory distortion for the traumatic aspects of an event, relative to the non-traumatic aspects (Strange & Takarangi, 2012, 2015).

Researchers have also investigated the distorting effects of suggestive techniques, such as guided imagery and repeated retrieval attempts, on memory for *entire* emotional events (e.g., Heaps

& Nash, 2001). These techniques have led participants to remember events that did not happen and would have been traumatic had they occurred. For example, Porter et al. (1999) questioned participants about several childhood experiences – one of which was false – over three sessions. The false target events included a serious medical procedure, getting lost and a serious animal attack. Throughout the sessions, the interviewers encouraged participants to focus on recovering their memory of the target event and generate related imagery (e.g., "visualise what it might have been like and the memory will probably come back to you"). Twenty-six per cent of participants came to report that they experienced the false incident, and a further 30 per cent of participants remembered aspects of it.

Clearly, external processes can drastically distort memories for emotional events. Commonly, researchers explain false memories for trauma – and false memories for *any* event – as a failure in source monitoring. According to the Source Monitoring Framework (Johnson, Hashtroudi, & Lindsay, 1993), people do not store the details of their experiences in memory with labels specifying where they originated from. Instead, they rely on heuristics, such as how familiar details of the event feel, to ascertain whether a remembered detail actually occurred or was merely suggested or imagined. Critically, post-event processing – such as learning new information from an external source – can cause inaccurate details to become incorporated into the original memory. When the familiarity of those new details increases, people may misattribute these details as genuine memory traces, resulting in memory distortion (e.g., Newman, 2017).

1.4.2. Internal factors. Traumatic memory distortion can also occur spontaneously, in the absence of specific suggestive influences. Indeed, memories of traumatic events seem to vary across time in a particular pattern: victims of trauma tend to endorse exposure to more traumatic events over the course of time, termed memory "amplification" (see, for review, van Giezen, Arensman, Spinhoven, & Wolters, 2005). As an example, Southwick, Morgan, Nicolaou, and Charney (1997) asked Gulf War veterans about their exposure to war-related stressors, such as seeing others killed or wounded, both one month and two years following deployment. Eighty-eight per cent of veterans

changed their response to at least one event at follow-up; most changes were from no to yes, with 70 per cent of the veterans recalling an event later that they had not reported originally.

Why might memory for traumatic events amplify over time? The idea that traumatic events are initially repressed and then later recovered is not supported by scientific evidence (e.g., Ernsdorff & Loftus, 1993; McNally & Geraerts, 2009). A second explanation is that external influences – such as media coverage of the event – play a role. This explanation is plausible, and as yet untested. However, people with severe re-experiencing symptoms (i.e., symptoms that involve mentally reliving the traumatic event) appear most prone to memory amplification (e.g., Roemer, Litz, Orsillo, Ehlich, & Friedman, 1998; Giosan, Malta, Jayasinghe, Spielman, & Difede, 2009; Oulton, Strange, & Takarangi, 2016; Takarangi, Oulton, Green, & Strange, 2016), suggesting that *internal* factors play a key role.

Although studies suggest memory amplification may occur due to re-experiencing, they do not shed light on *why* this relationship exists. It may be that people amplify their memories to justify distressing symptoms, or the symptoms themselves play some role in producing memory distortion. Furthermore, because researchers generally cannot corroborate the events, it is possible that participants' additional memories are erroneous or simply reflect participants underestimating events initially and giving more accurate reports later. Indeed, contrary to typical belief among judges and juries, research shows that reminiscent statements (i.e., instances where people remember new event details) are not necessarily problematic and are sometimes very accurate (Fisher, Brewer, & Mitchell, 2009).

Strange and Takarangi (2012) recently addressed this issue using a laboratory analogue. Participants watched a film showing a fatal car accident in a series of clips, allowing the researchers to remove traumatic and non-traumatic scenes. Twenty-four hours later, participants saw both original and removed (missing) footage, as well as new (control) clips, and identified whether each clip was old (i.e., from the film) or new (i.e., never seen). Participants successfully recognised old clips and rejected control clips. However, they also claimed to have seen 26 per cent of the missing

clips. Interestingly, the falsely recognised missing scenes tended to be the most traumatic (e.g., paramedics examining the driver's injuries), and the more participants reported re-experiencing parts of the film, the more inclined they were to remember the missing clips. This finding suggests that re-experiencing symptoms are related to memory distortion and not more accurate recollection.

Why might internal factors, such as re-experiencing symptoms, amplify people's memories for emotional events? Intriguingly, current dominant models of PTSD fail to account for the mechanism underlying amplification (Brewin et al., 1996; Ehlers & Clark, 2000). For example, Brewin et al.'s (1996) Dual Representation Theory describes intrusions as the involuntary retrieval of sensory information via the Situationally Accessible Memory (SAM) system, which is responsible for encoding sensory and perceptual information. This theory appears to assume that intrusions of a traumatic event represent re-experiencing the event *as it really happened*. More recently, however, Rubin, Berntsen and Bohni (2008), in their memory-based model of PTSD, argue that the current memory of a traumatic event, and not the traumatic event per se, determines symptomatology. According to this model, neither voluntary nor involuntary memories of trauma are consistent over time. Rather, trauma memories are distorted by a multitude of factors, including current emotions, expectations and feedback from other people.

Recently, Strange and Takarangi (2012; see also Strange & Takarangi, 2015) proposed that, like false memories for trauma that arise in the face of external suggestion, memory amplification might also result from source monitoring errors. One internal source may be intrusions, which could potentially spark other imagined thoughts and images related to the event. Indeed, Reynolds and Brewin (1998) found that intrusion content following a trauma consisted of real events as well as plausible extensions of the traumatic event (e.g., a stroke patient imagining having another stroke). Strange and Takarangi (2012) argue that the more these 'produced' thoughts and images intrude into a person's mind, the more familiar they become to the person and the more likely they are to be incorporated into the event memory, resulting in amplification. Notably, source monitoring errors are especially likely when imagined details lack information about cognitive operations (e.g.,

memories of elaborating on information) and are focused on perceptual details (e.g., colours and sounds); both of these characteristics have been associated with the experience of intrusions (Crombag et al., 1996). Recently Takarangi and Strange (2015) found evidence to support the role of source confusion in memory amplification: when participants received warnings designed to encourage more careful source monitoring, they were less likely to exhibit memory distortion for a traumatic film.

Taken together, a growing number of studies confirm that emotional memories can become distorted over time in the absence of any deliberate misinformation. Although the exact mechanism is unclear and further research is warranted, research suggests that re-experiencing symptoms may contribute to memory amplification. Recent experimental research also suggests that such symptoms are associated with memory distortion, as opposed to more accurate appraisals of the event, and that source monitoring errors may produce this effect.

1.5. Practical Implications

Research shows that memories for our most emotional life events are, like memories for everyday events, reconstructive and prone to distortion by a host of variables. This research not only raises significant implications for scientists' understanding of how memory operates, but has considerable relevance for the legal system and people who counsel or treat victims of trauma.

1.5.1. Legal implications. Commonly, events that lead people to interact with the legal system – such as being abused or witnessing an assault – are emotional. Often, these events occurred months, years or even decades earlier. The accuracy and stability of emotional memories are critical when assessing the credibility of witness testimony. What, then, does the scientific evidence mean for this assessment process?

As we have noted, although emotional events are frequently recalled with confidence, memories for emotional events can be corrupted by post-event information, suggestive questioning and techniques, social influences and even PTSD symptoms. In the real world, these distorting

influences can take several forms. People are often exposed to various sources of information about a traumatic event following its occurrence: they may see television or newspaper reports, be questioned by police or confer with other witnesses before police arrive on the scene (Paterson & Kemp, 2006). Moreover, when people experience intense emotion, social sharing often follows (Rime, Mesquita, Philippot, & Boca, 1991). People discuss emotional incidents with friends, relatives, therapists or even other victims, in group-based debriefing, for example. Because all of these factors can distort memory, it is clear that traumatic memories in the real world are susceptible to alteration over time. Importantly, the distorting effects of post-event misinformation are *exaggerated* when the event has a negative emotional tone, compared to a neutral or positive tone (e.g., Porter et al., 2003).

Considering this, jurors should be especially cautious of cases in which witnesses have come into contact with several external sources following an emotional event. Moreover, triers of fact should not give testimony more credibility when it is accompanied by emotion: witnesses can be genuinely emotional and confident about events that never occurred (e.g., Porter et al., 1999; Laney & Loftus, 2008). Considering memory amplification research (e.g., Southwick et al., 1997), it is possible that testimony provided by victims with PTSD may sometimes be distorted by symptomatology. This possibility, however, must be treated with caution given that research in this area is still in its infancy. Finally, law enforcement investigators should be vigilant when questioning witnesses. We know that suggestive questions, or even subtle changes in how a question is worded, can drastically diminish memory accuracy. Indeed, erroneous eyewitness memory is the major contributing factor to known wrongful convictions (Technical Working Group for Eyewitness Evidence, 2003). Minimising misconceptions about memory for trauma and educating investigators about their potential influence is an important step in addressing this critical problem.

1.5.2. Clinical implications. The accuracy of traumatic memory is also critical in the clinical realm. Some mental health practitioners have been shown to assume that (1) emotional

memories can become buried in the unconscious by "special" processes and (2) when recovered, these memories are an almost perfect reproduction of the event (e.g., Fredrickson, 1992). Importantly, however, evidence for the "specialness" of traumatic memory is undeniably scant (e.g., Ernsdorff & Loftus, 1993). Further complicating matters, we know it is possible, and relatively easy, to implant rich false memories of *entire* emotional events using suggestive techniques, and these memories can be expressed with great confidence, detail and emotion. Thus, there is a real possibility that some "recovered" memories brought about in therapy are mistaken. This possibility is especially worrisome considering such cases harm the integrity of the clinical profession and reduce public sympathy and available resources for genuine abuse victims.

How might research help address this problem? Mental health practitioners can benefit from awareness that certain techniques can lead to confidently held false memories and that memory for trauma is not "special" but abides by the same basic principles that memories for ordinary events do. Educating practitioners about these misconceptions concerning traumatic memory may help to reduce the rate of false recovered memories and prevent the devastating outcomes for clients, families and the accused.

1.6. Concluding remarks

Taken together, research suggests that memories for our most defining emotional life events are not immune from distortion. Although aspects of emotional experiences are remembered differently than neutral events, our memories for trauma generally abide by the very same laws that our memories for neutral events do. The reconstructive nature of traumatic memories has significant implications for applied contexts, including legal and clinical practice.

2. Memory Amplification for Trauma: A Critical Review of the Literature

As discussed in Chapter 1, the fact that traumatic memories can become amplified over time has significant legal and clinical implications. Given these implications, determining the mechanisms that underlie the memory amplification effect is critical. However, such a task first requires a comprehensive understanding of what previous work has revealed about memory amplification and its relationships with other variables. In the following chapter, I therefore provide a critical review of research to date on how victims of trauma remember their experiences over time and proposed theories for this effect.

Southwick, Morgan, Nicolaou and Charney (1997) first investigated the memory amplification effect among veterans of Operation Desert Storm. In this prospective investigation, veterans (*N*=62) completed a questionnaire where they indicated whether they had been exposed to a series of combat-related traumatic events (e.g., "sitting with the dying", "witnessing bizarre disfigurement of bodies as a result of wounds") a month after returning from the war, and again two years later. Veterans were inconsistent in their responses across time: the vast majority (88%) of veterans changed at least one of their responses to the questionnaire. Moreover, out of the 19 items on the exposure questionnaire, only two items (i.e., "being in an aircraft that is shot down" and "being responsible for someone else's death") were given consistent responses across both time points by all participants. Overall, the number of events veterans said they had experienced significantly increased over time by 0.69 events (*SD*=2.18). Further, 70% of veterans indicated that they had experienced an event at two years, which they never previously reported, compared to 46% who changed at least one response from yes to no over time. There was also a significant relationship between PTSD symptoms and memory amplification; the more severe PTSD symptoms were at the second time point, the more veterans tended to change their responses from no to yes over time, *r*=.32.

Since Southwick et al.'s (1997) initial investigation, other researchers have subsequently

examined the consistency of memory among different combat-exposed samples, including peacekeepers (e.g., Bolton, Gray, & Litz, 2006; Bramsen et al., 2001; Roemer et al., 1998), former prisoners of war (Dekel et al., 2016), Vietnam veterans (e.g., Koenen et al., Krinsley et al., 2003; Niles et al., 1999), Gulf War soldiers and veterans (Brewer, Hallman, & Kipen, 2008; King et al, 2000; Wessely et al., 2003), Royal Netherlands Army troops (Engelhard et al., 2008), and army soldiers and veterans deployed to Iraq (Alosco et al., 2016; Wilson et al., 2010). Many of these researchers also observed inconsistencies in memory for combat exposure over time, despite often using different measures of combat-exposure and varying delays between questionnaire administration. In one example, King and colleagues (2000) asked 2942 Gulf War veterans to respond "yes" or "no" to a number of questions about their war-zone exposure (e.g., "*Did your unit engage the enemy in a firefight?*") immediately after returning from deployment—before being re-united with their family—and then again 18-24 months later. Consistent with Southwick et al. (1997), there was a significant increase in exposure frequency scores across time and severity of PTSD symptoms at Time 2 was positively associated with the number of no-to-yes changes (r=.26). Similarly, Engelhard et al. (2008) found that Dutch soldiers deployed to Iraq were frequently inconsistent in recalling exposure to events over time and the more PTSD symptoms participants reported, the more they increased frequency estimates over time, r=.18. Importantly, however, not all of these investigations have revealed significant relationships between PTSD and memory amplification (e.g., Bramsen et al., 2001; Wessely et al., 2003). For example, a study by Wessely and colleagues (2003) among veterans of the Gulf War and Bosnian conflict found increased exposure reports over three years in the Gulf War cohort only and no significant relationship between inconsistencies and PTSD symptoms for either cohort However, the researchers assessed PTSD with four questionnaire items rather than standardized self-report measures typically used in other studies. One possible explanation for this discrepancy is that their PTSD measure failed to adequately capture the features of PTSD that are associated with memory amplification, such as repeated and disturbing memories, dreams and flashbacks about the trauma.

In addition to military populations, some studies have assessed memory for exposure to war and torture among refugee populations (Mollica et al., 2007; Spinhoven et al., 2006; Wyshack, 1994). In general, findings from this area of the literature are more mixed. In one example, Spinhoven and colleagues (2006) asked unaccompanied refugee minors whether they had been exposed to a number of stressful events (e.g., being hit, kicked or shot at) at two time points, separated by a year. Consistent with findings from military populations, most (86.4%) minors changed at least one response. However, minors with *less* severe PTSD symptoms were more likely to be inconsistent over time, relative to those with heightened PTSD symptoms. Similarly, in their investigation among refugees from South-East Asia (*N*=30), Wyshack (1994) observed an inverse relationship between PTSD symptoms and memory inconsistency; that is, the more PTSD symptoms participants reported, the more consistent participants tended to be over time. However, neither of these studied examined the relationship between PTSD symptoms and remembering more traumatic events over time—i.e., memory amplification as it is classically defined—but overall inconsistency, which could reflect participants changing responses from no to yes, changing responses from yes to no, or a mixture of both. Moreover, Wyshack (1994) assessed memory over a very short delay period (i.e., one week), relative to other field studies. Interestingly, a later study (Mollica et al., 2007) that examined memory amplification as it is typically operationalized, among Bosnian refugees, aligned with much of the military population research. In this study, PTSD was uniquely associated with reporting more wartime trauma and torture events over a three-year period. However, the mean number of events reported *overall* significantly reduced over time; that is, the refugees reported fewer stressful events as time passed. Taken together, findings from refugee samples suggest that PTSD does not predict overall inconsistencies in reporting, however may be uniquely associated with responding "yes" to more traumatic or stressful events over time.

In recent years, a number of studies have assessed consistency of memory for highly emotional, *shared* public events, including natural disasters (e.g., Heir et al., 2009; Weems et al., 2014), the September 11 attacks (e.g., Dekel & Bananno, 2013; Giosan et al., 2009) and a fatal

school shooting (Schwarz et al., 1993). For example, Heir and colleagues asked 532 citizens who experienced the South-East Asia Tsunami about their perceived life-threat during the tsunami (i.e., "how great do you think the danger was that you would die?") six and 24 months after the disaster. An increase in perceived life threat over time was associated with a lack of improvement in PTSD symptoms (Wald=4.93). Similarly, in their study of school personnel (N=12) exposed to a school shooting, Schwarz et al. (1993) found that all personnel changed at least some of aspect of their report of the event from 6 months to 18 months. Critically, although overall participants were more likely to diminish their reports of exposure, inflation in recall for sensory experiences (e.g., saw the perpetrator, heard the shooting) was positively associated with PTSD symptomology (r=.69) and enlargement in recall of life threat (e.g., worried about own/loved one's safety) was associated with the arousal symptoms of PTSD (r=.61). Importantly, other studies have observed similar patterns with objective measures of trauma exposure and much larger samples. Indeed, in their investigation of disaster restoration workers (N=2641) deployed at the World Trade Centre after 9/11, Giosan and colleagues (2009) found that an increase in "yes" responses to objectively traumatic events (e.g., witnessing people jump from the towers, seeing human remains) was associated with more severe PTSD symptoms.

Taken together, while there are some exceptions, growing evidence from naturalistic studies suggests that: (1) people tend to be inconsistent when recalling trauma and (2) the symptoms of PTSD are modestly associated with recalling more objective and subjective indicators of trauma exposure over time. Importantly, these findings do not appear to be specific to war-exposed populations, the type of exposure assessment used, or the length of delay between assessments. Indeed, associations between PTSD and memory amplification have been observed with dichotomous (yes/no) checklists to assess trauma exposure (e.g., Giosan et al., 2009; Southwick et al., 1997), as well as more fine grained Likert-type rating scales, such as questionnaires asking participants to report their degree of exposure to certain events from "not at all" to "over 50 times" (Roemer et al., 1998). Moreover, researchers have observed relationships between PTSD and

amplification for time delays ranging from as little as three months (Wilson et al., 2010), up to 17 years between assessments (Dekel et al., 2016). In addition, researchers have observed instances of inconsistent recall for events that are highly objective and traumatic in nature, and not merely peripheral or trivial details about participants' past. While the overall direction of inconsistencies differs across studies—with some researchers finding an overall increase in endorsements over time (e.g., Southwick et al., 1997; King et al., 2001) and some finding an overall diminishment (e.g., Mollica et al., 2007; Schwarz et al., 1993)—PTSD severity is associated with memory amplification. A natural question arising from these findings, therefore, is why PTSD might be associated with such an effect?

Researchers have proposed several explanations for this association. As discussed in Chapter 1, some authors have argued that the effect might simply reflect people's memories for traumatic events being initially denied or repressed and then later becoming recovered (e.g., Southwick et al., 1997). A second proposal is that people come to remember new events over time due to external influences, such as discussions with co-victims (Bolton et al., 2006; King et al., 2000; Southwick et al., 1997). For example, a veteran might discuss their experiences at war with another reservist and, through these discussions, new—and potentially inaccurate—information about the conflict might come to light. This information could then become incorporated into one's memory of the trauma, leading to memory amplification. A third possibility is that traumatic events people previously considered irrelevant may be reappraised as significant to make sense of emerging psychopathology (Bolton et al., 2006; Engelhard et al., 2008; King et al., 2000; Southwick et al., 1997). That is, people who experience an increase in PTSD symptoms over time may inadvertently—or perhaps even knowingly—exaggerate or reinterpret trauma memories to understand their increasing distress. For example, a veteran suffering from highly distressing nightmares and flashbacks about their time in service might come to reinterpret the sight of blood as "seeing human remains" (Engelhard et al., 2008) to make sense of their rising distress. A related fourth possibility is that the memory amplification effect reflects mood congruent recall. According

to this hypothesis, stimuli that are consistent with a person's current mood state are learned and remembered better than stimuli of a different valence (Blaney, 1986). Thus, when experiencing rising distress and negative affect, trauma victims may be more inclined to remember negative events, consistent with these states, that they previously never recalled.

As discussed in Chapter 1, researchers have proposed an alternative explanation: that memory amplification is a consequence of reality-monitoring errors (King et al., 2000; Strange & Takarangi, 2012, 2014; Mollica et al., 2007). According to the Source Monitoring Framework (Johnson, Hashtroudi, & Lindsay, 1993; Lindsay, 2008), people do not store the details of their experiences in memory with labels specifying their origin, or source. Instead, people tend to rely on certain shortcuts—or heuristics—such as how familiar event details feel, to decide whether they actually witnessed a certain detail or whether they only imagined it. Sometimes, these heuristics can lead to mistakes: people can erroneously label imagined details—or even entirely imagined events—as memories of real events that they actually experienced. For example, when people repeatedly and vividly imagine details—and if there is no memory of the cognitive effort involved in imagining these details—people can mistake the sense of familiarity these details provoke with the familiarity that usually accompanies memories for our true past experiences, causing memory distortion. One potential route through which these imagined details could be introduced is involuntary cognitions, i.e., thoughts, images or memories that come to mind spontaneously. Although these cognitions might sometimes reflect aspects of the traumatic event that the victims actually experienced; sometimes they might also contain traces of similar—but never before experienced—events. Over time, these new details may become incorporated into one's existing memory of the trauma, resulting in memory amplification.

There is empirical support for the reality-monitoring explanation; re-experiencing symptoms (e.g., repeated nightmares about the trauma) are positively associated with memory amplification (Giosan et al., 2009; Koenen et al., 2007; Roemer et al., 1998). For example, Roemer et al. (1998) asked 460 US soldiers whether they had been exposed to several war-zone stressors within one year

after returning from a peace-keeping mission in Somalia and one to three years after deployment. Critically, the more that the soldiers reported an increased number of events at follow-up, the more PTSD re-experiencing symptoms they experienced, but not symptoms of anxiety, depression or other clusters of PTSD symptoms. A more recent study of 1462 Vietnam veterans showed similar findings (Koenen et al., 2007). The researchers mailed participants surveys assessing combat exposure in 1984, and again in 1998. Aligning with Roemer et al.'s (1998) findings, the more that people reported an increased number of traumatic events in 1998, the more likely they were to have increased re-experiencing symptoms. Giosan et al. (2009) also replicated this finding in their investigation of 9/11 disaster restoration workers. They found concurrent re-experiencing symptoms at follow up—but not avoidance or hyperarousal symptoms—significantly predicted an increase in the number of stressful events reported at follow-up.

Taken together, evidence from field studies suggests that re-experiencing symptoms—specifically—may play an important role in contributing to memory amplification. Although these findings are consistent with the reality-monitoring explanation, importantly, other proposed explanations for memory amplification also fit with this association. First, it is possible that the more a person re-experiences a trauma, the more motivated they may feel to justify these distressing symptoms, and consequently, the more they exaggerate or reinterpret their memories of what happened to make sense of intrusion-related distress. Second, it might be that a rehearsal-based explanation can account for these findings. That is, re-experiencing the trauma might *improve* peoples' memory for previously forgotten details, by allowing rehearsal of event details or by increasing the accessibility of trauma memories. Third, it is plausible that the more a person involuntarily re-experiences their trauma, the more likely they are to voluntarily discuss the events with other people, to make sense of their symptoms, for example. These discussions could lead to more opportunity for inaccurate information about the trauma to be incorporated into memory, leading to more "yes" responses to trauma exposure items over time. Finally, it may be that memory amplification actually contributes to an enhancement of re-experiencing symptoms. That

is, the more exaggerated a person's memory becomes, the more likely their memory for that trauma will intrude into consciousness.

If the reality-monitoring explanation for memory amplification is true, then we should expect to observe several key findings. First, contrary to a rehearsal-based explanation and a mood-congruence explanation, re-experiencing the trauma should be associated with *falsely* remembering more traumatic experiences over time, rather than improved memory accuracy for the trauma over time. Second, according to this explanation, victims of trauma should sometimes experience involuntary cognitions about their trauma that possess imagined details—i.e., involuntary elaborative cognitions. These cognitions should possess similar characteristics to memories of experienced details, therefore allowing the opportunity for source confusion. Finally, manipulating the occurrence of imagined event details and/or involuntary elaborative cognitions should in turn affect the extent to which one's memory for a trauma amplifies. More specifically, the more one internally generates new information about the trauma, the more one's memory of the trauma should amplify. Importantly, considered together, these findings would be consistent with the reality-monitoring explanation but would be *inconsistent* with other proposed explanations for memory amplification.

Importantly however, the field studies mentioned previously cannot test these predictions. In particular—because exposure to traumatic events is not verified in these studies—these studies do not tell us whether people's new memories are false or whether amplification reflects people underestimating events initially and giving more accurate reports at follow-up. Furthermore, based on the field research, it is unclear whether the memory amplification effect reflects people's difficulty in discriminating what they really experienced from related events that they did not experience, or a change in response bias, where people became more biased to respond "yes" to exposure events over time when they have severe re-experiencing symptoms. Finally, because these studies lack experimental control, they do not shed light on what mechanisms underlie the relationship between re-experiencing symptoms and memory amplification. The goal of my thesis is

to address these limitations to test the predictions underlying the reality-monitoring explanation for memory amplification.

3. Overview of Research Objectives

The overarching objective of my thesis will be to expand upon existing research on memory amplification to investigate *why* people with PTSD tend to exhibit a memory amplification effect for trauma. In particular, our broad aim is to examine the proposal that errors in reality-monitoring cause victims of trauma to report more traumatic experiences over time. To this end, across several studies my thesis will test the key assumptions that underlie the reality-monitoring explanation for memory amplification. Specifically, we will examine whether: (1) re-experiencing symptoms are associated with memory distortion and/or response biases, (2) victims of *real-life* trauma experience involuntary trauma-related cognitions that include imagined (non-experienced) details, and (3) whether manipulating imagination of new (non-experienced) trauma details, using different experimental methods, affects memory amplification.

By rigorously testing the assumptions underlying reality-monitoring explanation, we hope to elucidate the potentially important role that the re-experiencing symptoms of PTSD play in how people remember their past. Indeed, as discussed in Chapter 1, current dominant models of PTSD fail to account for how or why victims of trauma might remember their experiences differently over time (Brewin, Dalgleish, & Joseph, 1996; Ehlers & Clark, 2000). Thus, the purpose of my thesis will be to extend existing models by examining the viability of one potential pathway that could lead to such inconsistencies in memory. The following sections provide a brief overview of the structure of my thesis and the main objective of each chapter. Conclusions on the basis of these studies are discussed in Chapter 9.

3.1. Chapter 4

The primary aim of this chapter was to examine, across two studies, whether we could replicate the memory amplification effect within a controlled, laboratory setting using a novel trauma analogue design. Our secondary objective was to determine whether analogue re-experiencing symptoms are correlated with memory amplification, as commonly found in the field

research.

3.2. Chapter 5

The main objective of this study was to determine whether victims of trauma experience involuntary cognitions that contain imagined details (i.e., involuntary elaborative non-memories), consistent with the reality-monitoring explanation for memory amplification. Furthermore, in this study we examined whether people with heightened PTSD symptoms are more susceptible to these cognitions, and how such cognitions are experienced, relative to involuntary memories of trauma. We were specifically interested in whether involuntary memories and involuntary elaborative non-memories were comparable in their experience, and therefore easily confusable, consistent with the reality-monitoring hypothesis.

3.3. Chapter 6

In this chapter we investigated whether instructing people to elaborate on—i.e., imagine new details and expand upon—their memories of a trauma analogue would affect memory for that trauma analogue. We were primarily interested in whether internal generation of new details would cause people to endorse exposure to more trauma over time, consistent with a reality-monitoring error mechanism.

3.4. Chapter 7

In this study we aimed to determine whether it is possible to provoke involuntary cognitions that contain imagined details about trauma within the laboratory. Specifically, we examined whether the presentation of written cue words would lead to an enhancement of involuntary elaborative cognitions about a trauma analogue. The primary goal of this study was to develop an effective manipulation that would allow us to examine the impact of involuntary elaborative cognitions on memory.

3.5. Chapter 8

The purpose of this study was to examine whether experimentally manipulating the frequency of involuntary cognitions—using the methods described in Chapter 7—would lead to changes in memory amplification for a trauma analogue. In particular, we examined whether provoking involuntary cognitions about a trauma analogue would result in participants becoming more likely to endorse trauma exposure over time, consistent with the reality-monitoring explanation for memory amplification.

4. Memory amplification for trauma: Investigating the role of analogue PTSD symptoms in the laboratory[2]

Author Contributions

All authors developed the study design. J.O. performed data collection, data analysis and interpretation under the supervision of M.T. and D.S. J.O drafted the paper, and M.T. and D.S. provided critical revisions. All authors approved submission of the final version.

Abstract

Victims of trauma often remember their experience as being more traumatic later, compared to immediately after, the event took place. This finding—the "memory amplification effect"—is associated with increased re-experiencing symptoms. However, the effect has been found almost exclusively in field-based studies. We examined whether the effect could be replicated in the laboratory. In two studies, we exposed participants to negative photographs and assessed their memory for the photographs and analogue PTSD symptoms on two occasions. In Study 1, analogue symptoms at follow-up were positively associated with remembering more negative photos over time. In Study 2, we focused on "memory amplifiers": people whose memory of the photos amplified over time. Consistent with field research, analogue re-experiencing symptoms were associated with memory amplification. Overall, our findings confirm that analogue PTSD symptoms are also associated with an amplified memory for a trauma analogue.

4.1. Introduction

Memories for traumatic events are subject to distortion via several different suggestive influences (e.g., Crombag, Wagenaar, & van Koppen, 1996; Nourkova, Bernstein, & Loftus, 2004). However, victims of trauma can be inconsistent about what they remember, in the absence of explicit suggestion. Specifically, people with poor adjustment following trauma often come to

[2] Oulton, J. M., Takarangi, M. K., & Strange, D. (2016). Memory amplification for trauma: Investigating the role of analogue PTSD symptoms in the laboratory. *Journal of Anxiety Disorders, 42*, 60-70. doi: 10.1016/j.janxdis.2016.06.001

remember their experience as being more traumatic over time: the "memory amplification effect" (e.g., Southwick, Morgan, Nicolau, & Charney, 1997). This finding is important because a Post-Traumatic Stress Disorder (PTSD) diagnosis is contingent upon a person's memory for a traumatic event. Moreover, following diagnosis, an amplified trauma memory may impede recovery. At present, no controlled laboratory studies have investigated this effect and, thus, the underlying mechanism remains unclear. Therefore, we examined whether the memory amplification effect occurs in a laboratory-based trauma analogue design. Further, we examined the relationship between analogue PTSD symptoms and memory amplification.

The most convincing evidence for memory amplification comes from field studies assessing trauma exposure reports over time. For example, Southwick et al. (1997) asked Gulf War veterans one month and two years following their deployment whether they had been exposed to several war-related stressors (e.g., seeing others killed or wounded). Eighty-eight percent of veterans changed their response to at least one event at follow-up. Critically, most of these changes were from no to yes, with 70% of the veterans recalling at least one event later that they had not reported initially. This memory amplification pattern replicates among Vietnam veterans (King et al., 2000), Dutch soldiers (Engelhard, van de Hout & McNally, 2008), American peacekeepers (Roemer, Litz, Orsillo, Ehlich, & Friedman, 1998) and 9/11 disaster restoration workers (Giosan, Malta, Jayasinghe, Spielman, & Difede, 2009). Critically, people with poor adjustment following a trauma are more likely to exhibit memory amplification. Specifically, PTSD symptoms at follow-up are positively associated with the number of no-to-yes response changes participants make over time (e.g., Engelhard et al., 2008; Southwick et al., 1997). The correlations are typically small, but significant, including 0.20, 95% CI [0.16, 0.24] (Giosan et al., 2009), 0.23 [0.06, 0.38] (Engelhard et al., 2008), 0.26 [0.22, 0.30] (King et al., 2000) and 0.32 [0.17, 0.60] (Southwick et al., 1997).

Researchers have proposed several explanations for memory amplification. First, Southwick et al. (1997) suggest that some memories are initially denied or repressed and then, over time, recovered. However, given the lack of controlled laboratory evidence supporting the existence of

repression, this explanation is unlikely (e.g., McNally, 2003). Second, people may reinterpret previously remembered events due to external influences, such as discussions with co-victims (Bolton, Gray, & Litz, 2006; King et al., 2000; Southwick et al., 1997). Third, events people previously considered irrelevant may be reappraised as significant to make sense of emerging psychopathology (Bolton et al., 2006; Engelhard et al., 2008; King et al., 2000; Southwick et al., 1997). For example, people may unconsciously exaggerate trauma memories to understand their increasing distress. Alternatively, memory amplification might reflect mood-congruent memory processes (Bower, 1981), whereby people recall information that is congruent with their current mood or emotional state.

Recently, researchers have proposed that memory amplification reflects a failure in reality-monitoring (King et al., 2000; Strange & Takarangi, 2012, 2014). According to the Source Monitoring Framework (Johnson, Hashtroudi, & Lindsay, 1993), people do not store details of their experiences in memory with labels specifying their origins. Instead, people rely on heuristics, such as how familiar event details feel, to determine whether a detail actually occurred or was merely imagined. Critically, post-event processing—such as imagining new event details—can increase the familiarity of new details enough that people mistakenly claim those details as genuine memory traces, resulting in memory distortion. Intrusions—a hallmark symptom of PTSD— could provide one source of inaccurate details and may be a springboard for other imagined images related to the event. Indeed, intrusion content following a trauma can include real events, and plausible extensions of the trauma (e.g., a stroke patient imagining having another stroke; Krans, de Bree, & Moulds, 2015; Reynolds & Brewin, 1998). There is empirical support for this explanation; people with severe re-experiencing symptoms (e.g., repeated nightmares about the trauma) are more likely to exhibit memory amplification (Giosan et al., 2009; Koenen, Stellman, Dohrenwend, Sommer, & Stellman, 2007; Roemer et al., 1998; Takarangi, Oulton, Green, & Strange, 2015).

However, the field research has not been able to test these explanations. Moreover, although existing research shows that “yes” responses become more probable over time (i.e., there

appears to be an overall change in response bias), we do not know how or if participants' memory accuracy (or sensitivity) changes over time. Put differently, because exposure to traumatic events is not corroborated, we do not know whether memory amplification reflects an increase in memory distortion or whether it reflects people underestimating events initially and giving more accurate reports at follow-up. Moreover, we do not know how or if analogue symptoms are related to how memory accuracy changes over time. We addressed these limitations using a laboratory analogue.

As a step towards a laboratory analogue, Strange and Takarangi (2012) had participants watch a film of a fatal road accident that they divided up into clips separated by blank screens. The researchers removed several of these clips before screening to determine whether participants would later falsely remember seeing them as part of the film. Some removed clips were "cruxes" (scenes crucial to the story, e.g., paramedics examining the driver's injuries)—these clips were also rated as the most traumatic scenes—the remainder were "non-cruxes" (least critical scenes, e.g., the arrival of a rescue helicopter). The researchers removed both cruxes and non-cruxes to determine whether the likelihood of false memories would depend on how critical the scene was to the film's story. Twenty-four hours after watching the film, participants completed a recognition test comprised of Old (i.e., previously seen) and New clips (i.e., previously unseen). Participants identified clips as "old" (previously seen) or "new" (unseen). There were two types of New clips: "Missing" clips (cruxes and non-cruxes) that the researchers removed from the film, and Control clips, which depicted different road accidents. Participants successfully identified Old and Control clips; however they also falsely remembered seeing—by saying "old" to—26% of the Missing clips. Critically, participants were more likely to remember the missing cruxes (compared to non-cruxes) and re-experiencing the film was positively related to falsely remember missing cruxes.

Although Strange and Takarangi's (2012) study was informative, it also has limitations. First, because they used a short film (i.e., 3 min 49 s), they tested participants' memory for a restricted number of clips, which were further constrained by the criteria for cruxes and non-cruxes. Therefore, there were very few opportunities for participants to falsely remember aspects of the film

and hence limited scope to examine the relationship between re-experiencing and false memories. Second, Strange and Takarangi assessed participants' memory accuracy for the trauma analogue once. By contrast, field studies have defined memory amplification as the change from not reporting an event as experienced, to claiming that the event was experienced. This operationalization reflects a change in response bias, in that people are more likely to respond "yes" to items over time. Thus, Strange and Takarangi do not shed light on whether re-experiencing symptoms influence how traumatic memories and response bias change over time. A closer replication of the field methodology in a controlled environment is necessary to test the underlying mechanisms of memory amplification.

Our aim, therefore, was to determine whether memory amplification would occur in the laboratory. Moreover, we were interested in whether there was any evidence that memory amplification results from repression, justification of distress, or reality-monitoring errors. Because we were primarily interested in whether internally generated material causes memory amplification, we did not test the external influences hypothesis. To address our aims, we used negative photos from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) as a trauma analogue. The normative valence and arousal ratings for IAPS photos greatly exceeds what is usually available for negative films and also allowed us to use more than one version of our trauma analogue.

To determine whether we could replicate Strange and Takarangi's (2012) memory distortion effect using different stimuli, we tested half our participants (single-test condition) only once (one week after viewing the photos). To simulate how memory amplification is tested in field research, by using within-subject comparisons of memory performance, we tested the remaining participants (multiple-test condition) on two occasions: 20 mins and one week after photo exposure. Participants' change in response bias over time was our measure of memory amplification. However, because the field research has not been able to, we were also interested in examining how participants' sensitivity changed over time. Our manipulation of test frequency also allowed us to

account for the possibility that prior testing or—as in our paradigm, viewing more negative photos overall—might, in itself, lead to memory distortion at the later test. Previous research suggests that testing on multiple occasions can create false memories because of exposure to alternative choices in the prior memory test (Brainerd & Reyna, 1996).

To test the reality-monitoring hypothesis, we measured frequency of involuntary and voluntary rehearsal. Although we were primarily interested in the role of involuntary cognition, people might intentionally generate new trauma-related information to make their memory more "complete" (e.g., Foa & Riggs, 1993), resulting in reality-monitoring errors. We asked participants how frequently they voluntarily thought and spoke about the photos over the week period, and monitored involuntary thoughts immediately after exposure to the photos and for seven days after.

We predicted that analogue PTSD symptoms would be associated with falsely remembering New (previously unseen) photos at test, therefore replicating Strange and Takarangi's (2012) findings. However, we also expected that analogue PTSD symptoms would be associated with a reduction in overall sensitivity (i.e., an increase in memory errors) for the photographs over time, consistent with the reality-monitoring explanation. Finally, we predicted that analogue re-experiencing and PTSD symptoms would be associated with an increased tendency to endorse analogue trauma exposure (i.e., a liberal response bias) over time, consistent with the field research.

4.2. Study 1

4.2.1. Method

4.2.1.1. Participants. We recruited 109 participants but excluded data from eight participants who failed to complete the test, two who failed to follow instructions, two who inadvertently received the wrong test and one who had been exposed to similar IAPS photos previously. Our analyses focused on the remaining 96 participants (23.96% male). Nineteen were undergraduate students from Flinders University who received course credit; the remaining 77 were recruited through community advertising and received an honorarium.

4.2.1.2. Materials

4.2.1.2.1. *Trauma analogue.* We selected 80 standardized IAPS (Lang et al., 2008) photographs (See Appendix A.) depicting negative scenes (e.g., death) and divided them into four sets of 20 target photos that were matched for mean valence, *F*s < 1 (Set 1: *M* = 1.84, *95% CI* [1.75, 1.94], Set 2: *M* = 1.84 [1.72, 1.96], Set 3: *M* = 1.87 [1.76, 1.98], Set 4: *M* = 1.85 [1.80, 1.90]) and arousal (Set 1: *M* = 6.31 [6.06, 6.56], Set 2: *M* = 6.26 [5.93, 6.58], Set 3: *M* = 6.27 [5.91, 6.64], Set 4: *M* = 6.26 [6.00, 6.52]). Participants saw two sets at encoding. An additional 20 negatively valenced photos—10 at the beginning and 10 at the end of encoding—acted as primacy and recency buffers, which were the same for every participant and never appeared at test. Thus, participants saw 60 photos. Sets were counterbalanced across participants such that each combination was presented equally.

4.2.1.2.2. *Trauma History Screen (THS).* The THS (Carlson et al., 2011) is a brief self-report measure of frequency of exposure to high magnitude stressor (HMS) events and events associated with persisting posttraumatic distress (PPD). The test-retest reliability of overall HMS and PPD scores is excellent: *r* = 0.93 and *r* = 0.73 respectively (Carlson et al., 2011). Construct validity is supported by significant correlations between HMS scores and PTSD symptoms—as measured by the PTSD Checklist (PCL-C)—ranging from 0.22 for University samples to 0.41 for homeless veterans.

4.2.1.2.3. *Beck Depression Inventory (BDI-II*). We used the 21-item BDI-II (Beck, Steer, & Brown, 1996) to measure depression symptoms. Participants rate each item on a Likert scale (e.g., 0 = I do not feel I am worthless, 3 = I feel utterly worthless; range: 0–63). The BDI–II has high internal consistency (alpha = 0.93 among college students, alpha = 0.92 among outpatients; Beck et al., 1996) and correlates strongly with the Symptom Checklist-90-Revised (SCL-90-R) depression subscale (*r* = 0.89; Steer, Ball, Ranieri, & Beck, 1997) and the Hamilton Psychiatric Rating Scale for Depression (*r* = 0.71; Beck et al., 1996).

4.2.1.2.4. *State-trait anxiety inventory-trait scale (STAI-T).* We used the 20-item trait subscale of the STAI (Spielberger, Gorsuch, & Lushene, 1970) to measure participants' stable propensity to experience anxiety. Participants rate items (e.g., "*I feel like a failure*") on a Likert scale (1 = almost never, 4 = almost always; range: 20–80). The STAI-T has excellent internal consistency (alpha = 0.89) and test-retest reliability (r = 0.88) (Barnes, Harp, & Jung, 2002). Concurrent validity with other anxiety questionnaires ranges from 0.73 to 0.85 (Spielberger, 1983).

4.2.1.2.5. *Positive affect negative affect schedule (PANAS).* We measured participants' positive and negative affect using the 20-item PANAS (Watson, Clark, & Tellegen, 1988). The items (e.g., "*excited*" and "*nervous*") are measured on a Likert scale (1 = Very slightly or not at all, 5 = Extremely). Test-retest reliability is high: 0.81 (NA) and 0.79 (PA) (Watson et al., 1988). The scales have excellent convergent and divergent correlations with more extensive measures of mood (Watson et al., 1988). The Negative Affect subscale correlates highly with the Hopkins Symptom Checklist (HSCL) (r = 0.74) and the Positive Affect subscale has a modest negative correlation with the BDI (r = −0.34).

4.2.1.2.6. *Photo ratings.* After photo exposure, participants responded to the question "*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 they found the photos (1 = not at all, 7 = extremely).

4.2.1.2.7. *Intrusion monitoring and vigilance task.*

Participants pressed a key whenever they experienced an intrusive memory, for 5 min after encoding (e.g., Kubota, Nixon, & Chen, 2015). We described intrusions as recollections of the photographs that appeared spontaneously in consciousness. For each intrusion, participants recorded: (a) a description of the content in a few words; (b) the type (image, thought or combination) (c) level of distress associated with the intrusion (1 = not at all distressing, 5 =

extremely distressing); (d) vividness (1 = not at all vivid, 5 = extremely vivid); and (e) how hard they tried to push it out of their mind (1 = not at all, 5 = completely). Participants recorded these details in a booklet during the monitoring period, immediately after they pressed the key. Participants concurrently worked on a monotonous computer vigilance task that involved identifying rarely occurring vertical lines among a stream of horizontal lines. Such tasks reliably induce task-unrelated thoughts (Giambra, 1989). We used this task to encourage intrusions so that we would not be working with a low base rate or floor effect. Following the monitoring period, participants rated their compliance with the monitoring phase instructions (1 = not at all well, 7 = extremely well).

4.2.1.2.8. *Recognition test.* The immediate and delayed recognition tests comprised 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 neutral photos from the IAPS—included to assess attention—and the other set was a target negative photo set. Participants identified each photo as old or new and indicated their confidence (1 = not at all confident, 10 = extremely confident). There were twelve versions of the test, counterbalanced so that every photo appeared equally often as 'new' and 'old' across participants. The delayed recognition test contained different photos to the immediate test. Thus, inaccurate responses at T2 could not be the result of mistaking photos from the first test as originating from the encoding phase.

4.2.1.2.9. *Daily thought diary.*Participants recorded intrusions in a paper diary for one week following the laboratory session. The diaries were formatted identically to the monitoring booklet. Each night, participants copied their data from the paper diary to an online diary. We also asked participants whether they had voluntarily thought or spoken about the photos that day. If they responded yes, participants described the voluntary thoughts, and indicated thought frequency (1 = not at all, 5 = nearly all the time).

4.2.1.2.10. *PTSD checklist (PCL).* We used the PCL (Weathers, Litz, Herman, Huska, & Keane, 1993) to assess participants' analogue trauma symptoms in relation to the Photos 20 min after encoding[3] and a week after the encoding session. Participants rated how bothered they were by 17 items describing PTSD symptoms since viewing the photos (e.g., "*having difficulty concentrating*," 1 = not at all, 5 = extremely). The test-retest reliability of the PCL is high (r = 0.96; Weathers et al., 1993). The subscales of the PCL have high internal consistency (re-experiencing: a = 0.94, hyperarousal: a = 0.92, avoidance: a = 0.91; Keen, Kutter, Niles & Krinsley, 2008) and correlate with other measures of PTSD symptomology (Ruggiero, Del Ben, Scotti, & Rabalais, 2003), including the Impact of Event Scale (re-experiencing: r = 0.76, hyperarousal: r = 0.64, avoidance: r = 0.71; Horowitz,Wilner, & Alvarez, 1979) and the Mississippi Scale for PTSD-Civilian Version (re-experiencing: r = 0.71, hyperarousal: r = 0.74, avoidance: r = 0.78; Vreven, Gudanowski, King, & King, 1995).

4.2.1.2.11. *Experience of Intrusions Scale.* We used the Experiences of Intrusions Scale (EIS; Salters-Pedneault, Vine, Mills, Park & Litz, 2009) to assess intrusion qualities. Participants rated five items that assess the frequency, unwantedness and unpredictability of intrusions, including the distress and interference the intrusions caused (1 = not at all/almost never, 5 = extremely/very frequently). The EIS has good internal consistency (Cronbach's a's >0.83) and test-retest reliability (r = 0.83). It correlates with other intrusion measures, including the re-experiencing subscale of the PCL-C (Weathers et al., 1993; r = 0.22).

4.2.1.3. 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. We informed participants in the study advertisement and information form that

[3] For the first administration of the PCL, we omitted 5 items because they are meaningless for a 20-min 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 in total (see also Monds, Paterson, Kemp, & Bryant, 2013). Participants completed the full (17-item) version of the PCL a week later.

participation would involve viewing potentially disturbing images.

Following informed consent procedures, participants completed the THS, STAI-T, BDI-II and PANAS, respectively. Next, they viewed the buffer and target photographs on a computer screen; the latter appeared in a randomized order. Each photograph appeared for 2.5 s and was followed by a blank screen for 1.5s. We previously informed participants that we were interested in the effect of self-relevance on responses to emotional material, to minimize the likelihood of participants guessing the study aims or anticipating memory tests. To bolster the credibility of this cover story, and encourage deeper processing of the photos, we asked participants to rate each photo (i.e., "*Please indicate how relevant the content of the photo is to you or your life*") on a Likert scale (1 = not at all relevant, 7 = extremely relevant), following each presentation of the blank screen.

After encoding, participants completed the PANAS again, followed by the intrusion monitoring and vigilance task. We then thanked participants in the single-test condition for their participation and provided them with paper diaries and accompanying instructions. We informed participants that there would be an "online task" in a week's time, but did not reveal that it would be a memory test. The multiple-test condition completed crossword puzzles for 20 min after the monitoring period and then completed the immediate recognition test and PCL. We then gave participants the paper diaries and accompanying instructions. Participants completed the diary for seven days following their initial experimental session. On the eighth day, we emailed participants a link to a Qualtrics survey that contained the PANAS, the delayed recognition test, the EIS and PCL, respectively. Once completed, we debriefed participants.

4.2.2. Results and Discussion. Several measures were skewed. Log transformations only slightly reduced the skew and the overall pattern of results was the same; thus, we retained the original untransformed data for analysis. We first conducted analyses to determine the baseline characteristics of our sample.

4.2.2.1. Sample characteristics. Approximately 79% of the sample reported experiencing at least one high magnitude stressor in their lifetime and 36.5% reported one or more events associated with significant subjective distress lasting more than one month (PPD events). Independent samples t-tests with a Bonferroni-adjusted significance level of 0.01 revealed that our conditions were comparable on all baseline measures (*p*s > 0.01). Table 4-1 displays the descriptive statistics.[4]

Table 4-1.

Baseline measures by test condition, including means (with 95% confidence intervals) and inferential statistics.

	Multiple Test Condition	Single Test Condition	Statistic
BDI-II	10.85 [7.99, 13.72]	12.37 [9.04, 15.70]	$t(94)=-0.70$, $p=.49$, $d=0.14$ [-0.26, 0.54]
STAI-T	42.56 [39.46, 45.65]	43.02 [39.53, 46.52]	$t(94)=-0.20$, $p=.84$, $d=0.04$ [-0.36, 0.44]
TS	1.02 [.66, 1.38]	1.25 [.91, 1.59]	$t(94)=-0.94$, $p=.35$, $d=0.19$ [-0.21, 0.59]
HMS	3.72 [2.30, 5.14]	5.47 [3.64, 7.30]	$t(88.61)=-1.52$, $p=.13$, $d=0.31$ [-0.09, 0.71]
PPD	.44 [.24, .64]	.54 [.32, .77]	$t(94)=-0.70$, $p=.49$, $d=0.14$ [-0.26, 0.54]

Note. BDI-11=Beck Depression Inventory, STAI-T=Trait Subscale of State Trait Anxiety Inventory, TS=Traumatic Stressor Exposure, HMS=High Magnitude Stressor Exposure, PPD=Persisting Posttraumatic Distress Events

4.2.2.2. Emotional impact of photos. We compared positive and negative affect scores before and after viewing the photos, using 2 (single-test, multiple-test) × 2 (before, after) mixed ANOVAs. There were no main effects of condition, *F*s < 1. However, there were significant main effects of time for positive (F (1, 94) = 70.70, MSE = 20.61, $p < 0.001$, $\eta_p^2 = 0.43$, *95% CI* [0.28, 0.54]) and negative ($F(1, 94) = 68.76$, MSE = 31.03, $p < 0.001$, $\eta_p^2 = 0.42$ [0.27, 0.54]) affect. Participants experienced a decline in positive (before: $M = 30.03$, *95% CI* [28.52, 31.54], after: $M =$ 24.52, [22.90, 26.14]); $t(95) = 8.45$, $p < 0.001$, $d = 0.71$ [0.52, 0.91], and an increase in negative

[4] We transformed data for High Magnitude Stressors from the Trauma History Screen (THS) using Winsorization, which has the advantage of retaining all data and their magnitudes (Sheskin, 2003). This transformation was necessary because some participants exposed to repeated stressors (e.g., childhood abuse) reported extreme HMS levels. 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).

affect (before: M = 14.30 [13.30, 15.31]), after: M = 20.97 [19.12, 22.82]; $t(95) = -8.31$, $p < 0.001$, d = 0.91 [0.66, 1.16].

Participants rated the photos as being moderately to very unpleasant (M = 4.85, *95% CI* [4.49, 5.22]), moderately distressing (M = 3.45 [3.08, 3.82]) and moderately to very disgusting (M = 4.43 [4.01, 4.84]). Ratings did not differ significantly between conditions (ps > 0.05), with the exception of distress: perhaps merely a coincidence given random assignment, the single-test condition rated the photos as more distressing (M = 3.85 [3.36, 4.35]) than the multiple test condition (M = 3.04 [2.51, 3.58]), $t(94) = -2.24$, p = 0.03, d = 0.46, *95% CI* [0.05,0.86]. Participants paid very close attention to the photos (M = 5.74 [5.51, 5.97]) and there was no significant difference between conditions, $p > 0.05$. Participants' mean PCL score was 23.84 (*95% CI* [21.97, 25.71]) a week after encoding[5], with scores ranging from 17 to 76. PCL and subscale scores were comparable across conditions (ps > 0.05), suggesting that exposure to additional photographs via a second test did not alter analogue PTSD symptoms.

4.2.2.3. Memory accuracy. Before turning to our primary aim to examine memory amplification, we first analyzed participants' memory accuracy following Strange and Takarangi's (2012) approach, to examine whether we replicated their memory distortion effect. We calculated the mean proportion of "old" responses to Old and New negative photos, and Neutral photos (e.g., the number of times a participant responded "old" to a New negative photo, divided by the total number of New negative photos presented at test). A week after viewing the photos (i.e., at T2), participants incorrectly identified Neutral (control) photos only 4.69% (*95% CI* [0.03, 0.06]) of the time[6]. We did not consider this floor effect any further. Both conditions correctly identified most Old photos, but incorrectly identified New negative photos (see Table 4-2). Indeed, our memory distortion rate was comparable to Strange and Takarangi (2012; M = 0.26 [0.20, 0.31]). A 2 (condition: multiple-

[5] Four participants had missing data for one item on the PCL a week after encoding. For these participants, we substituted missing values with the mean of all valid items on the PCL for that participant

[6] A total of 14 participants (7 in each condition) had technical difficulties when completing the delayed test online (e.g., the test crashed and restarted). For these participants, we used their responses to the first time they saw each item on the test, rather than their 'final' completed test.

test, delayed test) x 2 (photo type: old, new) mixed model ANOVA confirmed no interaction between condition and photo type, F (1, 94) = 0.13, MSE = 0.02, p = 0.72, η_p^2 < 0.01, *95% CI* [0.00, 0.05]; and no main effect of condition, F (1, 94) = 3.28, MSE = 0.02, p = 0.07, η_p^2= 0.03 [0.00, 0.13]. Thus, multiple testing did not lead to more memory distortion at T2. There was a main effect of photo type (F (1, 94) = 520.83, MSE = 0.02, p < 0.001, η_p^2= 0.85 [0.79, 0.88]): participants responded "old" to Old photos significantly more frequently than New photos.

Table 4-2.

Mean proportion 'OLD' responses for the delayed test (with 95% confidence intervals) for Old, New and Neutral (control) photos in each condition.

	Condition		
Photo Type	Multiple Test Condition	Single Test Condition	Statistic
Neutral (control)	.06 [.04, .09]	.03 [.01, .05]	*t*(81.42)=2.09, *p*=.04*, *d*=0.43 [0.02, 0.83]
Old	.72 [.66, .77]	.77 [.72, .81]	*t*(94)=-1.64, *p*=.11, *d*=0.33 [-0.07, 0.73]
New	.25 [.19, .30]	.31 [.26, .35]	*t*(94)=-1.35, *p*=.18, *d*=0.27 [-0.13, 0.67]

Note. * p< .05

Next we turned to our primary interest in whether participants' memory of the trauma analogue would amplify over time. Specifically, we wanted to know whether participants would respond "old" to more negative photos at Time 2 (T2) compared to Time 1 (T1) (change in response bias), therefore replicating the field research. Moreover, we were interested how participants' memory sensitivity changed over time, because the field research has not addressed this issue. To separate participants' ability to correctly remember whether they have seen a photo (i.e., sensitivity) from their response bias (i.e. their inclination toward saying "old"), we used a signal detection approach (Stainslaw & Todorov, 1999). We classified Old photos as signal events and New negative photos as noise events: correctly classifying an Old photo as "old" was a hit, and incorrectly classifying a New negative photo as "old" was a false alarm. We calculated signal detection measures *d'* (sensitivity) and *c* (response bias); c < 0 is a response bias toward saying old

to test items, and $c > 0$ is a response bias toward saying new to test items. A *d'* value of 0 indicates an inability to distinguish between Old and New photos, whereas larger values indicate an increasing ability to distinguish Old from New photos.

Participants' sensitivity significantly worsened over time (T1: $M = 2.67$, *95% CI* [2.51, 2.82]); T2: $M = 1.48$ [1.32, 1.65], $t(47) = 11.28$, $p < 0.001$, $d = 2.12$, *95% CI* [1.55, 2.68][7]. This finding is inconsistent with the repression hypothesis because memory for the trauma analogue did not improve (or "recover") over time, but deteriorated. Contrary to expectations, we did not observe a memory amplification effect overall: participants became less biased to respond "old" over time. That is, participants' *c* scores became closer to 0 over time (T1: $M = -0.24$ [−0.33, −0.16]); T2: $M = 0.06$ [−0.11, 0.24], $t(47) = -3.74$, $p=0.001$, $d = 0.64$ [0.28, 1.00]). Thus, although we find a decrease in sensitivity, we know that this effect does not result from exclusively endorsing additional negative photos (i.e., a response bias). Put another way, people were increasingly unable to identify what they really experienced: they incorrectly identified both New negative photos as "old" and Old negative photos as "new."

Of course, our trauma analogue was likely less distressing than real-life traumas, potentially reducing the likelihood of memory amplification. Furthermore, perhaps "memory amplification" occurred among a particular subset of individuals who found the photos to be particularly distressing. Indeed, we found that distress ratings predicted "old" responses to New negative photos (i.e., false memories) at T2 ($r = 0.26$, *95% CI* [0.06, 0.44], $N = 96$, $p = 0.01$), as well as a response bias to respond "old" at T2 ($r = -0.22$ [−0.40, −0.02], $N = 96$, $p = 0.03$). Note however that the relationship between sensitivity and distress ratings was not significant, $r = -0.12$ [−0.31, 0.08], $N = 96$, $p = 0.24$.

4.2.2.4. Memory accuracy and analogue PTSD symptoms. Next, we turned to our main hypotheses regarding the relationship between memory and analogue symptoms. We predicted that

[7] Neither *d*' nor *c* scores significantly differed between conditions, *ps* > 0.05. Thus, multiple testing did not affect bias or sensitivity.

analogue symptoms would be positively associated with memory distortion. Importantly, we operationalized memory distortion in two distinct ways. Specifically, we considered both participants' proportion of "old" responses to New negative photos (i.e., memory distortion as defined by Strange and Takarangi, 2012) and participants' sensitivity over time (i.e., participants' overall ability to distinguish between Old and New photos). We predicted that analogue symptoms would be positively associated with "old" responses to New negative photos a week after encoding, consistent with Strange and Takarangi's findings. However, we also predicted that analogue symptoms would be associated with a reduction in sensitivity over time, consistent with the reality-monitoring hypothesis.

Consistent with Strange and Takarangi (2012), the more analogue symptoms people experienced in relation to the photographs, the more they responded "old" to New (previously unseen) photos (total: $r = -0.23$, *95% CI* [−0.41, −0.03], $N = 96$, $p = 0.03$, re-experiencing: $r = -0.13$ [−0.32, 0.07], $N = 96$, $p = 0.21$, avoidance/numbing: $r = -0.26$ [−0.44, −0.06], $N = 96$, $p = 0.01$, arousal: $r = -0.21$ [−0.39, −0.01], $N = 96$, $p = 0.04$). However, analogue PTSD symptoms were not significantly related to change in sensitivity (i.e., *d'* scores at T2 subtracted from *d'* scores at T1), $r = -0.24$ [−0.49, 0.05], $N = 48$, $p = 0.10$ (re-experiencing: $r = -0.09$ [−0.36, 0.20], $p = 0.53$; avoidance: $r = -0.27$ [−0.51, 0.02], $p = 0.06$; hyperarousal: $r = -0.25$ [−0.50, 0.04], $p = 0.09$). Thus, analogue symptoms did not predict how participants' overall memory accuracy changed over time. Note however, that analogue PTSD symptoms at T2 were associated with an increase in "old" responses to New photos (i.e., false memories) over time[8], $r = 0.47$ [0.21, 0.66], $N = 48$, $p = 0.001$ (reexperiencing: $r = 0.35$ [0.07, 0.58], $p = 0.01$, avoidance: $r = 0.37$ [0.10, 0.59], $p < 0.01$, hyperarousal: $r = 0.51$ [0.26, 0.69], $p < 0.001$). Thus, although analogue symptoms do not predict how participants' general memory distortion (i.e., performance on New and Old items) for the trauma analogue changes over time, they are associated with an increased tendency to respond "old" to photos that have never been seen before, which is consistent with the reality-monitoring

[8] We computed a change in false memory score to run this analysis. Specifically, we subtracted the proportion of "old" responses to new photographs at T1 from the proportion of "old" responses to new photographs at T2.

hypothesis.

Finally, we turned our attention to our main research question: are analogue PTSD symptoms associated with an increase in response bias toward saying "old" over time (i.e., memory amplification) in the lab? We expected that participants who became more biased to respond "old" over time—"amplifiers"—would experience more analogue symptoms compared to the people whose memory did not, non-amplifiers, consistent with the field research. We calculated a change in response bias (or memory amplification) score by subtracting *c* scores at T2 from *c* scores at T1. Positive values represented becoming more biased to respond "new" over time, and negative values represented becoming more biased to respond "old" over time (i.e., memory amplification). Fourteen participants (29.17%) were amplifiers (i.e., they became more biased to respond "old"), 33 (68.75%) became more biased to respond "new", and one participant's bias did not change. Notably, the proportion of amplifiers was lower than findings from field research, for example; 61% (Giosan et al., 2009) and 51%[9] (Krinsley, Gallagher, Weathers, Kutter, & Kaloupek, 2003). Amplifiers and non-amplifiers did not differ on any of our baseline measures (*p*s > 0.05), with the exception of past trauma: non-amplifiers reported significantly more past events associated with persisting posttraumatic distress than amplifiers, $t(44) = 2.04$, $p=0.048$, $d = 0.52$, *95% CI* [−0.01, 1.15].

Consistent with the field research and our prediction, the more participants reported analogue symptoms at T2, the more likely they were to exhibit memory amplification in the form of a change in response bias[10] (total: $r = -0.29$, *95% CI* [−0.53, −0.01], $N = 48$, $p = 0.047$, re-experiencing: $r = -0.26$ [−0.51, 0.03], $N = 48$, $p = 0.08$, avoidance/numbing: $r = -0.17$ [−0.43, 0.12], $N = 48$, $p = 0.26$, hyperarousal: $r = -0.33$ [−0.56, −0.05], $N = 48$, $p = 0.02$). Note however,

[9] Giosan et al. (2009) defined memory amplifiers as the proportion of participants who increased the number of variables endorsed at T2. Krinsley et al. (2003) defined memory amplifiers as the participants who reported more lifetime traumatic events at the second interview.

[10] Following prior prospective research on memory amplification (e.g., Giosan et al., 2009), we also correlated memory change scores (i.e., the change in number of photos (both old and new) endorsed over time) with PCL scores. Consistent with prior research, the correlation between T2 PCL scores and memory change scores was significant (total: $r = -0.32$, *95% CI* [−0.55, −0.04], $N = 48$, $p = 0.03$, reexperiencing: $r = -0.27$ [−0.02, 0.51], $p = 0.06$, avoidance/numbing: $r = -0.17$ [−0.43, 0.12], $p = 0.24$, arousal: $r = -0.39$ [−0.61, −0.12], $p = 0.01$).

that the relationship between analogue re-experiencing symptoms and memory amplification was not significant. The correlation between T1 PCL scores and change in response bias (i.e. memory amplification) was less strong, and only approached statistical significance (total: $r = -0.23$ [−0.48, 0.06], $N = 48$, $p = 0.12$, re-experiencing: $r = -0.25$ [−0.50, 0.04], $N = 48$, $p = 0.09$, avoidance/numbing: $r = -0.08$ [−0.36, 0.21], $N = 48$, $p = 0.60$, arousal: $r = -0.24$ [−0.49, 0.05], $N = 48$, $p = 0.11$).

4.2.2.5. Memory confidence. Participants were more confident in their responses to Old ($M = 8.07$, *95% CI* [7.84, 8.30]) compared to New negative photos ($t(95) = -4.32$, $p < 0.001$, $d = 0.33$, *95% CI* [0.17, 0.48]) and neutral ($M = 9.12$ [8.89, 9.35]) compared to New negative photos, $t(95) = 11.30$, $p < 0.001$, $d = 1.13$ [0.87, 1.38]. Critically however, participants were relatively confident in their memories for New photos a week after viewing them ($M = 7.65$ [7.36, 7.94]), despite falsely remembering approximately 28% of them.

4.2.2.6. Intrusive thoughts. We measured participants' intrusions at three time points: immediately after encoding, during the week following encoding, and at the conclusion of the study using the EIS. We predicted that our intrusion measures would be positively associated with memory amplification because the more people re-experience or imagine an event, the greater the likelihood of reality monitoring errors. Prior to conducting analyses, we excluded several diary entries because they did not meet our definition of intrusions (i.e., recollections of the photographs that appeared spontaneously in consciousness)[11]. In addition, for some participants, we manually entered their paper diary entries for analysis.[12] Table 4-3 displays the descriptive data for intrusion characteristics and Table 4-4 shows the relationships between intrusion characteristics and our memory measures. Critically, immediate intrusions, weekly intrusions and EIS scores were not

[11] 15 participants reported at least one non-intrusion, which was subsequently excluded from the analysis. We removed 36 non-intrusions in total. All removed non-intrusions were first confirmed by a second coder for not meeting our criteria of intrusions.

[12] A total of 25 participants had "irregular" online diary entries (e.g., too many or not enough entries, missing data). For these participants we manually entered their paper diary data for analysis. For the remaining participants, we randomly selected 3 paper diary entries for each participant and checked for any discrepancies against their online diary data. We found discrepant entries for 22 participants and therefore manually entered all of the paper data for these participants.

related to any of our memory measures. Moreover, intrusion characteristics were not significantly related to test performance, with the exception of suppression: suppression of intrusive thoughts predicted poorer memory sensitivity at T2. It is possible that suppression resulted in a rebound of intrusions, causing more confusion at test.

Inconsistent with our primary hypothesis, none of our intrusion measures correlated with memory amplification (change in response bias) in the multiple-test condition (*p*s > 0.05), but the relationship was in the predicted direction for diary intrusions ($r = -0.11$, *95%CI* [−0.38, 0.18], $N = 48$, $p = 0.44$) and the EIS ($r = -0.13$ [−0.40, 0.16], $N = 48$, $p = 0.39$). Moreover, amplifiers tended to report more intrusions in their diary ($M = 5.43$, *95% CI* [1.63, 9.22]) compared to non-amplifiers ($M = 2.79$ [1.82, 3.76]), $t(45) = -1.96$, $p = 0.17$, $d = 0.63$ [−0.01, 1.27].

Table 4-3.

Means (with 95% confidence intervals) for intrusion characteristics in the multiple-test and delayed test.

	Multiple test Condition	Single Test Condition	Statistic
Immediate Intrusions			
Frequency	1.67 [1.26, 2.07]	1.96 [1.46, 2.46]	*t*(94)=-.91 , *p*=.37, *d*=0.18 [-.22, .58]
Vividness	2.95 [2.10, 3.20]	3.32[3.00, 3.63]	*t*(67)=-1.86 , *p*=.07, *d*=0.45 [-0.03,0.93]
Distress	2.59 [2.18, 2.99]	3.01 [2.67, 3.35]	*t*(67)=-1.63 , *p*=.11, *d*=0.39 [-.09, 0.87]
Suppression	3.35 [2.91, 3.77]	3.19 [2.84, 3.54]	*t*(67)=0.56 , *p*=.58, *d*=0.14 [-0.33, 0.61]
Diary Intrusions			
Frequency	3.46 [2.19, 4.73]	3.54 [2.41, 4.67]	*t*(94)=-.10, *p*=.92, *d*=0.02 [-.38, .42]
Vividness	2.74 [2.44, 3.04]	2.89 [2.63, 3.15]	*t*(79)=-.77, *p*=.44, *d*=0.17 [-0.27, 0.61]
Distress	2.39 [2.02, 2.76]	2.34 [2.07, 2.62]	*t*(78)=.20 , *p*=.84, *d*=0.04 [-0.40, 0.48]
Suppression	3.07 [2.62, 3.51]	2.72 [2.37, 3.07]	*t*(74.87)=1.24 , *p*=.22, *d*=0.28 [-0.16, 0.72]
Experience of Intrusions (EIS)	9.17 [8.15, 10.18]	10.23 [9.25, 11.21]	*t*(94)=-1.52, *p*=.13, *d*=0.31 [-.09, .71]

4.2.2.7. Voluntary thoughts. Most (78.1%) participants voluntarily thought or spoke about the photos on at least one day following photo exposure, however only occasionally (1 = not at all, 5 = nearly all the time; multiple-test: *M* = 2.06, *95% CI* [1.95, 2.18], single-test: *M* = 2.20 [2.01, 2.39]). Frequency of voluntary thoughts was not related to any of our memory amplification measures (*p*s > 0.05).

Table 4-4.

Correlations (and 95% CIs) between intrusion characteristics and "old" responses to New photos, response bias and sensitivity in the multiple-test and single-test condition.

	"Old" Responses to New Photos		Response Bias		Sensitivity	
	Multiple-test Condition	Single-test Condition	Multiple-test Condition	Single-test Condition	Multiple-test Condition	Single-test Condition
Immediate Intrusions						
Freq	-.03 [-.31, .26]	.07 [-.22, .35]	.00 [-.28, .28]	.03 [-.26, .31]	.19 [-.10, .45]	-.16 [-.42, .13]
Vivid	.04 [-.25, .32]	-.26 [-.51, .03]	.03 [-.26, .31]	.19 [-.10, .45]	-.13 [.40, .16]	.13 [-.16, .40]
Distress	.26 [-.03, .51]	-.16 [-.42, .13]	-.23 [-.48, .06]	.17 [-.12, .43]	-.06 [-.34, .23]	.04 [-.25, .32]
Supp	-.14 [-.41, 0.15]	-.17 [-.43, .12]	.15 [-.14, .42]	.31 [.03, .55]	.18 [-.11, .44]	-.03 [-.31, .26]
Diary Intrusions						
Freq	.04 [-.25, .32]	-.02 [-.30, .27]	-.10 [-.37, .19]	.09 [-.20, .36]	.15 [-0.14, .42]	-.10 [-.37, .19]
Vivid	.04 [-.25, .32]	-.12 [-.39, .17]	-.05 [-.33, .24]	.07 [-.22, .35]	-.16 [-.42, .13]	.08 [-.21, .36]
Distress	-.02 [-.30, .27]	.22 [-.07, .47]	-.03 [-.31, .26]	-.06 [-.34, .23]	-.11 [-.38, .18]	-.26 [-.51, .03]
Supp	.08 [-.21, .36]	.19 [-.10, .45]	.07 [-.22, .35]	.06 [-.23, .34]	-.33 [-.56, -.05]*	-.36 [-.58, -.08]*
EIS	.15 [-.14, .42]	-.10 [-.37, .19]	-.17 [-.43, .12]	.15 [-.14, .42]	.03 [-.26, .31]	.00 [-.28, .28]

Note. *p < .05, Freq= frequency, Supp= suppression, EIS=Experience of Intrusions Scale

4.2.3. Conclusions. Our results indicate that analogue PTSD symptoms are correlated with memory amplification in the laboratory. However, unlike prior research, analogue re-experiencing symptoms were not significantly related to memory amplification. One potential problem with our analyses is that amplifiers and non-amplifiers are grouped together. It is possible that analogue re-experiencing symptoms predict memory amplification only among amplifiers. One reason for this

difference between groups might be that amplifiers use different strategies at test (e.g., relying on the severity of their symptoms to form judgements) compared to the non-amplifiers who outnumber them. Indeed, when we excluded amplifiers from the analysis, analogue PTSD symptoms had very minimal effect on memory amplification, $r = -0.02$, *95% CI* [−0.36, 0.33], $N = 33$, $p = 0.92$. Furthermore, unlike our study, amplifiers typically outnumber non-amplifiers in field research: meaning that our ability to detect an effect could be limited. To determine whether the relationship between memory amplification and analogue symptoms exists among amplifiers, we ran a follow-up study, using a larger sample to increase the number of memory amplifiers overall. This strategy allowed us to determine whether the relationship between memory amplification and analogue symptoms occurs exclusively among amplifiers or whether it is a ubiquitous effect.

4.3. Study 2

4.3.1. Method

4.3.1.1. Participants. We recruited participants from Amazon's Mechanical Turk; 398 participants completed the study. We excluded data from 33 participants who failed attention checks (see Oppenheimer, Meyvis, & Davidenko, 2009), 17 who experienced technical issues, and 20 who took more than 8 days to complete the second test. Of the remaining participants, we excluded six outliers with a *d'* value of 0 or less at T1, and eight participants who had a negative *d'* value at T2, to reduce noise in the data. A *d'* of 0 indicates that a participant responded "old" equally as often to new photos as to old photos. Thus, a *d'* of 0 just 20 min after viewing the photos likely indicates that a participant did not encode the photos or failed to understand test instructions. Moreover, a *d'* of less than zero indicates that a participant responded "old" more frequently to new photos than they did to old photos, which occurs when there is response confusion (Stanislaw & Todorov, 1999). Finally, we excluded 60 participants who reported looking away from the photos or closing their eyes at either test. Participants with more analogue PTSD symptoms (particularly avoidance) are more inclined to look away from test items (Takarangi et al., 2015), reducing their ability to answer questions accurately. In the field research this problem is unlikely – since the

memory "tests" do not involve people viewing their traumatic experiences, but descriptions of distressing events. We therefore removed these participants to: (1) reduce noise in our data and (2) to create a better simulation of field research.

Our analyses focus on the remaining 254 participants. Participants were US residents, aged 18–69 (M = 36.33, SD = 11.38). Over half (53.1%) were male and the majority identified their ethnicity as Caucasian (including White; 75.1%). Other participants identified as African American (including Black; 7.9%), Hispanic (5.1%), Asian American (5.1%), European (3.2%), or mixed ethnic origin (2.8%).

4.3.2. Materials and procedure. We altered the photo sets used in Study 1 to increase the thematic coherence of the photos. One possibility is that some test items were too dissimilar, so that people were unlikely to mistake New photos as "old," even if participants imagined new details, as we propose. Using pilot data, we selected 80 photos—from among Study 1 photos and 20 additional photos (from Krans, Langner, Reinecke, & Pearson, 2013)—that were most representative of the overall "theme" of the photos. The final sets of photos were matched on valence (Set 1: M = 1.94, *95% CI* [1.80, 2.08], Set 2: M = 1.82 [1.70, 1.95], Set 3: M = 1.93 [1.76, 2.10], Set 4: M = 1.78, [1.65, 1.92]) and category membership (1 = A very good example of a category member, 7 = A very poor example (or not a category member at all); Set 1: M = 1.92 [1.67, 2.16], Set 2: M = 1.95 [1.70, 2.21], Set 3: M = 1.98 [1.72, 2.25], Set 4: M = 2.00 [1.74, 2.27]), Fs < 1. The remaining materials and procedure were identical to Study 1. However, all participants completed two tests and participants did not complete the THS, BDI-II or STAI-T. Moreover, due to the technological restraints of online research, participants did not complete an intrusion diary or monitor their intrusions.

4.3.3. Results and discussion. As in Study 1, several measures were skewed. Log transformations only slightly reduced the skew and the overall pattern of results was the same; thus, we retained the original untransformed data for analysis.

4.3.3.1. Emotional impact of photos. Participants experienced a decrease in positive affect (before: M = 29.58, *95% CI* [28.49, 30.67]; after: M = 23.57 [22.57, 24.56], $t(253) = 16.33$, $p < 0.001$, d = 0.71, *95% CI* [0.46, 0.97]), and an increase in negative affect (before: M = 12.08 [11.62, 12.54]); after: M = 18.19 [17.24, 19.13]), $t(253) = -14.68$, $p < 0.001$, d = 1.02 [0.76, 1.28]) after viewing the photos. Participants rated the photos as very unpleasant (M = 6.00 [5.83, 6.17]), distressing (M = 5.51 [5.30, 5.72]) and disgusting (M = 6.01 [5.85, 6.17]). Notably, these ratings were higher than in Study 1, potentially due to the different demographic characteristics of this sample or prior level of exposure to graphic material. It is unlikely that the result is due to different stimuli, because the mean valence of photos used in Study 1 (M = 1.85 [1.80, 1.90]) and Study 2 (M = 1.87 [1.80, 1.94]) were comparable. Participants' scores on the PCL ranged from 17 to 74 (M = 23.28 [22.25, 24.30]). Participants reported that they paid very close attention to the photos (M = 6.69 [6.62, 6.76]).

4.3.3.2. Memory accuracy. Participants incorrectly identified control photographs as "old" only 5.10% (*95% CI* [0.04, 0.06]) of the time, and were mostly successful in identifying Old photographs (M = 0.72 [0.70, 0.75]). However, on average they falsely remembered 21% of New photographs (M = 0.21 [0.19, 0.22]). Critically, participants were less likely to respond "old" to New negative photos compared to Study 1, suggesting that increasing the thematic coherence of the photos did not enhance the probability of source monitoring errors. Study 2 participants also had better sensitivity than Study 1 participants at both T1 and T2, a potential by-product of our stricter inclusion criteria.

Next, we examined how sensitivity (as measured by d') and response bias (as measured by c) changed over time. Unsurprisingly, participants' sensitivity significantly worsened over time (T1: M = 2.76, *95% CI* [2.67, 2.86]; T2: M = 1.61 [1.53, 1.70], $t(253) = 23.81$, $p < 0.001$, d = 1.60, *95% CI* [1.32, 1.88]). Consistent with Study 1, participants were less biased to respond "old" at T2 (M = 0.11 [0.05, 0.18]) compared to T1 (M = −0.15 [−0.19, −0.11]), $t(253) = -8.59$, $p < 0.001$, d = 0.60 [0.36, 0.87].

4.3.3.3. Memory confidence. As in Study 1, at T1 participants were significantly more confident in their responses to Old (*M* = 9.41, *95% CI* [9.30, 9.52]) compared to New negative photos (*M* = 8.37 [8.20, 8.55]; t(253) = 16.86, $p < 0.001$, *d* = 0.89, *95% CI* [0.62, 1.14]) and more confident for neutral photos (*M* = 9.80 [9.70, 9.88]) compared to New negative photos, *t*(253) = −19.00, $p < 0.001$, *d* = 1.27 [1.00, 1.54]. These effects were weaker but still significant at T2: participants were more confident in identifying Old (*M* = 8.04 [7.87, 8.21]) compared to New photos (*M* = 7.71 [7.51, 7.92]; *t*(253) = 5.16, $p < 0.001$, *d* = 0.22 [0.03, 0.46]) and more confident identifying neutral (*M* = 8.73 [8.55, 8.92]) compared to New photos, *t*(253) = −13.98, $p < 0.001$, *d* = 0.65 [0.39, 0.90].

4.3.3.4. Memory amplification and analogue PTSD symptoms. Analogue PTSD symptoms were not significantly associated with a change in sensitivity or false memories (i.e., old responses to new photos) over time, *p*s > 0.05. Note however, that the number of non-amplifiers was much higher in the current study compared to Study 1, which may explain this inconsistency. As in Study 1, among memory amplifiers, there was a negative relationship between analogue PTSD symptoms overall (i.e., total PCL scores) and change in response bias, although it did not reach statistical significance (total: *r* = −0.19, *95% CI* [−0.41, 0.05], *N* = 70, *p* = 0.11, hyper-arousal: *r* = −0.12 [−0.35, 0.12], *p* = 0.33, avoidance: *r* = −0.12 [−0.35, 0.12], *p* = 0.31). Notably however, when we focused on the re-experiencing subscale of the PCL exclusively, there was a significant relationship between analogue re-experiencing symptoms and change in response bias, *r* = −0.28 [−0.48, −0.05], *p* = 0.02. That is, the more analogue re-experiencing symptoms amplifiers experienced, the more likely they were to amplify their memory over time, in line with our reality-monitoring explanation. Importantly, the relationship between analogue PTSD and memory amplification was not significant among non-amplifiers, *r* = 0.10 [−0.05, 0.24], *N* = 184, *p* = 0.17 (re-experiencing: *r* = 0.04 [−0.11, 0.18], *p* = 0.61; avoidance: *r* = 0.08 [−0.07, 0.22], *p* = 0.31). Thus, our findings are consistent with the idea that the relationship is not ubiquitous. However, we found a weak, significant positive relationship between hyper-arousal and memory amplification among non-

amplifiers: $r = 0.16$ [0.02, 0.30], $p = 0.03$. One possible explanation for this finding is that high levels of arousal when taking the test impaired participants' ability to concentrate on the photos presented. This reduction in attention might result in a response bias toward saying "new" because the likelihood of recognition occurring would be reduced.

4.3.3.5. Experience of intrusions. EIS scores and change in response bias were not significantly related, $r = -0.04$, *95% CI* [−0.16, 0.08], $N = 254$, $p = 0.48$, even among amplifiers, $r = -0.05$ [−0.28, 0.19], $N = 70$, $p = 0.67$. Thus, although the re-experiencing subscale of the PCL is related to amplification among amplifiers, the relationship is less clear for the experience of intrusions. Note however that the EIS measures the unpredictability, unwantedness, interference and distress associated with the experience of intrusions, as well as their frequency.

4.3.4. Conclusions. In summary, our results indicate that the relationship between memory amplification and analogue symptoms occurs exclusively among amplifiers. Moreover, our findings are consistent with the reality-monitoring explanation for memory amplification, because we observed a significant relationship between analogue re-experiencing symptoms and change in response bias (memory amplification) among amplifiers.

4.4. General discussion

Our findings show that memories for emotional events are often flawed—even when no explicit suggestive influences are present. Indeed, in both studies, participants falsely remembered seeing approximately a quarter of New negative photos. Moreover, we found that a certain subset (approximately one third) of our participants exhibited memory amplification: that is, they became more biased to respond "old" over time. Consistent with field research (e.g., Giosan et al., 2009; Roemer et al., 1998), the greater the severity of their analogue PTSD symptoms, the more these participants' memory amplified. Indeed, our effect sizes are comparable to effects from the field research (Giosan et al., 2009; Engelhard et al., 2008; King et al., 2000; Southwick et al., 1997). Thus, our paradigm may be a promising tool for investigating the mechanisms underlying memory

amplification.

One of our main findings was that analogue PTSD symptoms were positively related to memory amplification in the laboratory. Specifically, we found that analogue re-experiencing symptoms were related to a change in response bias toward saying "old" more frequently among amplifiers. One explanation is that amplifiers engage in more motivated recall at test (e.g., Engelhard et al., 2008); amplifiers unconsciously overestimate the quantity of negative photos they viewed to justify why, a week later, they are still affected by the images. This overestimation leads them to lower their decision criteria at test for what constitutes a "real" memory, therefore responding "old" more often. Indeed, in Study 1, memory amplifiers had experienced less past trauma compared to non-amplifiers. This finding is consistent with field research showing a trend for amplifiers to have experienced less lifetime trauma, compared to non-amplifiers (Krinsley et al., 2003). It also fits the justification of distress explanation: the less familiar people are with PTSD symptoms, the more distressing they might find them, and therefore the more motivated they might be to justify their occurrence. Future research should consider investigating the role of past trauma more systematically.

Alternatively, perhaps PTSD symptoms result in systematic information-processing biases that lead to higher frequency estimates of negative events. This is certainly the case for anxiety and depression, which commonly co-occur with PTSD (see Mathews, 1990). In addition to symptom-related biases, our findings might reflect an availability heuristic: when making frequency estimates of events, people commonly rely on the ease with which they can bring examples of such events to mind (Tversky & Kahneman, 1973). Perhaps participants exhibiting analogue PTSD symptoms can easily recall certain photos because the photos are frequently rehearsed via re-experiencing symptoms. Thus, these participants may be prone to overestimating the number of photos they viewed and, therefore, more biased to respond "old" to photos of an emotional nature. Memory amplifiers, who experienced more intrusions, might rely on cognitive heuristics (e.g., the availability heuristic) more heavily than non-amplifiers.

Consistent with the reality-monitoring hypothesis, amplifiers tended to report more intrusions in their diary compared to non-amplifiers in Study 1. Moreover, amplifiers' analogue re-experiencing symptoms, as measured by the PCL, were significantly related to memory amplification. We suggest that amplifiers elaborated on their intrusions and later mistakenly attributed this internally-generated material as originating from the photos. However, overall, diary intrusions and amplification were not related. Therefore, it might be the case that, like analogue PTSD symptoms, intrusions are related to memory amplification among amplifiers exclusively. One potential explanation for this is that some people are more prone to elaboration, consistent with research showing individual differences in concrete rumination (i.e., situationally-specific; Watkins & Moulds, 2005). Future research should manipulate or measure people's tendency to elaborate or engage in post-event processing to determine if it predicts amplification.

We must acknowledge several limitations of this research. First, we cannot determine the directionality of the relationship between analogue PTSD symptoms and memory amplification. It is conceivable that PTSD causes memory amplification, but also that an amplified memory causes PTSD. Future research should employ experimental paradigms to identify the direction of this relationship. Moreover, our paradigm markedly differs to the field research because participants were never tested on the same test item twice (which would have introduced additional source confusion). Thus, our findings do not speak to how memory changed over time for individual photos, but how memory sensitivity and bias changed overall. We must also acknowledge that our sample may not be entirely representative of the real-world because we removed participants (N = 60) who looked away from the photos in Study 2. It is likely that these participants are, on average, different than those that did not. Indeed, research has shown that participants who look away from such photos have more elevated analogue PTSD levels (Takarangi et al., 2015). This obviously limits the generalizability of our findings. Furthermore, our sample was predominantly female, which potentially influenced our findings. Indeed, the neural networks engaged when remembering emotional experiences differs between the sexes (e.g., Cahill et al., 2001) and there are sex

differences in physiological reactivity to emotional stimuli, even when comparable subjective emotional experiences are evoked (Lang, Greenwald, Bradley, & Hamm, 1993).

We also recognize that our paradigm is necessarily artificial due to the constraints of studying trauma in the laboratory. Viewing graphic images cannot replicate the fear resulting from real-life trauma exposure. Moreover, the intrusion monitoring task and diary do not represent ecologically valid tasks, because victims of real-life trauma do not consciously track intrusions in this way. Furthermore, asking participants to "press a key" whenever a target thought occurred, in addition to completing a monotonous vigilance task, may have resulted in more photo-related thoughts than if participants did nothing. However, the purpose of the current study was not to determine the true intrusion rate following trauma analogue exposure, but rather to simulate real-life responses to trauma and generate sufficient intrusions to investigate their relationship with memory amplification. Moreover, assessment of intrusions via short monitoring periods (e.g., Davies & Clark, 1998; Horowitz & Becker, 1971; Nixon, Cain, Nehmy, & Seymour, 2009a; Nixon, Cain, Nehmy, & Seymour, 2009b) and diaries (see Holmes & Bourne, 2008 for review) are both established methods for trauma analogue research, and have been used to significantly advance clinical theory. Thus, our paradigm is a useful tool to inform these potential research avenues in an ethical way.

Our findings have important clinical and theoretical implications. Previous field research has not verified trauma exposure and, therefore, is uninformative regarding which two time points depict a more accurate representation of reality. Therefore, our study is the first to suggest that the memory amplification effect represents a change in response bias towards endorsing more traumatic experiences, and a reduced ability to differentiate between experienced and non-experienced events over time.

We also observed a relationship between analogue PTSD symptomology and memory amplification. Although the magnitude was small, and only occurred among amplifiers, we believe the relationship is noteworthy. It is widely assumed that frequency of trauma exposure causes PTSD

symptoms (i.e., the relationship is unidirectional). This assumption is based on the finding that symptoms and self-reports of exposure to traumatic events are related. However, any relationship between analogue symptom severity and response bias calls this relationship's direction into question, because it suggests that a person's reaction to a trauma can influence how they remember it. There are implications for diagnosing PTSD, given that a client's self-reported level of trauma exposure is a key criterion for diagnosis. Indeed, our findings suggest that retrospective reporting of trauma exposure may not always be a reliable indicator of true exposure, especially when a person presents with severe PTSD symptoms. This conclusion is consistent with the recent theoretical perspective that a person's symptomatic response results from their memory of the trauma, not necessarily the event itself (Rubin, Bernsten, & Bohni, 2008). Critically, however, we cannot draw any firm conclusions about the mechanisms driving the relationship between response bias and symptoms. Disentangling the mechanisms involved should be a research priority because it may help to identify points of clinical intervention in the memory amplification-PTSD relationship, as well as refine current models of PTSD.

5. PTSD and the role of spontaneous elaborative "non-memories": A preliminary investigation [13]

Authors' Contribution

J.O. and M.T. developed the study design. J.O. collected and analyzed the data, and drafted the manuscript. M.T., D.S. and R.N. provided critical revisions. All authors approved submission of the final version.

Abstract

Following a traumatic experience, people often experience involuntary cognitions—i.e., spontaneously occurring thoughts, memories, or images. Although trauma victims commonly experience involuntary memories, they also experience involuntary *non-memories*, a subset of which are elaborative (i.e., cognitions about event details that did not actually occur). These cognitions may help to maintain PTSD symptomology by contributing to an ongoing sense of current threat. However, it is unclear whether trauma-exposed people with PTSD are more prone to elaborative non-memories about past trauma compared to healthy, trauma-exposed people. Further, the *experience* of elaborative non-memories has largely been overlooked by previous research. Our objective in the current study was to address both of these gaps in the literature. A large sample of US adults described recent involuntary cognitions about their most traumatic experience and rated them on various characteristics (e.g., vividness and distress). Participants also completed several measures of psychopathology, including PTSD symptoms. Two independent raters blind to our hypotheses later coded cognition descriptions according to their content. Although memories were predominant, 18.8% of cognitions were *non-memories*, which commonly involved *imagination* of new event details, and were more frequent among probable-PTSD participants than non-PTSD participants. Critically, memories and non-memories were indistinguishable for many phenomenological characteristics, including vividness and associated distress. Our findings suggest

[13] Oulton, J. M., Strange, D., Nixon, R. D. V., & Takarangi, M. K. T. (2017, revised and resubmitted). PTSD and the role of spontaneous elaborative "non-memories": A preliminary investigation *Psychology of Consciousness: Theory, Research, and Practice.*

that PTSD may be characterized by involuntary elaborative non-memories that are largely indistinguishable from memories in terms of their phenomenological experience.

5.1. Introduction

Involuntary cognitions are thoughts, memories or images that arise spontaneously, without any conscious attempt at conjuring them (Krans, de Bree, & Moulds, 2015). They occur everyday for most people, but also feature in clinical disorders such as posttraumatic stress disorder (PTSD) and Obsessive Compulsive disorder (OCD; American Psychiatric Association, 2013). Although many cognitions are involuntary memories—autobiographical memories that arise without intention—trauma victims also report experiencing involuntary *non-memories:* non-deliberately occurring cognitions that are not a memory from the victim's past. Importantly, some involuntary non-memories are elaborative (cognitions about event details that did not actually occur; e.g., Reynolds & Brewin, 1998), including imagined future events. These cognitions can be experienced similarly to episodic memories, in that they may contain a sense of reliving and involve the self (e.g., Rubin & Umanath, 2015). However, they are distinct from pseudo-memories or inaccurate memories, because the experiencer is aware that they do not accurately represent past experience. Critically, cognitive theorists propose that these types of cognitions help to maintain perceptions of current threat and therefore contribute to the development and maintenance of several anxiety disorders. Indeed, we know that people with anxiety disorders, such as panic disorder and social phobia, frequently experience involuntary images of future threatening situations (see Clark, 1999, for a review). It is possible that these cognitions also encourage both the development and maintenance of PTSD symptomology. However, we don't know whether trauma-exposed people with PTSD experience more elaborative non-memories than healthy, trauma-exposed people, or whether elaborative non-memories of traumatic events *specifically* are as distressing and "here and now" as involuntary memories, therefore contributing to an ongoing sense of threat. Here, we address these two important gaps in the literature.

Involuntary memories are memories of personal experiences that come to mind

spontaneously (Berntsen, 1998). These memories are a common occurrence in most people's lives. Diary studies show that, on average, these memories arise several times a day among nonclinical samples, often during relatively routine and mundane tasks, such as making a cup of tea (e.g., Berntsen, 1998). Although involuntary memories are a normal and generally harmless phenomenon most of the time, persistent recurrence of such memories is a hallmark symptom of Post-Traumatic Stress Disorder. Thus, much empirical research has focused on investigating the occurrence and phenomenological characteristics of involuntary memories about trauma, as opposed to other types of cognitions. Interview and questionnaire studies have shown that, just like involuntary memories generally, these involuntary trauma memories commonly consist of relatively fleeting sensory fragments (e.g., Ehlers et al., 2002), are predominantly visual (e.g., Ehlers & Steil, 1995), experienced as if they are happening in the "here and now" (e.g., Hackmann, Ehlers, Speckmens, & Clark, 2004) and are often triggered by a wide range of different stimuli and reminders of the trauma (Ehlers & Clark, 2000).

According to Ehlers and Clark's (2000) PTSD model, involuntary *memories* contribute to the development and maintenance of PTSD symptomology. Specifically, according to this model, PTSD becomes persistent when people have a sense of severe, current threat. Two processes contribute to this sense of threat; (1) excessively negative appraisals of the trauma and its consequences, and (2) a poorly elaborated and contextualized memory for the trauma. Ehlers and Clark propose that involuntary memories may encourage negative appraisals by contributing to a feeling and perception that "worse is to come". This perception arises primarily because intrusive memories are distressing, commonly lack context and often possess a "here and now" quality, i.e., the sense that the event is happening in the present. Thus, the more people experience involuntary memories possessing these characteristics, the greater likelihood of PTSD being maintained. Indeed, supporting this proposal, one longitudinal study of assault survivors (Michael, Ehlers, Halligan, & Clark, 2005) showed that initial intrusion frequency explained only a small proportion (8%) of the variance in PTSD symptomology six months later, however the "here and nowness",

associated distress and lack of context of involuntary memories explained an additional 43% of the variance.

But involuntary cognitions following trauma are not always accurate, trauma-related recollections. Indeed, we know that trauma victims sometimes experience involuntary thoughts—defined here as spontaneous, verbally-based cognitions related to the trauma and/or its consequences (e.g., "*why did this happen?"*; Tait and Silver, 1989). These cognitions are distinct from overgeneral memories (e.g., Williams & Broadbent, 1986) because they do not necessarily include retrieval of the past. However, intrusive thoughts may also *include* memory-based details. For example, a trauma victim might involuntarily replay events in their mind and dwell on what they could have done differently to prevent the trauma from happening (e.g., "*If I never got into that car, this never would have happened*"). Similarly, we know people experience a subset of non-memories that involve imagination of new (non-experienced) details—defined here as "elaborative non-memories". Indeed, involuntary elaborative non-memories—such as imagined future events (Berntsen & Jacobsen, 2008), daydreams and imaginary worst-case scenarios (Krans et al., 2015)—are ubiquitous in everyday cognitive experience; they also occur following trauma. For example, trauma victims can experience "worst case scenario" or "projected" intrusions (e.g., Merckelbach, Muris, Horselenberg, & Rassin, 1998), where the cognition is an exaggerated version of what happened. Similarly, trauma victims can experience elaborative non-memories that are dissociated from the trauma event itself, but are related to their appraisal of the trauma or its consequences. For example, Ehlers and colleagues (2002) report a patient suffering from PTSD who frequently experienced intrusive images of himself in a wheelchair after being involved in an accident. This cognition was related to the patient's appraisal that he was unable to lead a normal life due to the accident.

Many cognitive theorists propose that elaborative *non-memories*—particularly future based images—are critical in the maintenance and development of anxiety disorders (see Clark, 1999, for a review). Specifically, they argue that these cognitions strengthen people's beliefs that a feared

outcome is probable and contribute to a sense of ongoing threat. For example, Beck (1976) proposes that people with anxiety disorders commonly experience involuntary images of feared events that enhance their perception of current threat. Similarly, Clark and Wells (1995) argue that, among people with social phobia, spontaneous future-based images of performing poorly during social interactions maintain negative beliefs and thus contribute to people's anxiety. Indeed, consistent with these arguments, prior studies show that people with anxiety disorders—such as social phobia and OCD—are susceptible to involuntary cognitions of future-based threatening situations (see Clark, 1999, for a review). Interestingly however, although PTSD has previously been classified as an anxiety disorder, minimal empirical work has investigated the occurrence of these cognitions among people with PTSD. One potential explanation for this gap is that researchers and theorists have commonly conceptualized PTSD as a disorder caused by *past* events. Thus, most empirical work has focused on how the trauma is *remembered* (Berntsen & Rubin, 2015).

If elaborative non-memories contribute to ongoing threat in PTSD, these cognitions should be predominant among people with this disorder. Consider, for example, a stroke victim who frequently experiences involuntary images of suffering a stroke in the future. These images might strengthen negative appraisals that nowhere is safe and that a future stroke is both probable and imminent. Further, these images may contribute to a poorly contextualized memory for the event itself. For example, due to these images, the stroke victim may struggle to form a more elaborate trauma memory that links the experience to its true context, i.e., the past. Both of these outcomes could encourage maladaptive coping strategies that exacerbate PTSD symptomology. For example, the victim might attempt to suppress all stroke-related images. Importantly, prior research shows that when people attempt to suppress certain thoughts this process can lead to a paradoxical enhancement in such thoughts, relative to when there are no suppression attempts (e.g., Wegner et al., 1987). One explanation for this finding (i.e., "the rebound effect") is that people direct attention toward different distractors when suppressing thoughts and these distractors later become cues for the return of the suppressed material (e.g., Wenzlaff & Wegner, 2000). This rebound effect may

subsequently enhance anxiety and exacerbate PTSD symptoms.

Several lines of research are consistent with the expectation that elaborative non-memories will be predominant among people with PTSD. For example, in one study, researchers developed a measure of involuntary autobiographical memory frequency and involuntary future thoughts frequency (the Involuntary Autobiographical Memory Inventory (IAMI); Berntsen, Rubin, & Salgado, 2015). Interestingly, they found that the frequency of future thoughts—scores on future thought subscale—was significantly and positively related to measures of emotional distress, including PTSD symptoms (e.g., Berntsen & Rubin, 2015; Berntsen, Rubin, & Salgado, 2015). Critically however, the IAMI assesses the frequency of non-specific cognitions about the future (e.g., "*when I am bored, imaginary future events come to my mind by themselves*") and not cognitions about trauma specifically. Moreover, the IAMI does not assess the frequency of other, non-future-oriented non-memories, such as those that involve elaboration of past experiences. Thus, based on this research, the extent to which people with PTSD are prone to elaborative non-memories about trauma overall is unclear. Moreover, these studies relied on subjective assessments of future thought frequency and collected no data about the actual content of participants' cognitions. Thus, these data do not speak to the specific content of participants' cognitions and how often these cognitions are related to prior traumatic experiences.

However, Reynolds and Brewin (1998) examined the specific content of involuntary cognitions among people with PTSD. Participants with a) PTSD, b) depression and c) non-clinical controls described intrusive cognitions about stressful life events, which were categorized as memories (personal, generic) or cognitions (elaborative, evaluative). Personal and generic memories are autobiographical, while evaluative cognitions are thoughts about blame, responsibility, or the event's impact. Elaborative cognitions are typically image-based cognitions about non-experienced (but plausible) events (e.g., a stroke victim imagining having another stroke). A small but consistent proportion of participants in all groups experienced elaborative cognitions. However, with only 17 control participants, the study may have lacked sufficient power

to detect differences. Moreover, participants described cognitions about "stressful life events". Whether these findings would replicate for events involving actual or threatened death or injury (i.e., Criterion A for PTSD in the DSM-5) is unclear.

If elaborative non-memories contribute to ongoing threat in PTSD, we would expect these cognitions to be as distressing, vivid and "here and now" as involuntary memories about trauma. We know that involuntary non-memories and memories are experienced similarly *in everyday life*. Krans et al. (2015) asked participants to describe spontaneous cognitions experienced within the last month. Many cognitions (38.7%) were non-memories, including daydreams, imagined future events, hypothetical reconstructions of unresolved events and ruminations. Critically, memories and non-memories were equally of positive or negative valence, and comparable on emotional intensity. Similarly, Berntsen and Jacobsen (2008) showed that non-specific involuntary future event representations are qualitatively similar (e.g., on vividness and mood impact) to involuntary autobiographical memories. But would these results replicate for trauma specifically?

Based on some clinical PTSD theories, we might expect the answer to be no. Some research suggests intrusive memories are more common than other involuntary cognitions following trauma (e.g., Ehlers et al., 2002). One possibility is that involuntary *memories* about trauma are functionally distinct from other involuntary phenomena and, consequently, experienced differently (e.g., more detailed and emotional; Brewin, Dalgleish, & Josephs, 1996; Ehlers, Hackmann, & Michael, 2004). However, fMRI studies reveal neural overlap when people mentally re-experience past events and simulate future events (e.g., Addis, Wong, & Schacter, 2007). Since remembering past events and imagining new events appear to rely on similar mechanisms, we expect involuntary memories and non-memories to be phenomenologically similar.

Our goal in the current study was to establish whether people with PTSD experience elaborative non-memories more frequently than non-PTSD participants, and whether involuntary non-memories are comparably visual, distressing, vivid, "here and now" and emotional as involuntary memories about trauma. In this study a large sample of participants—not recruited

through clinical services—described recent involuntary cognitions about their most traumatic experience and rated their characteristics (e.g., vividness). We measured PTSD symptoms and compared participants above and below the cut-off for probable PTSD. Consistent with Ehlers and Clark's PTSD model (2000) and cognitive theories regarding the maintenance of anxiety disorders (e.g., Beck, 1976), we hypothesized that (1) probable-PTSD participants would experience more elaborative non-memories compared to non-PTSD participants, 2) people with probable-PTSD would experience more involuntary cognitions that are predominantly visual and emotional, like memories for perceived events, compared to non-PTSD participants and (3) non-memories would be phenomenologically comparable to memories.

5.2. Method

5.2.1. Participants. We aimed to survey a large enough sample to allow us to conduct meaningful comparisons between participants who did meet and did not meet the criteria for probable-PTSD, among a subset of participants who experienced involuntary cognitions in the past month. We therefore expected we would need a larger sample than Krans et al. (2015; N=70). Given the research was exploratory, we had no prior estimates of effect size to guide us. However, we estimated—based on prior research—that approximately 55% of our sample would be trauma exposed (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995) and that, of these trauma-exposed participants, around 18-22% would meet the criteria for probable-PTSD (Bardeen & Fergus, 2016). Thus, to ensure a minimum of 100 probable-PTSD participants overall, we estimated a target sample size of approximately 1200 participants.

We recruited participants (*N*=1,264) from Amazon's Mechanical Turk. Mechanical Turk is a useful tool to collect highly valid and reliable data from clinical and subclinical populations (Shapiro, Chandler, & Mueller, 2013). The prevalence of trauma exposure among MTurk users is comparable to the general population and their demographic characteristics are more diverse than convenience samples (e.g., Berinsky, Huber, & Lenz, 2012; Paolacci, Chandler, & Ipeirotis, 2010). We anticipated that recruiting from MTurk would allow us to collect data from trauma-exposed

people not currently undergoing clinical treatment, and provide participants with a response format that promotes more comfortable disclosure relative to in-person interviews (Shapiro et al., 2013). We excluded data from 49 who failed a check to ensure they were paying attention to the instructions (see Oppenheimer, Meyvis, & Davidenko, 2009). Our analyses include the remaining 1,215 participants. Participants were US residents, aged 18-87 (*M*=37.63). Most (56.8%) were female and identified as Caucasian (including White; 73.3%). Others identified as African American (including Black; 7.1%), Hispanic (4.7%), Asian American (7.7%), European (4.0%), mixed (2.5%) or other (0.7%). Participants were reimbursed with payment for their time.

5.2.2. Materials and Procedure. The Flinders University Social and Behavioural Research Ethics Committee approved this research. We warned participants the study would involve answering potentially distressing questions about trauma. Following informed consent, participants answered demographic questions and questionnaires:

(1) The 21-item version of the Depression Anxiety Stress Scale (DASS-21; Lovibond & Lovibond, 1995) contains three 7-item subscales for depression, anxiety and stress. Participants rated each item (e.g., "I felt downhearted and blue") on frequency/severity (0=*did not apply to me at all*, 3=*applied to me very much, or most of the time*). The DASS-21 has adequate construct validity (Cronbach's alpha: .87-.94) and good temporal stability. Test-retest correlations are strong over a 3-month period (depression: *r*=.59, anxiety: *r*=.65, stress: *r*=.77; Gomez, Summers, Summers, Wolf, & Summers, 2014). Internal consistency was high for the present sample, Cronbach's alpha=.95.

(2) The Global Rumination Scale (GRS; McIntosh, Martin, & Clark, 1992) measures tendency toward rumination, including mental rehearsal of future and past events. Participants rated 10 statements (e.g., "I seldom think about things that happened in the past") according to how well it described them (1=*does not describe me well*, 7=*describes me well*). The scale has good 2-week test-retest reliability (*r*=.78) and correlates significantly with anxiety measures (Segerstrom, Tsao, Alden, & Craske, 2000). Cronbach's alpha was 0.82 for the present sample.

(3) The Trauma History Screen (THS; Carlson et al., 2011) assesses exposure to high magnitude stressor (HMS) events (i.e., sudden events previously found to cause extreme distress in most people exposed, e.g., a really bad accident at work or home), traumatic stressor (TS) events (i.e., HMS events experienced by the participant accompanied by emotional distress) and persisting posttraumatic distress (PPD) events (i.e., HMS events associated with extreme distress lasting more than one-month). Participants indicated (1) exposure to HMS events, and (2) whether the event "really bothered [them] emotionally" (yes/no). If no, participants were automatically advanced to the end of the survey and received debriefing information. If yes, participants described the event *that bothered them the most* and indicated: their age during the event; whether (yes/no): anyone was hurt or killed, they were afraid anyone would be hurt or killed, they felt afraid, hopeless, or horrified; how long the event bothered them (0=*not at all*, 3=*a month or more*); and how much (1=*not at all*, 5=*very much*). Questions regarding actual or threatened injury or death determine whether someone meets criterion A1 for PTSD in the DSM-IV. Unlike the traditional THS format, participants completed these questions once, for the most emotionally distressing event. The THS has excellent one-week test-retest reliability (r=.93) and significantly correlates with PTSD symptom measures (Carlson et al., 2011).

(4) Participants then completed the 20-item PTSD Checklist-5 (PCL-5; Weathers et al., 2013) in relation to the TS, rating how bothered they were by their symptoms in the last month (e.g., "repeated, disturbing, and unwanted memories of the stressful experience"," 0=*not at all*, 4=*extremely*; range: 0 - 80). For several analyses, we divided our sample into PTSD-probable and Non-PTSD participants using the recommended PCL cut-off score of 33 (Weathers et al., 2013; see also Bovin et al., 2016). Recent work shows that the PCL-5 has good diagnostic utility: a cut-off score between 31-33 yields good sensitivity (.88) and specificity (.69) in diagnosing PTSD based on DSM-5 criteria (Bovin et al., 2016). The PCL-5 has high one-month test-retest reliability (r=.84) and correlates with the original PCL (r=.87; Bovin et al., 2016). Internal consistency was high for the present sample, Cronbach's alpha =.96. That is, the individual items of the PCL-5 were highly

correlated with one another and shared a large amount of covariance.

(5) Finally, participants completed the Involuntary Cognitions Questionnaire (ICQ; Krans et al., 2015) which assesses the type, quality, content and function of participants' involuntary cognitions. Participants first read a description of involuntary cognitions (i.e., "*a certain image, a certain thought, or a certain memory comes to mind, without them deliberately thinking about this"*) and examples (e.g., *"Someone who just experienced a car accident can keep seeing images of the experience in their mind"*). Next, participants indicated (yes/no) whether they experienced any spontaneous images, thoughts, or memories about the TS, within the last month. If "yes", participants described the cognition's content and personal meaning, and indicated: whether it was of an actual event they had experienced (yes/no), associated emotions (e.g., fear, anger), and how strongly they experienced the emotion(s) (1=*not at all,* 7=*very strongly*). Participants also rated cognitions on associated distress (1=*not at all distressing*, 5=*extremely distressing*) and vividness (1=*not at all vivid,* 5=*extremely vivid*), how much it felt like it was happening "right now" when it occurred (1=*not at* all, 5=*extremely*) and how hard they tried to push it out of their mind (1=*not at all*, 5=*completely*). Participants answered these questions for a maximum of three cognitions. The structure of the ICQ is based on previous intrusive memory interviews (e.g., Ehlers et al., 2002).

Finally, participants read a debriefing statement. We informed participants that we were interested in the types of involuntary cognitions people experience about trauma and how common it is for these cognitions to consist of details or events that were never directly experienced. Note that, due to the sensitive nature of the task, we provided contact details for participants who would like to talk to somebody about their traumatic experience. The study took approximately 15 minutes to complete and upon completion participants received $1.50 for their time. Note that participants who reported involuntary cognitions received an undisclosed bonus of 75 cents because on average it took these participants longer to complete the survey.

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study. Our data can be found on the Open Science Framework (OSF) at

https://osf.io/x3etp/files/. Note that, due to their sensitive nature, qualitative data for trauma descriptions and cognition descriptions are not included within the uploaded data sets.

5.2.3. Coding. Two independent graduate students blind to our hypotheses coded cognition descriptions. Prior to coding, we provided these raters with a set of guidelines for categorizing cognitions (including examples) that were based on definitions and descriptions of cognitions given by Krans et al. (2015) and Reynolds and Brewin (1998). For training purposes, raters were first given a small subset of cognition descriptions and were asked to categorize the cognitions using the coding guidelines independently. Both raters and the primary investigator (JO) then met to discuss any points of discrepancy and clarify areas of confusion in the guidelines. Following this meeting, both raters independently categorized cognitions. Where subsequent inconsistencies arose, a consensus was reached following discussion with each other and the primary investigator (JO). Raters coded all involuntary cognitions according to their type and quality. Cognition descriptions were also coded for function and content (see Krans et al., 2015); however, because these features are unrelated to our hypotheses we do not discuss them here.

5.2.3.1. Type. Raters coded involuntary cognitions as a personal memory if participants described a single event that occurred at a particular time and place (e.g., "…*I remember running and the sound the knife made…*"), or a generic memory if participants described similar events without identifying an example (e.g., "*I have frequent memories about the times I was unkind to him…")*. Remaining cognitions were coded as non-memories. Elaborative cognitions included verbal or imaginal cognitions about events or outcomes that had not, but could, happen. They could include similar images to personal memories, but not correspond to anything experienced (e.g., *"I just get an image of defibrillator and someone grabbing it - the actual image is probably from a television show because I wasn't there when it happened"*). Evaluative cognitions included cognitions concerning blame or responsibility, or the event's present and future consequences (e.g., "*Thoughts of my daughter pop into my head…I am reminded by all of the things I never saw her*

do"). Inter-rater agreement was moderate for cognition type, *K*=.55, *N*=444, *p*<.001. We also coded non-memories using Krans et al.'s categories (2015; e.g.., daydreams and imaginary worst case scenarios). We observed low rates in most categories (excluding daydreams and ruminations) and therefore do not report these data here.

5.2.3.2. Quality. Raters coded each cognition description as predominantly visual (e.g., "*I was in a hospital with a family member and images appeared…"*), verbal (e.g., "*I was thinking about what I am doing now and how much she would enjoy helping me…*"), emotional (e.g., "*…a song played that reminded me of my deceased niece…it made me feel sad and scared…"*) or a bodily sensation ("*…I just froze and started shaking*"). Inter-rater agreement for quality was moderate, *K*=.61, *N*=392, *p*<.001.

5.3. Results

5.3.1. Trauma Exposure and Involuntary Cognition Frequency. Most participants (75%; *N*=918) indicated exposure to a stressor. To determine trauma categories for the event that bothered participants the most, two independent raters coded participants' descriptions of the trauma according to the High Magnitude Stressor categories of the Trauma History Screen. Inter-rater agreement was high, *K*=.90, *p*<.001. Discrepancies between codes were resolved through discussion. Where participants did not give sufficient detail to determine stressor type (*N*=29), these participants were excluded from the frequency analysis. The event participants most often reported to emotionally bother them the most was exposure to the sudden death of a close family member of friend (38.2%), followed by some other sudden event (11.4%), sudden abandonment by a spouse, partner, parent or family (9.7%), and forced sexual contact as a child (6.9%). The number of years between the trauma experience and the time of assessment varied greatly between participants, ranging from 2 days to 60 years, *M* (in years) = 13.51 [12.73, 14.30]. Of the trauma-exposed participants, 42.81% (*N*=393) reported involuntary cognitions about the trauma in the ICQ: 315 (80.2%) participants described one cognition; 70 (17.8%) and 8 (2.0%) participants reported two

and three cognitions, respectively. Thirteen participants reported two distinct cognitions (e.g., "*wishing there was something I could have done … Dreams about him, and nightmares…"*) when asked to describe just one in the ICQ. Raters split and coded these cognitions separately. Thus, raters coded 492 cognitions in total. Most analyses focus on the 393 participants who reported involuntary cognitions. Among these participants, the reported involuntary cognitions were most often about the sudden death of a close family member or friend (37.1%), followed by some other sudden event (12.2%), forced sexual contact as a child (10.3%) and sudden abandonment by a spouse, partner, parent or family (10.1%).

5.3.2. Sample Characteristics. We first examined depression, stress, anxiety, rumination and PTSD symptoms for our entire sample. Table 5-1 shows statistics for these measures, classified according to trauma-exposure and experience of an involuntary cognition. Trauma-exposed participants reported significantly higher depression, stress and anxiety symptoms[14] and rumination levels than non-exposed participants (*p*s<.001). Trauma-exposed participants with involuntary cognitions scored significantly higher on all symptom measures compared to trauma-exposed participants with no involuntary cognitions (*ps*<.001). Effect sizes were medium for depression (*d*=0.44, *95% CI* [.31, .57]) and rumination (*d*=0.44, [.31, .57]), and largest for PTSD symptoms (*d*=0.74, [.59, .86]). See Table 5-1 for descriptive statistics. We chose to dichotomize our PTSD measure because PCL scores were significantly negatively skewed. We used the recommended cut-off score of 33, based on prior psychometric research (e.g., Weathers et al., 2013; see also Bovin et al., 2016). Among participants with involuntary cognitions, we classified over one-third (38.4%; *N*=151; Mean PCL score: 49.41 [47.68, 51.14]) as probable-PTSD, and compared them to participants below the PCL cut-off (*N*=242; Mean PCL score: 16.01 [14.88, 17.14]). Note that, among participants who experienced a Criterion A1 event, 27.5% met the criteria for probable PTSD. Our observed PTSD rate is higher than what is typically found in the general population;

[14] Note that participants also completed the trait subscale of the State Trait Anxiety Inventory (STAI; Spielberger, 1983). Like the anxiety subscale of the DASS, trauma-exposed participants had significantly higher scores than non-exposed participants.

indeed lifetime prevalence estimates for PTSD include 6.8% (Kessler, Berglund, Demler, Jin, Merikangas, & Walters, 2005), 5.6 % (Frans, Rimmo, Aberg, & Fredrikson, 2004) and 5.7% (Kessler, Petukhova, Sampson, Zaslavsky, & Wittchen, 2012). This discrepancy may be due to the fact that we specifically selected participants who were trauma-exposed. Indeed, our mean PCL-5 score was comparable to a recent study using a sample of trauma-exposed undergraduate students (Blevins, Weathers, Davis, Witte, & Domino, 2015).

Table 5-1.

Comparison of mean [and 95% CIs] symptom scores for trauma-exposed participants who experienced at least one involuntary cognition, trauma-exposed participants who experienced no involuntary cognitions and participants with no prior trauma exposure.

	Trauma Exposed Participants (*N* =918)		Non-Exposed Participants (N=297)
	With ICs (*N*= 393)	Without ICs (*N* = 525)	
Measure			
DASS total	19.72 [18.32, 21.11]	13.88 [12.79, 14.98]	11.36 [10.01, 12.72]
DASS depression	6.67 [6.11, 7.24]	4.64 [4.20, 5.08]	3.83 [3.26, 4.39]
DASS anxiety	5.12 [4.64, 5.61]	3.50 [3.14, 3.86]	2.75 [2.31, 3.19]
DASS stress	7.92 [7.41, 8.44]	5.74 [5.32, 6.15]	4.79 [4.25, 5.32]
GRS	49.42 [48.51, 50.32]	45.31 [44.50, 46.13]	42.77 [41.69, 43.85]
PCL total	28.84 [26.97, 30.72]	15.80 [14.38, 17.22]	
PCL intrusions	7.45 [6.92, 7.97]	3.78 [3.37, 4.18]	
PCL avoidance	3.82 [3.58, 4.06]	2.21 [2.01, 2.42]	
PCL cognition & mood	9.91 [9.17, 10.65]	5.44 [4.90, 5.98]	
PCL arousal	7.67 [7.08, 8.26]	4.38 [3.93, 4.82]	

Note that 7 participants—3 of whom were above the recommended PCL cut-off—reported a trauma that occurred less than a month ago and therefore would not meet criteria for a PTSD diagnosis. Further, among the probable-PTSD group, 23.8% of participants described a trauma that

did not satisfy criterion A1 for a DSM-IV[15] PTSD diagnosis (i.e., exposure to actual or threatened death or injury), compared to 30.7% of participants in the non-PTSD group. Proportions did not significantly differ between groups, $\chi^2(1)=2.17$, $p=.14$, $\varphi= .07$. The overall pattern of findings for analyses comparing the probable-PTSD and non-PTSD group did not change when analyses only included participants who were exposed to a Criterion A1 stressor and reported a trauma from over a month ago, however we note specific differences.

5.3.3. Frequency of Non-memories. Our first hypothesis was that probable-PTSD participants would experience more non-memories than non-PTSD participants. Most (*N*= 336, 85.5%) participants experienced at least one *memory* in the past month. However, a subset reported at least one *non-memory* (*N*=74, 18.8%), lower than Krans et al. (2015; 38.7%) reported. Because Krans et al. did not focus on any specific subtype of cognition, it is possible a similar proportion (subset) of their non-memories were for traumatic events. Alternatively, our lower rate might reflect our asking about *a past trauma* specifically, making memories more probable.

Overall, 58 (14.8%) participants experienced at least one elaborative cognition and 18 (4.6%) experienced at least one evaluative cognition. Examples of elaborative cognitions are listed within Appendix B. We compared proportions for these cognitions between the probable-PTSD and non-PTSD group (see Figure 5-1). We expected that a higher proportion of probable-PTSD participants would report elaborative cognitions compared to non-PTSD participants. Indeed, we found this pattern, $\chi^2(1)=5.09$, $p=.02$, $\varphi= .11$. A Bayesian chi-square analysis with default Cauchy prior (Rouder, Speckman, Sun, Morey, & Iverson, 2009) revealed a $BF_{10}= 3.12$. That is, these data are 3.12 times more likely under the alternative hypothesis than under the null hypothesis. The effect was slightly larger when participants who did not report a criterion A stressor event and participants with traumas in the past month were excluded, $\chi^2(1)=5.56$, $p=.018$, $\varphi=.14$. We observed no significant differences for evaluative cognitions ($p>.05$). We also compared personal

[15] The Trauma History Screen (Carlson et al., 2011) assesses exposure to a criterion A1 stressor as defined by the DSM-IV.

and generic memory frequency between groups. A larger proportion of non-PTSD participants reported personal memories compared to the PTSD group, however this difference only approached statistical significance (p=.06). We observed no significant differences for proportion of generic memories (p>.05). Interestingly, time since the trauma also appeared to influence the likelihood of experiencing elaborative non-memories. Participants who experienced a recent trauma (i.e., less than 8 years ago), as defined by a median split, reported elaborative cognitions more frequently (19.8%) than participants with a distant trauma (i.e., 8 or more years ago; 9.7%), $\chi^2(1)=7.77$, p=.005, φ= .14. Thus, overall, participants with recent traumas and heightened PTSD symptomology appear most susceptible to involuntary elaborative cognitions.

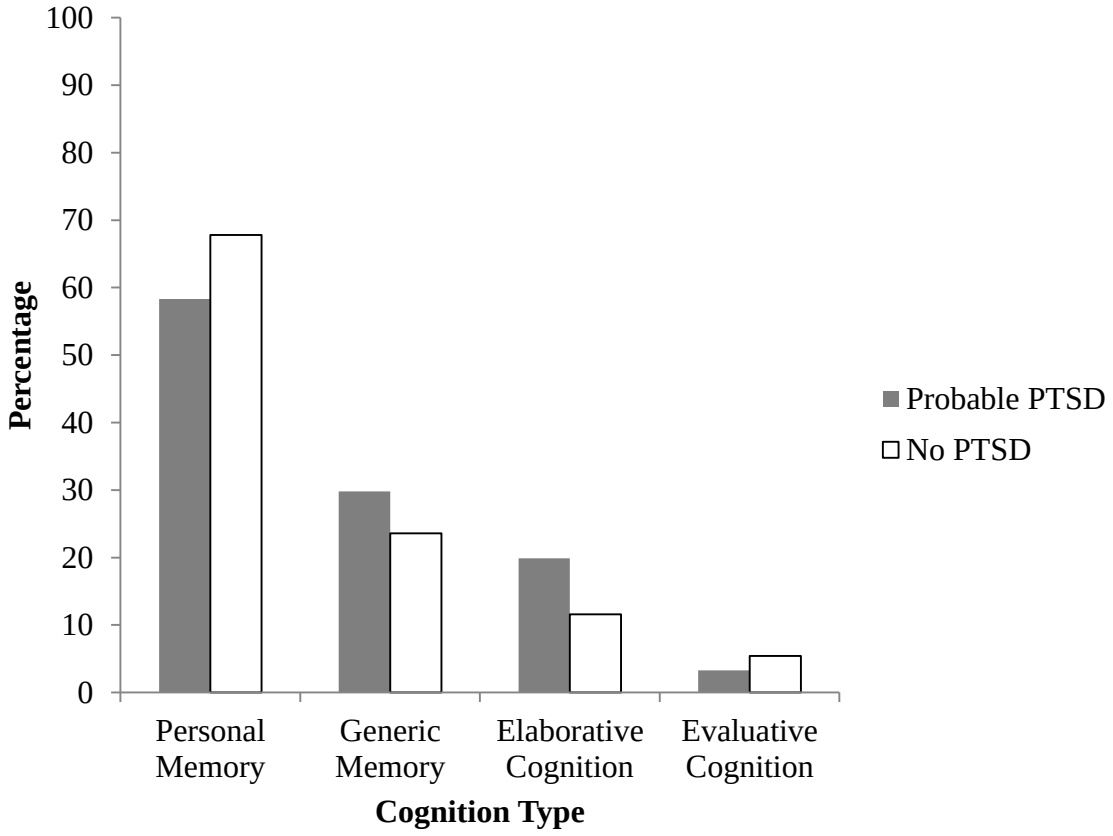

Figure 5-1. Percentage of participants who experienced at least one personal memory, generic memory, elaborative cognition and evaluative cognition in the past month by PTSD group.

To further explore the effect of PTSD symptoms and trauma recency on involuntary elaborative cognitions, we ran an exploratory logistic regression with PCL scores (i.e., our

continuous measure of PTSD symptomology) and number of years since trauma entered as predictor variables. The analysis revealed that when these two variables were entered together in the model ($\chi^2(2)=15.12$, $p=.001$), PCL scores were a significant predictor of elaborative cognitions (*B*=.02, *SE*=.01, *ExpB*=1.03 [1.01, 1.04], *p*=.001) but years since the trauma was not (*B*=-.03, *SE*=.02, *ExpB*=0.97 [.95, 1.00], *p*=.07). These findings suggest that the symptoms of PTSD predict elaborative non-memories even when accounting for the influence of years since the trauma occurred.

Finally, we examined whether gender moderated the effect of PTSD on involuntary elaborative cognitions. We conducted an exploratory logistic regression with gender and PTSD (PCL) scores entered as predictors, along with the interaction effect of these two variables. Gender was not a significant predictor (*B*=1.40, *SE*=.78, *ExpB*=4.04, *95% CI* [.88, 18.65], *p*=.07) and the interaction effect did not make a statistically significant contribution to the model (*B*=-.03, *SE*=.02, *ExpB*=0.97 [.94, 1.01], *p*=.97), $\chi^2(3)=15.31$, $p=.002$. Thus, gender did not moderate the effect of PTSD on the presence of elaborative cognitions.

5.3.4. Predominant Qualities of Cognitions. Our second hypothesis was that probable-PTSD participants would experience more visual and emotional involuntary cognitions compared to non-PTSD participants. We analyzed each cognition description according its predominant quality. Overall, predominantly visual cognitions were very common (71.0%), irrespective of PTSD symptoms. A subset of participants reported at least one predominantly verbal cognition (18.1%), whereas predominantly emotional (8.9%) and bodily sensation (4.6%) cognitions were less commonly experienced. We observed no significant group differences for any quality, all *p*s>.05. Thus, PTSD symptoms did not affect cognition qualities. Note, however, an exploratory analysis revealed that when we focused on only those participants who experienced a Criterion A1 stressor and reported a trauma from more than a month ago, the effect of condition on predominant quality was significant. Specifically, a significantly higher proportion (82.3%) of probable-PTSD

participants experienced at least one predominantly visual cognition compared to non-PTSD participants (70.7%), $\chi^2(1)=4.84$, $p=.028$, $\varphi= .13$

5.3.5. Involuntary Cognition Characteristic Ratings. Before testing our third hypothesis—that non-memories would resemble memories on phenomenology—we compared characteristic ratings between probable-PTSD and non-PTSD participants. Compared to non-PTSD participants, probable-PTSD participants rated involuntary cognitions as significantly more distressing (*d*=0.88, *95% CI* [.72, 1.15]), vivid (*d*=0.49 [.30, .72]), emotionally intense (*d*=0.52 [.35, .77]), and "here and now" (*d*=0.84 [.57, 1.00]), and tried to suppress the cognition more (*d*=0.62 [.44, .86]), all *ps*<.001. See Table 5-2 for descriptive and inferential statistics. Thus, although involuntary cognitions experienced by probable-PTSD and non-PTSD participants are comparable in their quality, our results suggest how people experience and respond to these cognitions differs according to symptomology.

Table 5-2.

Comparison of mean [and 95% CIs] involuntary cognition characteristic ratings between Non-PTSD and Probable-PTSD participants.

Rating	Non-PTSD	Probable-PTSD	Inferential Statistics
Distress	3.17 [3.02, 3.33]	4.16 [4.01, 4.32]	*t*(390)=8.52, *p*<.001, *d*=0.88 [.72, 1.15]
Vividness	3.79 [3.66, 3.92]	4.27 [4.13, 4.40]	*t*(390)=4.67, *p*<.001, *d*=0.49 [.30, .72]
Suppression	3.08 [2.90, 3.27]	3.90 [3.72, 4.08]	*t*(390)=5.93, *p*<.001, *d*=0.62 [.44, .86]
"Right now"	2.64 [2.48, 2.80]	3.67 [3.48, 3.86]	*t*(390)=8.09, *p*<.001, *d*=0.84 [.57, 1.00]
Emotional	5.34 [5.16, 5.52]	5.99 [5.83, 6.15]	*t*(386)=4.88, *p*<.001, *d*=0.52 [.35, .77]

Note. For distress, vividness, suppression and right now scales, 1 = *not at all* and 5= *extremely/completely*. For emotional intensity scale, 1=*not at all*, 7=*very strongly*. When participants reported multiple cognitions (*N*=78) we calculated a mean score for each variable. One participant failed to answer the rating scales and three did not rate emotional intensity.

Finally, we expected non-memories and memories would be comparable on our

characteristic ratings. Table 5-3 shows descriptive and inferential statistics. These analyses exclude cognitions later split by our coders. Consistent with our hypotheses, independent-sample Bayesian t-tests with default Cauchy prior revealed substantial evidence for the null hypothesis for distress (BF_{01}=4.76), vividness (BF_{01}=4.69), emotional intensity (BF_{01}=2.89) and suppression ratings (BF_{01}=7.12). Interestingly however, an independent-sample Bayesian t-test showed substantial evidence *against* the null hypothesis for "here and now" ratings (BF_{01}= 0.12): non-memories were rated as significantly more "here and now," perhaps because they do not necessarily involve the person retrieving past experiences.

Table 5-3.

Comparison of mean [and 95% CIs] characteristic ratings for memories and non-memories.

Rating	Non-Memories	Memories	Inferential Statistics
Distress	3.74 [3.42, 4.05]	3.59 [3.47, 3.71]	*t*(458)=.92, *p*=.36, *d*=0.12 [-0.17, 0.46]
Vividness	4.11 [3.86, 4.37]	3.99 [3.89, 4.09]	*t*(458)=.94, *p*=.35, *d*=0.12 [-0.13, 0.38]
Suppression	3.38 [3.02, 3.73]	3.39 [3.25, 3.53]	*t*(458)=-.06, *p*=.95, *d*=0.00 [-.37, 0.34]
"Right now"	3.53 [3.23, 3.82]	3.02 [2.88, 3.16]	*t*(458)=2.96, *p*=.003, *d*=0.38 [0.17, 0.85]
Emotional	5.85 [5.54, 6.15]	5.61 [5.47, 5.74]	*t*(458)=1.38, *p*=.17, *d*=0.18 [-.10, 0.57]

Note. For distress, vividness, suppression and right now scales, 1 = *not at all* and 5= *extremely/completely*. For emotional intensity scale, 1=*not at all*, 7=*very strongly.*

5.4. Discussion

To summarize, our aim was to examine whether probable-PTSD participants are more susceptible to spontaneous elaborative non-memories about trauma and whether the phenomenological experience of non-memories mirrors that of involuntary memories. Indeed, a greater proportion of probable-PTSD participants experienced elaborative non-memories, cognitions that involved imagination of new (non-experienced) event-related details. These findings converge with related research showing a positive association between PTSD symptomology and frequency of involuntary thoughts of possible future events (e.g., Berntsen & Rubin, 2015;

Berntsen, Rubin, & Salgado, 2015). Additionally, non-memories were comparable to memories for vividness, emotional intensity and associated distress. Perhaps unsurprisingly, therefore, motivation to suppress was equivalent for memories and non-memories. However, participants experienced non-memories as more "here and now" compared to memories.

Our data are consistent with cognitive models of anxiety disorders (e.g., Beck, 1976). According to these models, involuntary elaborative non-memories contribute to the development and maintenance of anxiety disorders by contributing to an ongoing sense of current threat. Our data shows that involuntary elaborative non-memories are distressing, high in emotional intensity and, perhaps most importantly, possess a "here and now" quality even stronger than that of involuntary memories of trauma. Thus, in accordance with Ehlers and Clark's (2000) PTSD model, like involuntary memories of trauma, these cognitions may also contribute to the perception that the person is under threat and may contribute to an inability to put the trauma in the past. Both of these outcomes could promote maladaptive coping strategies and safety behaviours that exacerbate PTSD symptomology.

Our finding that involuntary memories and non-memories were largely indistinguishable contradicts Brewin et al.'s (1996) proposal that involuntary *memories* about trauma are functionally distinct from other involuntary phenomena and, consequently, experienced differently (e.g., more detailed and emotional). Instead, our findings fit with the assumption that remembering past events and imagining new events rely on similar mechanisms and are thus similar in their phenomenology (e.g., Berntsen & Jacobsen, 2008). Indeed, our findings may help to explain why people with PTSD commonly remember exposure to more traumatic experiences later, compared to immediately after, a traumatic event took place (i.e., the "memory amplification effect"; e.g., Southwick et al., 1997). According to the source monitoring framework, vivid and emotional memories lacking information about cognitive operations (e.g., records of imagining and retrieving) are typically judged as originating from true experience (e.g., Lindsay, 2008). Our data shows that non-memories about trauma encompass all of these characteristics. Thus, people might mislabel non-memories as

genuine memory traces, resulting in an amplified trauma memory (see Oulton, Takarangi, & Strange, 2016; Strange & Takarangi, 2012). Future research should test this proposal experimentally.

Our findings show that involuntary *non-memories* about trauma are relatively common—18.8% of participants with involuntary cognitions experienced at least one. These non-memories consisted of evaluative cognitions, but also cognitions involving *imagination* of new event details. Although cognitive researchers do not typically characterize non-traumatic non-memories as "intrusive" or "involuntary", our data show they can be. Our findings support the view that "intrusiveness" is a judgment people make when they experience an involuntary cognition, not an inherent feature of certain types of involuntary cognitions (Hyman et al., 2015).

Our study has limitations. We cannot isolate cause and effect or determine the mechanism underlying the relationship between PTSD and involuntary elaborative non-memories. For example, although PTSD may create susceptibility to non-memories, susceptibility to non-memories may also heighten PTSD symptomology. Similarly, it is possible that probable PTSD participants are simply more liberal in reporting their cognitions, or do not as easily forget about the occurrence of cognitions compared to non-PTSD participants. Further, our data does not speak to whether involuntary non-memories play a causal role in maintaining PTSD symptomology. Both of these possibilities should be clarified in future research. We must also acknowledge that, because we did not have a comparison trauma-exposed group (i.e., people who were below the PTSD cut-off and matched on measures of general distress and psychopathology), we are limited in the conclusions we can draw about the role of PTSD specifically. Indeed, the differences we observed across groups may be a consequence of general distress and psychopathology, as opposed to the symptoms of PTSD exclusively.

Participants reported a maximum of three cognitions, which may have biased the results toward the most emotional—and therefore most memorable—recurrent cognitions. Furthermore, the number of cognitions reported likely underestimates their true frequency in the real-world.

Future research should employ diary methods to address some of these limitations. Additionally, people sometimes lack meta-awareness of intrusions concerning trauma (Takarangi, Strange, & Lindsay, 2014). Our study obviously would fail to capture such cognitions. Related to this point, it is possible that people might fail to distinguish between involuntary and voluntary thoughts. Thus, our study may have not have captured some involuntary cognitions that our participants experienced, but also may have included some cognitions that were voluntarily retrieved but incorrectly judged as involuntary. Similarly, although we assume that participants are aware that elaborative non-memories do not accurately represent the past, it is possible that some "memories" described by participants were actually elaborative non-memories at a previous time point. That is, it is conceivable that people might come to mistake elaborative non-memories as being true memories of their experience over time. Furthermore, we must acknowledge that findings within the area of involuntary cognition research likely depend on how the phenomena under study are defined and operationalized. Indeed, the terms we adopt here (e.g., "memory", "thought") have been described in diverse ways by different researchers. To improve our understanding of involuntary phenomena and avoid unnecessary confusion, clear definitions of key terms across different studies will be necessary. We must also acknowledge that—like Krans et al. (2015)—inter-rater agreement was moderate for coding classifications of type and predominant quality, thus the replicability of our findings is potentially limited. These data are thus preliminary and future research should work to identify more reliable classification systems. Finally, although the PCL-5 is a valid instrument for identifying probable-PTSD individuals (Bovin et al., 2015), we did not use a formal structured diagnostic interview. Note however, that our approach allowed us to access a trauma-exposed population without the need to recruit through clinical services, and we employed a test format previously shown to promote comfortable disclosure more than in-person interviews (Shapiro et al., 2013)

Current PTSD models fail to account for the role of elaborative non-memories in PTSD. Identifying and understanding the mechanisms involved in the relationship between PTSD

symptomology and elaborative non-memories will advance theory and may assist development of more effective PTSD treatments. Our findings are consistent with the proposal that spontaneous elaborative non-memories may contribute to the development or maintenance of PTSD. To provide stronger evidence for a casual role, future research should consider experimentally manipulating non-memories to determine whether such manipulations influence PTSD symptomology. Further, examining what *specific* types (e.g., hypothetical reconstructions or imagined worst-case scenarios) of elaborative cognitions and *specific* characteristics (e.g., "here and nowness" or vividness) are the strongest predictors of PTSD symptomology would provide more convincing evidence for a causal relationship. Indeed, this research might point to a small but possibly important intervention focus for clients with PTSD. For example, if imagined worst-case scenarios contribute to the development and maintenance of PTSD then practitioners working with those clients could identify and explore the underlying meaning and function of these cognitions, and address them using established therapy techniques (e.g., cognitive-behavioral). Our findings might also prompt clinical researchers to investigate new therapeutic methods designed to target elaborative cognitions about trauma.

6. Imagining trauma: Memory amplification and the role of elaborative cognitions[16]

Author Contributions

All authors developed the study design. J.O. performed data collection, data analysis and interpretation under the supervision of M.T. J.O. drafted the paper. M.T., D.S., & R.N. provided critical revisions. All authors approved submission of the final version.

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

[16] Oulton, J. M., Strange, D., Nixon, R. D. V., & Takarangi, M. K. T. (2017, revised and resubmitted). Imagining trauma: Memory amplification and the role of elaborative cognitions. *Journal of Behaviour Therapy and Experimental Psychiatry*.

exposure, which is consistent with the reality-monitoring explanation for memory amplification.

6.1. 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.

6.2. Method

6.2.1. 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[17], 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%).

[17] 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.

6.2.2. Materials

6.2.2.1. 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.

6.2.2.2. 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 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.

6.2.2.3. 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.

6.2.2.4. 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).

6.2.2.5. 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).

6.2.2.6. 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).

6.2.2.7. 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*).

6.2.2.8. 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.

6.2.2.9. 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 C 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.

6.2.2.10. 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.

6.2.2.11. 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[18] 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-Alexander, Buckley, & Forneris, 1996).

6.2.2.12. 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*

[18] 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)

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).

6.2.2.13. 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.

6.2.3. 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/.

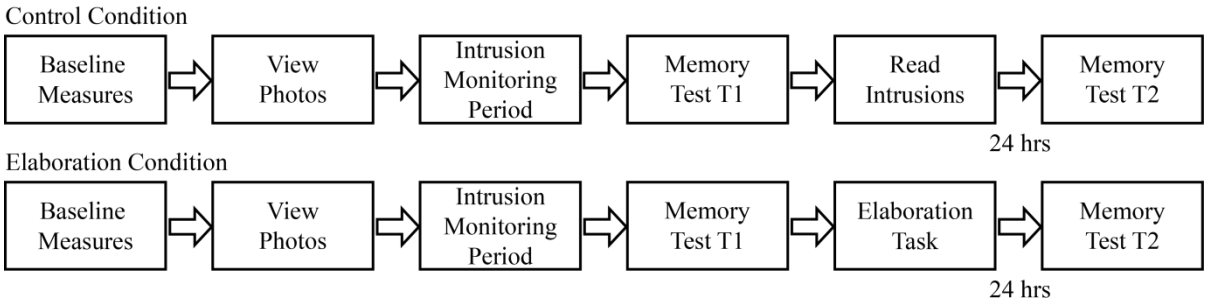

Figure 6-1. Illustration of procedure for the control condition and the elaboration condition.

6.3. Results & Discussion

6.3.1. 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 6-1 displays descriptive and inferential statistics for existing symptomology measures and trauma history[19]. Again, there were no significant differences.

[19] 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 6-1.

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

6.3.2. 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 6-2). 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 (*ps*>.05). However, there were significant main effects of time for positive ($F(1, 104)=117.90$, $p<.001$, $\eta_p^2= .53$, 95% *CI* [.40, .63]) and negative ($F(1, 104)=124.30$, $p<.001$, $\eta_p^2=.54$ [.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 6-2.

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[20], 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[21] (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 condition or interaction between condition and time, suggesting elaboration did not affect overall analogue PTSD symptoms ($ps>.05$).

[20] 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.

[21] 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.

6.3.3. 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[22]. 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 6-3 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.

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

[22] 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.

control participants (see Table 6-3). 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 6-3.

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.

6.3.4. 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[23] between condition 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].

6.3.5. 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 ($ps>.05$).

6.3.6. 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 6-4[24] shows the results.

[23] 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].

[24] 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.

Table 6-4.

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 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 view negative pictures with moderate outcome contextual statements ("there were many survivors") experience fewer intrusions than participants who viewed pictures paired with severe outcome statements ("there were few survivors"; Krans, Pearson, Maier, & Moulds, 2016). 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 of elaboration that does not also reduce 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.

7. Written cues provoke involuntary cognitions about a trauma analogue[25]

Author Contributions

Both authors developed the study design. J.O. performed data collection, data analysis and interpretation under the supervision of M.T. J.O drafted the paper, and M.T. provided critical revisions. Both authors approved submission of the final version.

Abstract

After trauma people commonly experience intrusive memories and involuntary elaborative cognitions, such as imagined future events. Involuntary elaborative cognitions differ from intrusive memories because they involve the construction of a *novel* scenario, rather than the retrieval of a specific past event. Presenting multiple, unrelated cues together—compared to isolated cues—might elicit more elaborative cognitions, by encouraging the extraction of distinct memory traces to construct a novel event. Conversely, isolated cues might elicit more intrusive memories by encouraging retrieval of a specific memory. We investigated these ideas using a vigilance task consisting of written cues. Participants viewed negative photos and then viewed either no cues, single cues (e.g., "*knife*"), or cues presented together as randomly selected triplets (e.g., "*skull sick hunger*"). Cues encouraged involuntary cognitions. However, frequency of intrusive memories and involuntary elaborative cognitions did not depend on whether cues were presented singularly or as triplets.

7.1. Introduction

People diagnosed with post-traumatic stress disorder (PTSD) can experience spontaneous "intrusive memories" of their trauma that are repetitive, often disruptive, and distressing (Kvavilashvili, 2014). These people can also experience involuntary elaborative cognitions: images or thoughts about the trauma that include imagined (non-experienced) details (Reynolds & Brewin,

[25] Oulton, J. M., & Takarangi, M.K.T. (2017). Written cues provoke involuntary cognitions about a trauma analogue. *Journal of Applied Research in Memory and Cognition* https://doi.org/10.1016/j.jarmac.2017.12.001

1998). We know little about whether the mechanisms underlying intrusive memories and involuntary elaborative cognitions differ. However, because involuntary elaborative cognitions involve the construction of a *novel* scenario using disparate details in memory, the presentation of multiple, unrelated cues *together* may elicit these cognitions more than an isolated cue, by encouraging people to extract and recombine different memory traces. Conversely, for intrusive memories, isolated cues may be superior to multiple cues because they activate a specific trace in the memory network. Our goal was to test this proposal.

Most involuntary-cognition research has focused on involuntary autobiographical memories (IAMs): memories of personal experiences that arise spontaneously (Berntsen, 1996). We know that IAMs typically occur in response to cues that resemble some central feature of the remembered event, such as a certain object or person (e.g., Berntsen, 1996; Berntsen & Hall, 2004; Mace, 2004; 2006). These cognitions often occur with little disruption to everyday activities (Kvavilashvili, 2014). IAMs are therefore distinct from *intrusive memories*, which are usually negative, repetitive, unwanted, and sometimes disruptive (Kvavilashvili, 2014).

Although intrusive memories feature in PTSD, not all cognitions in PTSD are memories. People with PTSD also experience involuntary elaborative cognitions: thoughts or images that contain imagined details (Reynolds & Brewin, 1998). For example, in one study, 22% of trauma victims reported that their intrusions were typically *exaggerated* versions of the trauma (Merckelbach, Muris, Horselenberg, & Rassin, 1998). Similarly, another study found patients with traumatic-hand injuries frequently experienced involuntary images in which their injury appeared more severe than reality (Grunert, Devine, Matloub, Sanger, & Yousif, 1987). More recently, Reynolds and Brewin found that participants with PTSD sometimes experienced involuntary cognitions about potential future events or imagined outcomes. For example, one participant experienced intrusive images of a funeral, after learning a relative had cancer. Although the cognitions reported across these studies likely contain details from memory, they also include imagined details.

Determining what mechanisms underlie intrusive memories and elaborative cognitions after trauma could potentially be used to devise therapeutic methods to *reduce* their occurrence. Within the cognitive literature a prevailing theory is that cues resembling features of previous events encourage a spreading of activation within the memory network, leading to IAMs (e.g., Berntsen, 2009; Mace, 2007). As the potential for overlap between a cue and a memory increases, IAM frequency should also increase (e.g., Berntsen, 2009; Conway, 2005). Given that IAMs and intrusive memories share features, perhaps this same mechanism explains intrusive memories in PTSD. Indeed, trauma-related cues provoke intrusive memories (e.g., Brewin, Huntley, & Whalley, 2012). For example, Michael, Ehlers, Halligan, and Clark (2005) found that displaying pictures of different assaults to assault victims provoked intrusive memories of participants' own assault. Trauma analogue studies (e.g., Krans, Näring, Holmes, & Becker, 2010) reveal similar findings; for example, after viewing negative photos, participants who later viewed blurred versions of those photos experience intrusive memories (Krans, Pearson, Maier, & Moulds, 2016).

But does this cue-overlap principle apply to involuntary elaborative cognitions? Although related theory is sparse, Berntsen and Jacobsen (2008) propose that involuntary future events—a type of elaborative cognition—reflect the automatic construction of a "false memory" through activation of the same associative network supporting IAMs. The person knows the cognition is not a memory, based on semantic knowledge, yet "relives" the cognition as if it truly happened. Like IAMs, the cognition is constructed almost entirely from elements of memory. However, unlike IAMs, people construct the imagined event using elements from *different* memories[a]. This idea aligns with theories of episodic future thinking (e.g., Tulving, 1983; Schacter & Addis, 2007). For example, according to Addis, Wong, and Schacter (2007), unlike remembering, imagining an event requires people to extract and flexibly recombine distinct memories to construct a novel and coherent image or event[b].

If this theory explains elaborative cognitions, then the more access one has to elements of distinct memories at a given time, the more frequently they should experience elaborative

cognitions. Thus, multiple and unrelated cues presented together—that activate elements of distinct memories simultaneously—may be better than isolated cues at eliciting involuntary elaborative cognitions, by assisting people to extract disparate details to construct a novel event. Conversely, for intrusive memories, multiple cues presented together may be *less* effective than singular cues. Indeed, researchers propose that a distinct cue related exclusively to one memory will elicit IAMs more than a cue related to many memories, because distinct cues isolate relevant nodes in the associate network but not irrelevant nodes that disrupt retrieval (e.g., Berntsen, Staugaard, & Sorensen, 2013). Thus, when a person is presented with multiple, unrelated cues together, network activation might be too imprecise and therefore intrusive memories might be unlikely. We investigated these ideas by manipulating the number of cues presented together after exposing participants to a series of negative International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) photos.

We had two aims: to determine whether (1) written cues provoke intrusive memories and elaborative cognitions about negative photos, and (2) multiple cues presented together elicit more elaborative cognitions than singular cues, consistent with proposed underlying mechanisms. To address these aims, we followed previous studies that have monitored and/or provoked involuntary cognitions with cues immediately after a trauma analogue for a short period (e.g., Nixon, Cain, Nehmy, & Seymour, 2009). Regarding the cuing procedure, we adapted a laboratory-based paradigm developed by Schlagman and Kvavilashvili (2008) in which participants completed a monotonous vigilance task, while viewing task-irrelevant cue phrases (e.g., *going on a holiday*) which successfully elicited IAMs. We chose this task because it provokes other task-unrelated cognitions, including future plans, thoughts, and intentions (e.g., Plimpton, Patel, & Kvavilashvili, 2015; Mazzoni, Vannucci, & Batool, 2014). For example, Plimpton et al. interrupted participants when completing this task, asking them to record their current thoughts. As well as memories, participants reported imagined future events, and abstract hypothetical thoughts. Here, we adapted Schlagman et al.'s procedure such that participants saw photo-related cue words (e.g., *knife*) on

random occasions throughout the vigilance task. Furthermore, to address our second aim, we manipulated cue presentation between participants: participants viewed either no cues, singularly presented cues, or cues presented together in randomly selected triplets (e.g. "*skull sick hunger*").

7.2. Method

We preregistered our study on the Open Science Framework and our data files can be found here: www.osf.io/j2g2y/. The Flinders University Social and Behavioural Research Ethics Committee approved this research.

7.2.1. Participants

Using a precision analysis (Cumming, 2013), we predetermined a sample size of at least 150 participants (50 per condition) to obtain a target margin of error (i.e., the half width of the target confidence interval) of 0.3, based on an estimated medium effect size of 0.50. We recruited 164 participants but excluded one participant who told the experimenter she was familiar with some photos and another participant who misunderstood instructions. Thus, our final sample consisted of 162 participants (80.2% female, 19.8% male); 157 were Flinders University students who received course credit or an honorarium; five were recruited through community advertising and received an honorarium. The study advertisement and information form explained that participation would involve answering potentially distressing questions about trauma and viewing potentially disturbing, graphic photos. To deter participants from guessing the study aims, we told participants we were interested in the effect of self-relevance on responses to emotional material. Participants were aged 18-63 (M = 22.64, *95% CI* [21.36, 23.93]) and most identified their ethnicity as Caucasian (including White; 65.8%). Other participants identified as Asian (14.3%), mixed ethnic origin (8.7%), European (6.8%), African (3.1%), or Indigenous Australian (1.2%). We did not collect socioeconomic data.

7.2.2. Materials

7.2.2.1. Pre-manipulation measures.

It is possible that variables that can predispose people to emotional processing difficulties—such as trauma exposure, depression, anxiety, and rumination—may enhance the likelihood of involuntary cognitions after trauma. Indeed, Ehlers and Clark (2000) propose that trauma exposure can lead to strong perceptual priming—whereby trauma-related cues are more likely to be noticed—and conditional association—whereby the person forms strong associations between stimuli present during the trauma and the trauma itself. These outcomes often lead the person to become more susceptible to involuntary memories when exposed to certain triggers, and may also make inhibiting these memories particularly difficult. Further, some theorists have proposed that involuntary cognitions reflect a failure in emotional processing (e.g., Rachman, 1980). Given these theoretical propositions, we included several baseline measures of trauma history and emotional processing difficulties to ensure that our conditions did not significantly differ on characteristics that might predispose them to involuntary cognitions.

7.2.2.1.1. *Trauma History Screen (THS)***.** The THS (Carlson et al., 2011) assesses frequency of exposure to high magnitude stressor (HMS) events (i.e., sudden events previously found to cause extreme distress in most people exposed, e.g., physical or sexual assault), traumatic stressor (TS) events (i.e., HMS events associated with extreme distress) and events associated with persisting posttraumatic distress (PPD events). Participants exposed to one or more traumatic stressors answered follow-up questions pertaining to actual or threatened harm or death, and the extent to which they were emotionally affected by the stressor. The THS has good temporal stability (HMS events: $r = 0.93$; PPD events: $r = 0.73$) and strong convergent validity across diverse samples (Carlson et al., 2011).

7.2.2.1.2. *PTSD Checklist (PCL-5).* We used the PCL-5 (Weathers et al., 2013) to measure participants' PTSD symptoms in relation to their worst life event. Participants rated 20 items according to how much the symptom bothered them in the past month (e.g., "repeated, disturbing, and unwanted memories of the stressful experience", 0 = not at all, 4 = extremely; range: 0 - 80).

The PCL-5 has high one-month test-retest reliability (r = .84) and correlates with the original PCL (r = .87; Bovin et al., 2015).

7.2.2.1.3. *Beck Depression Inventory (BDI-II).* The BDI-II (Beck, Steer, & Brown, 1996) is a 21-item self-report measure of depressive symptoms (e.g., sadness, worthlessness). Participants rate each item according to their experience during the past two weeks (e.g., 0 = I do not feel like a failure, 3 = I feel I am a total failure as a person; range: 0–63). The BDI-II has good internal consistency (a = 0.93; Beck et al., 1996) and construct validity among university students (Oliver & Burkham, 1979).

7.2.2.1.4. *State-Trait Anxiety Inventory-Trait Scale (STAI-T).* The 20-item trait subscale of the STAI (Spielberger, 1983) measures stable tendency to experience anxiety. Participants rate items (e.g., "I worry too much over something that really doesn't matter") from 1 (almost never) to 4 (almost always) (range: 20–80). The scale has good internal consistency (a = 0.89) and test-retest reliability (r = 0.88) (Barnes, Harp, & Jung, 2002). Concurrent validity with other anxiety questionnaires ranges from 0.73 to 0.85 (Spielberger, 1983).

7.2.2.1.5. *Global Rumination Scale (GRS).*
The GRS (McIntosh & Martin, 1992) measures propensity toward ruminative thought (e.g., "When I have a problem I tend to think of it a lot of the time"). Participants rate 10 statements according to how well it describes them (1 = does not describe me well, 7 = describes me well). The scale has good test-retest reliability (r = .78) and concurrent validity with anxiety measures (Segerstrom, Tsao, Alden, & Craske, 2000).

7.2.2.2. Positive Affect Negative Affect Schedule (PANAS). The PANAS (Watson, Clark, & Tellegen, 1988) is a 20-item self-report measure of positive affect (PA) and negative affect (NA). Participants rate feelings or emotions (e.g., "strong" and "afraid") according to how they feel in the present moment (1 = *Very slightly or not at all*, 5 = *Extremely*). The PANAS has good temporal

stability (NA: r = 0.81, PA: r = 0.79) and convergent and divergent validity with more comprehensive mood measures (Watson et al., 1988).

7.2.2.3. Trauma Analogue. We selected 80 standardized IAPS photographs (Lang, Bradley, & Cuthbert, 2008) showing negative scenes (e.g., death and mutilation). We divided the photos into four sets of 20 target photos (see Oulton, Takarangi, & Strange, 2016) that were matched on valence (Fs < 1), as measured by the Self-Assessment Manikins (SAM; Lang et al., 2008). Participants saw two sets (i.e., 40 target photos). We counterbalanced photo sets across participants such that each combination of photo sets was presented equally. Our rationale for all participants not viewing the same photos was to ensure that the effects and patterns we observed were not specific to a particular set of photos. This aspect of our method allowed us to test whether certain patterns and effects are generalizable to different sets of negative stimuli. An *additional* 20 negatively valenced IAPS photos—10 at the beginning and 10 at the end of the study phase—acted as primacy and recency buffers. Buffers were the same for every participant and appeared only once for 500 ms each. Buffer photos were completely new photos (i.e., not pictures from the 80 target photos we selected).

7.2.2.4. Photo questions. We included several questions as a check to ensure that the photos were an effective analogue of trauma, and that participants paid attention to the photos. We asked participants how disgusting, distressing, and unpleasant the photos were overall (1 = *not at all*, 7 = *extremely*). Participants also responded to the question "*how closely did you pay attention to the photos presented?"* (1 = *not at all*, 7 = *extremely closely*).

7.2.2.5. Cue stimuli.

To develop the cue stimuli, we extracted words from a series of photo descriptions generated by participants in a pilot study. In that study, participants from Amazon Mechanical Turk saw a subset of 24 photos and, for each photo, described the event depicted in one sentence (e.g., "*a man holds a knife to a woman's throat"*). In total, each of the 80 photos were described by 43 to 48

participants. We ran a word frequency text analysis (www.online-utility.org/text/analyzer.jsp) with all photo descriptions entered together. To ensure the cues would sufficiently overlap with the photos, we excluded words that were mentioned only three times or less. From the remaining words (N = 656), we selected those that fit the following criteria: (1) negatively valenced[26] singular nouns (e.g., *knife*), verbs (e.g., *crying*), adjectives (e.g., *dead*), or adverbs of manner (e.g., *violently*) used within the photo descriptions, AND/OR (2) nouns that described objects/people/body parts/places in a photo that were the source, victim, witness, outcome, or specific location of the harm, death, or violence (e.g., *man, police, hand, hospital*). A total of 258 words met our inclusion criteria. Note that because *all* photo descriptions were entered together in the word frequency analysis, it is likely that many of the final cue words had been used to describe more than one of the IAPS photos. Furthermore, because participants did not view all of the 80 photos, some cue words may have been used to describe photos that participants never previously saw. However, we were specifically interested in cue words that matched the overall *theme* of the photos.

We subsequently divided the cue words into three sets of 86 words. We matched the sets on frequency in photo descriptions; valence, arousal, and dominance ratings according to the Affective Norms for English Words database (Bradley & Lang, 1999); and concreteness, familiarity, imageability, written frequency, and meaningfulness norms from the MRC Psycholinguistic Database (Coltheart, 1981), all Fs < .50. We also matched sets on frequency of words meeting our second inclusion criterion (i.e., nouns that described objects/people/body parts/places in a photo) and frequency of words from different parts of speech (e.g., verbs, nouns, adjectives), ps > .05. We also composed one set of 86 triplet words (e.g., "*skull sick hunger*"). We created each triplet by randomly selecting one word from each of the three sets, unless the randomly generated triplet consisted entirely of 2nd criterion words, in which case we randomly selected an alternate word. We implemented this rule because we wanted the triplets to have a story-like structure and therefore not

[26] We determined valence ratings using the Affective Norms for English Words database (Bradley & Lang, 1999). For words not included in the ANEW database (N =154), we had 50 participants on Mechanical Turk rate their valence and arousal, following Bradley and Lang's method. We used words with a mean valence rating of less than four as cues.

consist entirely of nouns depicted within the photos. We thought that this structure might enhance the fluency of the triplets and therefore the possibility of cognitions with imagined details. We predetermined the word order (left, centre, right) in the triplet using a random number generator.

7.2.2.6. Intrusion monitoring and vigilance task. The 10-min monitoring and vigilance task consisted of 400 trials showing a large (41.1cm x 22.2cm) white rectangle with either a horizontal or vertical line pattern depicted within it (see Schlagman & Kvavilashvilli, 2008). Each trial displayed for 1.5 s. There were 12 non-target patterns (consisting of four to nine *horizontal* lines) and four target patterns (consisting of five to nine *vertical* lines). We randomized the order of pattern presentation across participants. We based the task duration on previous trauma analogue studies that have monitored intrusion frequency (e.g., Nixon, Cain, Nehmy, & Seymour, 2009; Nixon, Nehmy, & Seymour, 2007) or implemented intrusion provocation tasks (e.g., Michael, Ehlers, Halligan, & Clark, 2005). These studies generally terminate the task after 2 - 5 min. However, we extended the task duration to 10 min, to allow for the time participants would spend recording and rating their involuntary cognitions.

7.2.2.7. Monitoring booklet. In the monitoring booklet participants described each cognition's content and indicated whether it was triggered by anything either in the environment or internally (and if yes, what), the type of cognition (image, thought, combination), and whether it was a memory of a photo they had seen (yes/no). Participants also indicated (yes/no) if: all details of the cognition were from a single photo, the cognition contained details from several different photos, the cognition was a memory of some other experience from the past, the cognition contained some details from the photos but also other (imagined) details, or if all details of the cognition were imagined (i.e., did not appear in the photos). We asked these questions to determine whether cognitions were either involuntary elaborative cognitions or intrusive memories of the photos, in line with both of our aims. We also asked participants how strongly they experienced any emotion(s) associated with the cognition (1 = *not at all*, 7 = *very strongly*), how distressing (1 = *not at all distressing*, 5 = *extremely distressing*) and how vivid (1 = *not at all vivid*, 5 = *extremely*

vivid) the cognition was, how much it felt like it was happening "right now" when it occurred (1 = *not at* all, 5 = *extremely*), and how hard they tried to push the cognition out of their mind (1 = *not at all*, 5 = *completely*). Participants answered these questions for each involuntary cognition experienced during the vigilance task. We chose to measure these specific characteristics because prior research shows that involuntary cognitions in PTSD tend to provoke strong emotions and distress, are typically vivid, and are experienced in the "here and now" (e.g., Ehlers & Clark, 2000; Ehlers et al., 2002; Hackmann et al., 2004). Further, people with PTSD tend to suppress the occurrence of involuntary cognitions (Steil & Ehlers, 2000). We wanted to determine the extent to which the cognitions elicited in our paradigm were comparable to cognitions characteristic of PTSD and, for exploratory reasons, whether the presentation of cues would affect these involuntary cognition features.

7.2.3. Procedure. Following informed consent, participants first completed a demographics questionnaire, followed by the THS, PCL-5, BDI-II, STAI-T, GRS, and PANAS, respectively. Next, participants read instructions informing them that they were about to view a series of photos showing various negative scenes that have actually occurred throughout the world. Participants were instructed to closely concentrate on the photographs and view the images as if they were actually present at the scenes. Next, participants viewed the buffer and target IAPS photos on a computer. Participants viewed two target photo sets (i.e., 40 target photos). Each photo appeared for 500 ms on five separate, randomly timed occasions. Thus, participants saw each photo for a total of 2.5 s. We decided to present photos for 500 ms on different occasions because pilot testing suggested that this exposure time inflated the intrusion rate, relative to presenting each photo once for 2.5 s. We wanted to ensure that participants reported a sufficient number of intrusions to adequately test our key hypotheses regarding the effects of cuing. After viewing all of the photos, participants completed the photo questions, followed by the PANAS a second time.

Next, we instructed participants that the next part of the study would involve a 10-min vigilance task. We randomly assigned participants to one of three conditions: a single cue condition,

a triplet cue condition, and a control (no cue) condition. We told all participants that they would see a series of line patterns, one by one, and that their task was to detect the target pattern, which has vertical lines. We instructed participants to press the space bar each time the target pattern of vertical lines appeared on the screen. Target patterns appeared on eight trials; non-target patterns of horizontal lines appeared on the remaining 392 trials. Following Schlagman and Kvavilashvilli (2008), we also instructed participants in the single and triplet cue condition that they might sometimes see words appear in the centre of the patterns, but to ignore these words and focus on the line patterns. We explained that we were interested in how people keep their concentration on the patterns.

After explaining the vigilance task to participants, we defined involuntary cognitions to participants in accordance with the Involuntary Cognitions Questionnaire (Krans, de Bree, & Moulds, 2015; i.e., "*a certain image, a certain thought, or a certain memory comes to mind, without deliberately thinking about it"*). We instructed participants to press the "x" key if they experienced an involuntary cognition *that was related to the photos* when completing the vigilance task (e.g., Kubota, Nixon, & Chen, 2015; Takarangi, Strange, & Lindsay, 2014) and release the "x" key once the involuntary cognition had gone. Participants then completed the task. On 86 randomly selected non-target pattern trials, participants in the single and triplet cue conditions were presented with single cues or triplet cues respectively. Participants in the single cue condition viewed one of the three cue word sets; sets were counterbalanced across participants. Participants in the triplet cue condition viewed the set of 86 triplet words (e.g., "*skull sick hunger*"). Cue words were presented in lowercase size 20 Arial font in the centre of each rectangle. Triplet cues were separated by four spaces between each word. The control condition did not view any words. Each time participants released the "x" key—to indicate they had experienced an involuntary cognition—a black screen appeared with text prompting participants to fill out the monitoring booklet provided. After filling out the booklet, participants resumed the vigilance task by pressing the "n" key. The time participants spent recording their cognitions in the booklet was included within the 10-min

time limit of the vigilance task. Thus, the line pattern slides stopped appearing after 10 min, regardless of how many trials participants had completed. To maximize cue exposure, slides with cues appeared randomly within the first 300 trials. Following the monitoring period, we debriefed participants.

7.3. Results

7.3.1. Baseline Measures. Table 7-1 displays the descriptive and inferential statistics for all baseline measures. One-way ANOVAs showed no evidence for differences between conditions on baseline measures, all *p*s>.05.

Table 7-1.

Baseline measures by condition, including means (with standard deviations) and inferential statistics.

	Condition			
	Control	Single Cue	Triplet Cues	Statistic
HMS	4.16 (4.03)	3.72 (3.66)	5.04 (5.38)	$F(2, 159) = 1.25$, $p = .29$, $\eta^2 = .02$ [.00,.06]
TS	1.13 (0.95)	1.35 (1.05)	1.31 (1.02)	$F(2, 159) = 0.75$, $p = .47$, $\eta^2 = .01$ [.00,.05]
PPD	0.54 (0.77)	0.44 (0.72)	0.67(0.87)	$F(2,159) = 1.08$, $p = .34$, $\eta^2 = .01$ [.00,.06]
PCL-5	22.81 (15.12)	23.11(17.25)	24.61(18.27)	$F(2, 159) = 0.18$, $p = .84$, $\eta^2 = .00$ [.00,.02]
STAI-T	50.54 (9.85)	47.31(10.25)	49.91(10.81)	$F(2,159) = 1.48$, $p = .23$, $\eta^2 = .02$ [.00,.07]
BDI-II	15.94 (9.24)	14.65 (10.08)	15.09 (11.89)	$F(2, 159) = 0.21$, $p = .81$, $\eta^2 = .00$ [.00,.03]
GRS	51.78(8.83)	49.78 (7.24)	51.65 (7.42)	$F(2, 159) = 1.09$, $p = .34$, $\eta^2 = .01$ [.00,.06]

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

7.3.2. Emotional Impact of Photos. First, we analyzed how the photos influenced participants' affect. We compared positive and negative affect PANAS scores before and after viewing the photos, using 3 (Control, Single, Triplet) x 2 (Time 1, Time 2) mixed ANOVAs. Positive affect significantly reduced (Time 1: $M = 25.99$, $SD = 8.03$, Time 2: $M = 18.40$, $SD = 5.93$,

d = 1.08, *95% CI* [0.89, 1.26]), and negative affect significantly increased after viewing the photos (Time 1: *M* = 16.86, *SD* = 6.23, Time 2: *M* = 25.11, *SD* = 9.42, *d* = 1.03 [0.84, 1.23]). Thus, as predicted, there were significant main effects of time for positive, $F(1, 159) = 214.70$, $p < .001$, $\eta_p^2 = .57$, *95% CI* [.48, .65.], and negative affect, $F(1, 159) = 165.42$, $p < .001$, $\eta_p^2 = .51$[.40, .59]. There were no significant main effects of condition and no interactions between condition and time (*p*s > .05), suggesting our conditions were comparably affected.

Consistent with prior research (e.g., Oulton et al., 2016), participants rated the photos as a whole as very unpleasant (*M* = 5.84, *SD* = 1.25), disgusting (*M* = 5.59, *SD* = 1.51), and distressing (*M* = 4.75, *SD* = 1.51), and indicated they paid close attention to the photos (*M* = 5.59, *SD* = 1.05). Photo and attention ratings did not significantly differ between conditions, all *p*s > .05. We also compared vigilance task performance between conditions, to ensure that the presentation of cues did not influence participants' ability to detect the target patterns. A one-way ANOVA showed that target detection rates did not significantly differ between conditions[27], $F(2, 159) = 0.64$, $p = .53$, $\eta^2 = .01$, *95% CI* [.00, .05] . Thus, cue presence did not appear to affect participants' task performance.

7.3.3. Involuntary Cognitions. We had two aims: (1) to determine whether written cues provoke intrusive memories and elaborative cognitions (i.e., cognitions with imagined details) and (2) to determine whether multiple cues presented together elicit more elaborative cognitions than singular cues. Before addressing our aims, we first examined whether cues provoked involuntary cognitions by comparing the number of involuntary cognitions reported in the booklet *overall* across our three conditions. The mean number of involuntary cognitions reported in the booklet overall was 2.72 *(SD* = 1.85, range: 0-8). However, a one-way ANOVA revealed an overall effect of condition on involuntary cognition frequency,[28] $F(2, 159) = 4.65$, $p = .011$, $\eta^2 = .06$, *95% CI*

[27] Interestingly however, an exploratory analysis revealed that poorer performance on the vigilance task was associated with more involuntary cognitions. That is, target detection rate and involuntary cognition frequency were significantly related, $r = -.30$, $N = 162$, $p < .001$. One potential explanation for this relationship is that participants who allowed their mind to wander more during the task were more susceptible to involuntary cognitions (Takarangi et al., 2014).

[28] Note that the distribution for involuntary cognition frequency was positively skewed. To reduce this skew, we performed both log and square root transformations to our data, however both transformations only slightly reduced this

[.00, .13]. Consistent with our expectation that cue words would encourage involuntary cognitions about the photos, Tukey post-hoc tests revealed that the control condition experienced significantly fewer involuntary cognitions (M = 2.11, SD = 1.60) than both the triplet cue condition (M = 3.06, SD = 2.00, p = .020, M_{diff} = -.94 [-1.77, -.12]), and the single cue condition (M = 3.00, SD = 1.79, p = .031, M_{diff} = -.89 [-1.71, -.07]); the two cue conditions did not differ, p = .99, M_{diff} = .06 [-.77, .88]. Thus, although there was a medium effect of cues (compared to no cues) on involuntary cognition frequency, whether cues were presented singularly or as triplets did not affect involuntary cognition frequency.

Next, we analyzed how frequently cognitions were assigned to each category by participants (i.e., all details were from a single photo, all details from several different photos, a memory of some other experience from the past, some details from the photos but also other imagined details, all details of the cognition were imagined). Regarding intrusive memories, participants categorized 55.8% of cognitions as containing details exclusive to a single photo they viewed (e.g., "*the man holding the woman by the throat"*), and 19.7% of cognitions as containing details from several different photos (e.g., *"images of war and death from previous task"*). A further subset (11.3%) of cognitions were categorized as memories of another past experience related to the theme of the photos (e.g., "*argument with my mum turned violent*"). In terms of involuntary elaborative cognitions, participants labelled 13.6% cognitions as containing both imagined details and details from the photos viewed (e.g., *"hanging-remembered image but also thought about it happening to me"*), and 7.0% of cognitions as consisting entirely of imagined details (e.g., "*Images and thoughts of cold/ice burn and stuck in the snow*"). Thus, participants categorized over 20% of the cognitions as involuntary elaborative cognitions, consisting either entirely or partially of non-experienced details. Finally, for a small proportion of cognitions (2.7%) participants selected the "other" category.[29]

skew and the overall pattern of the results and significance remained the same. We therefore retained the original untransformed data for analysis.

[29] When participants selected the "other" category we asked participants to describe where the details originated. There was large variability in the participants' responses to this question (e.g., "*I wondered what happened", "image viewed*

We expected the single and triplet cue condition would experience more intrusive memories and involuntary elaborative cognitions than the control condition (Aim 1). Further, we expected triplet cues to be superior in provoking involuntary elaborative cognitions (relative to single cues) because cues that activate different memories simultaneously may be necessary to construct these cognitions (Aim 2). To address both predictions, we compared the number of intrusive memories and involuntary elaborative cognitions between conditions. Specifically, for intrusive memories, we compared the number of cognitions that were categorized as memories of a single photo, memories of multiple photos, or personal memories—but not cognitions with imagined details—between conditions. In contrast, for involuntary elaborative cognitions, we compared the number of cognitions that were categorised as consisting either partially or entirely of imagined details between conditions. A one-way ANOVA revealed a significant effect of condition on intrusive memories, F (2, 159) = 3.10, p = .048, η^2 = .04 [.00, .10]. Post-hoc Tukey tests revealed that the control condition experienced fewer intrusive memories (M = 1.59, SD = 1.57) than the triplet cue condition (M = 2.31, SD = 2.02; p = .093, M_{diff} = -.72 [-1.53, .09]), and single cue condition (M = 2.35, SD = 1.74; p = .073, M_{diff} = -.76 [-1.57, .05]). Note however that these differences did not reach statistical significance. Further, the mean number of intrusive memories did not differ between the single cue condition and the triplet cue condition (p = .99, M_{diff} = .04 [-.78, .85]), contrary to the proposal that single cues may provoke more intrusive memories than triplet cues. A one-way ANOVA revealed no significant effect of condition on involuntary elaborative cognitions, F(2, 159) = .50, p = .61, η^2 = .01 [.00, .04]. Thus, contrary to predictions, the number of involuntary elaborative cognitions experienced did not depend on whether participants saw cues, or whether cues were presented in isolation or presented together.

We also compared the mean number of cognitions from each of the five individual categories[30] (i.e., single photo, multiple photos, memory of other past experience, cognition with

and other image from tv show", "*the colour red was strong"*).

[30] We initially intended for raters who were blind to conditions to code participants' descriptions of cognitions as either intrusive memories or involuntary elaborative cognitions, however cognition descriptions were not sufficiently detailed

imagined details, and cognition with entirely imagined details) between conditions to determine how cues affected specific *types* of memories and elaborative cognitions. Results from these analyses appear in Table 7-2. Notably, the mean number of cognitions from each category did not significantly differ across conditions.

Table 7-2.

Mean number of cognitions (with standard deviations) categorised as a specific memory, generic memory, elaborative cognition (some imagined details), elaborative cognition (all imagined details) and memory from past by condition, including inferential statistics.

	Condition			
	Control	Single Cue	Triplet Cues	Statistic
Specific Memory (Details from One photo)	1.17 (1.34)	1.61 (1.42)	1.78 (1.65)	$F(2, 159)=2.48$, $p=.09$, $\eta^2=.03$ [.00, .09]
Generic Memory (Details from Several Photos)	.41 (0.66)	.65 (.96)	.56 (1.00)	$F(2, 159)=1.02$, $p=.37$, $\eta^2=.01$ [.00, .06]
Elaborative Cognition (Some Imagined Details)	.26 (0.52)	.37 (0.65)	.48 (0.82)	$F(2, 159)=1.46$, $p=.24$, $\eta^2=.02$ [.00, .07]
Elaborative Cognition (All Imagined Details)	.20 (0.60)	.24 (0.51)	.13 (0.34)	$F(2, 159)=.71$. $p=.49$, $\eta^2=.01$ [.00 .05]
Personal Memory (Details from Past)	.28 (0.71)	.37 (0.68)	.28 (0.60)	$F(2, 159)=.35$, $p=.71$, $\eta^2<.01$ [.00, .03]

7.3.4. Characteristics, Duration and Modality of Cognitions. We also measured the characteristics, duration and modality (i.e., thought, image, combination) of involuntary cognitions. Because no previous research has investigated whether presenting cues together versus in isolation influences these variables, we compared our conditions on these outcomes, using one-way ANOVAs. Importantly, there was no significant effect of condition on any of the cognition characteristics[31] (i.e., distress, vividness, emotional intensity, and suppression) we measured, all *ps*

for categorization. We therefore analyzed the categories that *participants* selected instead.

[31] Overall, involuntary cognitions were experienced as moderately distressing ($M = 3.04$, $SD = 1.18$), moderately vivid ($M = 3.52$, $SD = 1.05$), and emotionally intense ($M = 4.24$, $SD = 1.70$). Participants indicated that they tried moderately hard to suppress their involuntary cognitions from awareness ($M = 3.34$, $SD = 1.30$).

> .05. Thus, although our written cues affect how *often* involuntary cognitions occurred overall, our data suggest that they did not affect how cognitions were *experienced.*[32]

Next, we compared the number of images, thoughts, and image-thought combinations between our conditions using one-way ANOVAs. There was no significant effect of condition on frequency of thoughts or image-thought combination cognitions, *F*s < 1.00. There was, however, a significant effect for image-based cognitions, $F(2, 159) = 3.45$, $p = .034$, $\eta^2 = .04$ [.00, .11]. Post-hoc Tukey tests revealed that the control condition experienced fewer image-based cognitions ($M = 1.50$, $SD = 1.44$) than the triplet cue condition ($M = 2.24$, $SD = 1.80$; $p = .055$, $M_{diff} = -.74$ [-1.49, .01]), and single cue condition ($M = 2.20$, $SD = 1.70$; $p = .072$, $M_{diff} = -.70$ [-1.46, .05]). Note however that these differences did not reach statistical significance. Overall, these findings tentatively suggest that the cue words prompted more image-based cognitions *specifically*.

Finally, we compared the duration of involuntary cognitions between conditions. Among participants who experienced involuntary cognitions, the mean cognition duration[33] was 4.11 s ($SD = 19.23$, *range*: 0.15 s—3.78 min). Thus, cognitions tended to represent relatively fleeting experiences. Mean involuntary cognition duration did not significantly differ between conditions, $F(2, 137) = .93$, $p = .40$, $\eta^2 = .01$ [.00, .06]. Thus, the use of cue words did not appear to affect how long cognitions lasted.

7.4. Discussion

Replicating prior research (e.g., Mazzoni et al., 2014), written cues encouraged involuntary cognitions. Given that we extracted cues from photo descriptions, the written cues and the photos shared common features. Our findings therefore support the idea that cues resembling features of

[32] We also compared cognitions that contained imagined details (i.e., involuntary elaborative cognitions, $N = 91$) to cognitions that were entirely memory-based (i.e., cognitions that were categorised as containing details either from one photo, multiple photos, or a personal memory but not categorised as containing imagined details, $N = 341$) on characteristic ratings. Table S1 in the Supplemental Material available online presents the descriptive and inferential statistics. No significant differences emerged, except for vividness.

[33] To calculate duration, we calculated the difference in time between when the "x" key was pressed and released. For several participants ($N = 51$) data for the time the "x" was pressed or released was not recorded for one or more cognitions due to a technical issue. The mean score was calculated only for cognitions where both the x press and x release was recorded.

past events encourage a spreading of activation within the memory network (e.g., Berntsen, 2009). Importantly, our study extends existing research by showing that written cues elicit involuntary cognitions after a trauma analogue.

Contrary to predictions, however, whether cues were presented singularly or as triplets did not affect involuntary cognition frequency, content, or characteristics. Our findings therefore do not provide support for the hypothesis that multiple cues encourage elaborative cognitions. Thus, it is possible that the theory that multiple cues encourage the extraction of distinct memory traces to construct a novel event is wrong. Alternatively, it is possible that the triplet cue condition did not process cues together. Supporting this proposal, participants identified a minority of cognitions (5.0%; N = 12 for triplet cues, 10 for single cues) as triggered by multiple cue words. Thus, despite the single cue condition never viewing cues together, sometimes multiple cues—presumably appearing in close succession—triggered involuntary cognitions. Interestingly, however, triplet cue participants rarely indicated that multiple cues elicited their involuntary cognitions—especially when we consider that cues never appeared in isolation.

Participants may not have attended to the cue words together, due to short exposure and/or our instructions to "*focus on the line patterns.*" However, Schlagman and Kvavilashvili (2008) used the same instructions, exposure time, and presented multiple word cues (e.g., "*going on a holiday*") that successfully elicited cognitions. Thus, a more likely explanation is that people did not process our randomly grouped triplet cues holistically due to their reduced fluency and the cognitive effort required. Instead, key words may have "jumped out", causing spreading activation within the memory network. Indeed, this outcome may have been more likely because triplets always contained a negatively valenced word, whereas this was not true for every single cue presentation. Perhaps the negative word attracted participants' attention. Future research should examine what happens when the triplet cues are organized around a common theme or presented for longer, promoting more holistic processing. Determining whether our findings replicate when cue selection for triplets is entirely random would also be an interesting future direction.

Our study has limitations. First, participants interrupted the task by pressing the "x" key whenever they became aware of involuntary cognitions. However, people sometimes lack meta-awareness of trauma-related intrusions (Takarangi et al., 2014). Future research might consider intermittently asking participants about their mental contents. Although cue presence did not affect cognition characteristics, perhaps external cues influence meta-awareness of involuntary cognitions. Related to this point, to assess cognition duration, we asked participants to release the "x" key when they were no longer experiencing an involuntary cognition. Although this procedure is similar to other studies that have monitored intrusion duration by asking participants to signal when a thought has disappeared (e.g., Nixon, Flood, & Jackson, 2007), remembering to release the "x" key when a cognition has gone may itself encourage trauma-related thoughts, making this task particularly difficult. Further, rating cognition characteristics could also provoke new trauma-related thoughts. A related point is that duration data for involuntary cognitions may not accurately reflect the true length of time that participants experienced cognitions, due to the inherent difficulty of determining when a cognition has gone. Importantly however, because we asked participants to press and release the "x" key for every involuntary cognition they experienced during the task, we likely captured any additional involuntary cognitions about the photos that our procedure provoked. Even if we have underestimated the true rate of involuntary cognitions that participants experienced, and under or overestimated the duration of these cognitions, these discrepancies should be equivalent across conditions.

We must also acknowledge that our paradigm likely failed to replicate the same stress experienced during a real-life trauma and thus may not generalize to real-world trauma. Further, our involuntary cognition rate was lower than previous research (e.g., Schlagman & Kvavilashvili, 2008). This discrepancy could partly reflect participants being reluctant to report cognitions because this meant responding to multiple questions. Moreover, because time spent filling out the booklet was included within the 10-min time limit, participants could record a limited number of cognitions. The effect size we observed for cue presence might therefore be weaker than reality, due to a ceiling

effect. However, measuring cognition characteristics immediately after their occurrence is also a methodological strength. Relative to studies measuring cognitions after the task, our data likely provide more reliable estimates of phenomenological characteristics and content. Nevertheless, future research should determine if and how these findings change when participants judge characteristics after the monitoring period. We must also acknowledge that, because participants only viewed two photo sets, some cues they saw may have related more strongly to photos they had not seen, than photos they had seen. For example, the cue "*victim*" may have been a less effective cue for participants who did not view many photos depicting physical violence, relative to participants who viewed many of these photos. However, our cue words were designed to capture certain traumatic *themes,* and not specific features exclusive to a particular photo. Nevertheless, this aspect of our procedure may have also limited the involuntary cognition rate we observed and consequently the extent of data we could analyze, ultimately compromising our ability to detect whether cue type influences involuntary cognition type and characteristics.

Overall, our findings suggest that presenting cues together versus in isolation does not affect the likelihood of trauma-related intrusive memories or involuntary elaborative cognitions. Nevertheless, our data demonstrate that written cues elicit involuntary cognitions about a trauma analogue. Our adapted method may therefore prove useful in future research investigating the occurrence and experience of involuntary cognitions following trauma.

Endnotes

Responses to examiner's suggestions are placed here to maintain the consistency of the published works and material in the thesis

a) However, it is important to acknowledge that creating elaborative cognitions may at times also rely on semantic memory. If creating elaborative cognitions was entirely dependent on autobiographical memory, it would be impossible for people to imagine anything that they had not experienced firsthand. Yet we know that even patients with profound amnesia for past experiences can mentally imagine future scenarios within the public, non-personal (semantic) domain, such as scenarios related to medicine, technology and politics (e.g., Klein & Loftus, 2002). Thus, semantic memory may also sometimes be involved when constructing elaborative cognitions.

b) An alternative theory is that elaborative cognitions have a specific relation to goals. According to Conway, Meares, & Standart (2004), mental imagery is a type of mental representation that is specialised for representing information about our goals. In the case of trauma-related elaborative cognitions, these goals may relate to a person's future. For example, a person who survived a traumatic car accident might have the goal to never be involved in a car accident again. The survivor might consequently experience elaborative cognitions that represent states of the world they want to avoid (e.g., being involved in another car accident). These kinds of elaborative cognitions may maintain a set of dysfunctional beliefs (e.g., "nowhere is safe") that consequently preserve a person's goal system and protect the system from a need to change.

8. Does provoking intrusions in the lab lead to memory amplification for a trauma analogue?[34]

Author Contributions

J.O. and M.T. developed the study design. J.O. performed data collection, data analysis and interpretation under the supervision of M.T. J.O. drafted the paper. M.T., D.S., & R.N. provided critical revisions. All authors approved submission of the final version.

Abstract

When asked about stressful events during war, trauma survivors often remember being exposed to more stressful events when asked at a later point compared to an earlier time point: the "memory amplification effect". This effect is associated with the re-experiencing symptoms of posttraumatic stress disorder (e.g., involuntary trauma-related images). We also know that trauma survivors experience involuntary trauma-related cognitions that contain imagined details (i.e., "involuntary elaborative cognitions"). One possibility, therefore, is that people gradually confuse new, imagined information about the trauma—generated by intrusions—with their actual experience, causing memory amplification. We investigated this possibility. Participants viewed negative photos and then completed a recognition test. After the test, participants completed a monotonous vigilance task. During this task, we randomly assigned participants to view photo-related cue words (e.g., *dead*) or no cue words. Twenty-four hours later participants completed a second recognition test. Cue words provoked intrusive memories of the photos, but not elaborative cognitions. Interestingly, there was no significant effect of this manipulation on participants' ability to distinguish between old and new photos over time or their bias to respond "old" to photos over time. Our results do not provide evidence that intrusive *memories* are causally related to memory amplification for a trauma analogue. However, we are limited in our ability to test the reality-monitoring explanation with these data, due to participants experiencing few involuntary elaborative cognitions.

[34] Oulton, J. M., Strange, D., Nixon, R. D. V., & Takarangi, M. K. T. (2017). Does provoking intrusions in the lab lead to memory amplification for a trauma analogue?

8.1. Introduction

When asked about their exposure to stressful events during war (e.g., *"being shot at"*), veterans often report that they were exposed to more events when asked at a later time point (e.g., several years after service) compared to an earlier time point (e.g., one month after service). This finding, termed the "memory amplification effect" (e.g., Southwick, Morgan, Nicolaou, & Charney, 1997), replicates across diverse samples, including 9/11 disaster restoration workers (Giosan, Malta, Jayasinghe, Spielman, & Difede, 2009) and adults present at a school shooting (Schwarz, Kowlaski, & McNally, 1993). Interestingly, the re-experiencing symptoms of posttraumatic stress disorder (PTSD)—such as involuntary trauma-related images—are positively associated with memory amplification (e.g., Roemer, Litz, Orsillo, Ehlich, & Friedman, 1998). Therefore, one possibility is reality-monitoring errors cause memory amplification. Specifically, over time, victims of trauma mistakenly confuse *imagined* details about the trauma—generated via involuntary cognitions—with true memories of their experience. Indeed, supporting this explanation, trauma victims experience involuntary cognitions that contain imagined (i.e., non-experienced) details: termed "involuntary elaborative cognitions" (e.g., Reynolds & Brewin, 1998). However, the reality-monitoring proposal remains untested; no research has investigated whether involuntary cognitions and memory amplification are causally related. Our aim here was to address this gap in the literature.

Trauma victims tend to exhibit memory amplification (e.g., King et al., 2000; Southwick et al., 1997). In one example (Roemer et al., 1998), U.S. soldiers responded to identical surveys about their experience within the first year of returning from deployment in Somalia and 1-3 years later. Within each survey soldiers read items (e.g., "*being fired at*") and indicated their exposure (0=*not at all*, 4=*over 50 times*). Soldiers reported more exposure on the second survey compared to the first survey. Further, the severity of soldiers' PTSD symptoms—particularly intrusive symptoms—was positively correlated with increased reporting of exposure frequency over time. Other studies have replicated the typically small, but significant relationship between PTSD symptoms and number of response changes from no to yes over time, with reported correlation coefficients of 0.23, *95%* CI

[0.06, 0.38] (Engelhard, van den Hout, & McNally, 2008), 0.26 [0.22, 0.30] (King et al., 2000) and 0.32 [0.17, 0.60] (Southwick et al., 1997). Importantly, the relationship between memory amplification and symptoms is usually stronger when focusing on the re-experiencing symptoms specifically (e.g., Giosan et al., 2009; Roemer et al., 1998) compared to other symptom clusters (e.g., avoidance).

Although field studies suggest that re-experiencing symptoms may contribute to memory amplification, experimental control is necessary to study the underlying mechanisms of this association. Thus, recently we investigated whether the memory amplification effect replicated in a controlled laboratory environment (Oulton, Takarangi, & Strange, 2016). Participants viewed highly negative photos (e.g., death and violence) and later completed two recognition tests, one week apart. During those tests, participants identified each photo as either "old" (i.e., previously seen) or "new" (i.e., previously unseen). Participants' ability to differentiate between new and old photos (i.e., sensitivity) decreased over the week. Moreover, among participants exhibiting memory amplification—i.e., people responding "old" to more photos over time—re-experiencing symptoms (in relation to the photos) were associated with memory amplification (r=-.28, *95%* CI [-0.48, -.05]).

Reality-monitoring errors may cause memory amplification. Specifically, victims might mistake *imagined* details about the trauma—that are introduced via re-experiencing symptoms—with what actually happened (e.g., King et al., 2000; Oulton et al., 2016; Strange & Takarangi, 2012). This proposal is consistent with the Source Monitoring Framework (SMF; Johnson, Hashtroudi, & Lindsay, 1993). According to the SMF, when people decide whether a certain memory represents an experienced event versus an imagined event, they will commonly rely on certain memory characteristics—such as its vividness or familiarity—to make this decision. Indeed, according to the SMF, if the memory of an imagined event is highly vivid and familiar, people may erroneously decide the event actually happened: i.e., make a reality-monitoring error. These errors may cause victims of trauma to endorse exposure to more traumatic events over time, i.e., memory

amplification. Consistent with the reality-monitoring proposal, victims of trauma *do* experience involuntary cognitions—or "intrusions"—that include imagined details, i.e., involuntary elaborative cognitions. For example, trauma victims can experience trauma-related intrusions that are exaggerated versions of what happened (e.g., Merkelbach, Muris, Horselenberg, & Rassin, 1998) and intrusions involving plausible extensions of the trauma, such as a stroke victim imagining experiencing a future stroke (Reynolds & Brewin, 1998). Furthermore, our findings from Study 3 (Chapter 5) suggest that people with probable PTSD are susceptible to these kinds of cognitions.

In Study 4 (Chapter 6), we investigated this reality-monitoring explanation experimentally. In particular, using our lab-based paradigm (Oulton, Takarangi, & Strange, 2016) we examined whether instructing participants to elaborate on—i.e., imagine new details and expand upon—their intrusions of a trauma analogue would affect memory for that trauma analogue. We expected that elaboration would cause people to endorse exposure to more graphic photos over time, consistent with a reality-monitoring error mechanism. However, elaboration led to participants experiencing fewer involuntary cognitions about the photos and endorsing exposure to negative photos *less frequently* over time, compared to controls who did not elaborate. These results suggest that the elaboration instructions enhanced conceptual processing of the trauma: i.e., elaboration assisted participants with processing the meaning of the photos in an organized way and placing the photos into context, therefore causing fewer involuntary cognitions. However, consistent with the reality-monitoring proposal, this decrease in involuntary cognitions led to less memory amplification relative to controls.

Although Study 4 suggested a potentially causal relationship between intrusion frequency and memory amplification, we cannot make conclusions about the precise underlying mechanisms from these data because several factors associated with intrusion frequency may drive this relationship. Indeed, there are several potential reasons why intrusion frequency and memory amplification may be related. First, the relationship may reflect an availability heuristic, whereby trauma survivors make estimates about prior trauma exposure according to how frequently they can

recall similar examples (Roemer et al., 1998). When a trauma victim experiences intrusions frequently, similar examples will presumably be easier to recall. Alternatively, in line with the reality-monitoring explanation, intrusions may become confused with true memories of the event, leading to source monitoring errors and therefore a reduction in memory accuracy. Similarly, experiencing many intrusions may cause a person to infer that they experienced many distressing experiences. Thus, when asked about prior exposure, the person might lower their response criterion—i.e., how much evidence they require to respond they experienced that event, such as feelings of familiarity—because they assume that the probability of exposure is high. This proposal is also consistent with the reality-monitoring proposal. Indeed, reality-monitoring errors may *lead to* a mistaken inference that trauma exposure was higher than reality, causing a person to lower their response criterion. Our goal here was to empirically examine these explanations. In particular, we wanted to determine whether manipulating the *frequency* of intrusions—i.e., involuntary memories *and* involuntary elaborative cognitions—affects one's response bias and/or their memory accuracy (i.e., sensitivity) for a trauma analogue. According to the reality-monitoring proposal, we would anticipate that the more intrusions a person experiences, the greater the opportunity for source errors, and therefore the less evidence participants will require to endorse trauma exposure over time, causing memory amplification.

To address our aim, following Oulton et al. (2016), participants viewed negative photos and then completed a recognition test. However, after the test, participants completed a vigilance task (see Schlagman & Kvavilashvili, 2008). During this task, participants were randomly assigned to view photo-related cue words (e.g., *dead*) or no cue words. Critically, past research using this paradigm suggests that this procedure elicits both involuntary memories and other mental contents that include *imagined* details, such as future-based thoughts and abstract hypothetical thoughts (e.g., Plimpton, Patel, & Kvavilashvili, 2015; Mazzoni, Vannucci, & Batool, 2014; Vannucci, Batool, Pelgatti, & Mazzoni, 2014). Twenty-four hours after this task, participants completed a second recognition test. We compared sensitivity and response bias over time between conditions.

8.2. Method

8.2.1. Participants. Based on our counterbalance scheme, we predetermined a target sample size of at least 48 participants per condition; a precision analysis (Cumming, 2013) revealed this sample size was sufficient to obtain a target margin of error (i.e., the half width of the target confidence interval) of 0.41, based on an estimated medium effect (*d*=0.50). One hundred participants completed the study. We excluded one participant who completed the test more than 36 hours after receiving the link to the second test, one participant who had seen the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) stimuli before, and two participants who reported technical issues (i.e., test items not loading) during the second test. Therefore, our final sample consisted of 96 participants (84.4% female). Participants were Flinders University students who received either course credit or an honorarium, aged 18-46 (*M* =21.28 *95% CI* [20.19, 22.37). Most indicated their ethnicity was Caucasian (including White; 57.3%). Other participants identified as Asian (15.6%), mixed ethnic origin (12.5%), European (6.3%), African (3.1%) or Other (5.2%). We did not collect any socioeconomic data.

8.2.2. Materials

8.2.2.1. Photographs. We chose 80 standardized International Affective Picture System photographs (Lang, Bradley, & Cuthbert, 2008) of negative content (e.g., violence and body mutilation) and divided them into four sets of 20 target photos (see Oulton et al., 2016) that we matched for mean valence, *F*s < 1 (Set 1: M = 1.84, 95% CI [1.75,1.94], Set 2: *M* = 1.84 [1.72, 1.96], Set 3: *M* = 1.87 [1.76, 1.98], Set 4: *M* = 1.85 [1.80, 1.90]) and arousal (Set 1: *M* = 6.31 [6.06, 6.56], Set 2: *M* = 6.26 [5.93, 6.58], Set 3: *M* = 6.27 [5.91, 6.64], Set 4: *M* = 6.26[6.00, 6.52]). Participants studied two sets of target photos during the encoding phase. We counterbalanced sets across participants so that every combination was presented evenly. Each target photo appeared for 500ms on five, randomly timed, occasions at encoding. That is, each photo appeared for 2.5 seconds overall. Another 20 negatively valenced IAPS photos—10 at the beginning and 10 at the end of

encoding—acted as primacy and recency buffers. Buffers were presented only once for 500ms and were the same for all participants.

8.2.2.2. Trauma History Screen (THS). We used the THS (Carlson et al., 2011) to measure participants' previous exposure to high magnitude stressor (HMS) events (i.e., potentially traumatic events, e.g., a really bad car accident), traumatic stressor (TS) events (i.e., HMS events associated with extreme distress) and events associated with persisting posttraumatic distress (PPD events). Participants first indicated their frequency of exposure to 14 HMS events. Next, participants answered whether any HMS events really bothered them emotionally (Yes/No). If "yes", for each emotionally bothersome event, they described the event, indicated their age when it happened, whether there was actual or threatened harm, whether they felt very afraid, helpless or horrified, how long they were bothered by the event (1=*not at all*, 4=*a month or more*), and how much it bothered them emotionally (1=*not at all*, 5=*very much*). The THS has good temporal stability (HMS events: r= 0.93; PPD events: r=0.73) and convergent validity with self-reported symptoms of PTSD among university students (Carlson et al., 2011).

8.2.2.3. PTSD Checklist for DSM-5 (PCL-5). We assessed PTSD symptoms in relation to the participant's most bothersome event using the PCL-5. Participants rated how much they had been bothered (0=*not at all*, 4=*extremely*) by 20 symptoms (e.g., "*repeated, disturbing and unwanted memories of the stressful experience*") in relation to that specific event in the past month. Participants also completed the PCL-5 *in relation to the photos* after completing the first memory test[35], and again after completing the second memory test. We used the PCL-5 to calculate a total severity score (*range*: 0-80), along with the four symptom cluster severity scores: re-experiencing (Cluster B), avoidance (Cluster C), negative changes in cognition and mood (Cluster D) and arousal

[35]For the first administration of the PCL-5, we omitted 6 items because they are meaningless for a short delay period (i.e., "repeated, disturbing dreams", "avoiding external reminders of the stressful experience", "loss of interest in activities that you used to enjoy", "taking too many risks or doing things that could cause you harm", "trouble falling or staying asleep" and "feeling distant or cut off from other people"). The revised scale therefore consisted of 14 items (see also Monds, Paterson, Kemp, & Bryant, 2013). Participants completed the full 20-item PCL-5 24 hours later.

(Cluster E). The PCL-5 has strong convergent validity and test-retest reliability (*r*=.82; Blevins, Weathers, Davis, Witte, & Domino, 2015).

8.2.2.4. State-Trait Anxiety Inventory-Trait Subscale (STAI-T). We used the trait scale of the STAI-T to measure proneness to anxiety. Participant read statements (e.g., "*I have disturbing thoughts*") and indicated how much they generally feel that way (1= *almost never*, 4=*almost always*). The STAI-T has good test-retest reliability (*r*=0.88) (Barnes, Harp, & Jung, 2002) and concurrent validity with other anxiety questionnaires (Spielberger, 1983).

8.2.2.5. Global Rumination Scale (GRS). We used the GRS (McIntosh & Martin, 1992) to measure tendencies toward repetitive thought. Participants rated 10 statements (e.g., "*I often become "lost in thought"*") according to how well it described them (1=*does not describe me well*, 7=*describes me well*). Test-retest reliability (*r*=.78) is good and the scale correlates significantly with anxiety measures (Segerstrom, Tsao, Alden, & Craske, 2000).

8.2.2.6. Beck Depression Inventory (BDI-II). The BDI-II (Beck, Steer, & Brown, 1996) measures depression symptoms experienced in the last two weeks. Participants rated 21 items (e.g., self-dislike) on a 4-point scale (e.g., 0 = *I feel the same about myself as ever*, 3 = *I dislike myself*). The inventory has good internal consistency (*a*=0.93; Beck et al., 1996) and construct validity (Oliver & Burkham, 1979).

8.2.2.7. Positive Affect Negative Affect Schedule (PANAS). We measured participants' positive and negative affect using the PANAS (Watson, Clark, & Tellegen, 1988). Participants viewed words (e.g., "*jittery*") and then indicated how much they felt that way in the present moment (1=*Very slightly or not at all*, 5=*Extremely*). Test-retest reliability (NA: *r*=0.81, PA: *r*=0.79) and convergent and divergent validity (Watson et al., 1988) is good.

8.2.2.8. Photo Ratings. After the photos finished displaying, participants responded to the question "*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 overall (1 = *not at all*, 7 = *extremely*).

8.2.2.9. Recognition Test. For the recognition test, participants viewed three sets of 20 photos: one set of "Old" (previously seen) target photos and two sets of "New" (previously unseen) photos. One set of New photos were neutrally valenced IAPS photos—used to check participants were attending to the test—and the other New set was a target negative photo set that was never previously seen by participants. Photos from the three sets appeared in a random order. Participants indicated whether each photo was old or new and how confident they were in their decision (1=*not at all confident*, 10=*extremely confident*). There were six versions of the test, counterbalanced so that every photo appeared equally often as 'new' and 'old' across participants. For every participant, the delayed recognition test contained completely different photo sets to the immediate recognition test. Thus, inaccurate responses 24 hours later could not reflect the participant mistaking photos from the first test as originating from the encoding phase.

8.2.2.10. Intrusion provocation task. In the intrusion provocation task, participants viewed a large (41.1cm x 22.2cm) white rectangle on a computer with either a horizontal (non-target) or vertical line (target) pattern within it over 400 trials (see Schlagman & Kvavilashvilli, 2008). We instructed participants to press the space bar when a target pattern appeared. There were 12 non-target patterns (patterns of four to nine horizontal lines) and four target patterns (patterns of five to nine vertical lines). Target patterns appeared on eight trials; non-target patterns displayed on 392 trials. Trials appeared for 1.5 seconds and were randomized. The intrusion provocation task terminated after 10 minutes.

On 258 randomly selected non-target pattern trials, the intrusion provocation condition viewed cue words that were presented in lowercase size 20 Arial font in the white rectangle's center. We extracted these cue words from a series of photo descriptions generated by Amazon Mechanical Turk participants in a pilot study. In that study, participants viewed a subset of 24 photos and, for each photo, described the event depicted in one sentence (e.g., "*gunshot wound to*

the head"). Each target photo was described by 43 to 48 participants. We entered all photo descriptions together in a word frequency text analysis (www.online-utility.org/text/analyzer.jsp). We excluded words that participants mentioned only three times or less. From the remaining words (*N*=656), we selected: (1) negatively valenced[36] singular nouns (e.g., *knife*), verbs (e.g., *crying*), adjectives (e.g., *hurt*) or adverbs of manner (e.g., *violently*), AND/OR (2) nouns that described objects/people/body parts/places in a photo that were the source, victim, witness, outcome or specific location of the harm, death, or violence (e.g., *man, firefighter, head* etc.). In total, 258 words met our inclusion criteria and were used as cues in this study. Results presented in Study 5 showed that the cues were effective at encouraging involuntary cognitions about the photos[37]. Participants in the control condition did not view any cue words during the task.

8.2.2.10.1. *Task Instructions.* Before completing the intrusion provocation task, we informed participants that they would see a series of line patterns, one by one, and that their task was to detect the target pattern, which has vertical lines. We instructed participants to press the space bar each time the target pattern (i.e., the vertical line pattern) appeared. Following Schlagman and Kvavilashvilli (2008), we also instructed participants in the intrusion provocation condition that they might sometimes see words appear in the centre of the patterns, but to ignore these words and focus on the line patterns. We explained that we were interested in how people keep their concentration on the patterns.

After explaining the vigilance task to participants, we defined involuntary cognitions to participants in accordance with the Involuntary Cognitions Questionnaire (Krans, de Bree, & Moulds, 2015; i.e., "*a certain image, a certain thought, or a certain memory comes to mind, without deliberately thinking about it"*). We instructed participants to press the "x" key if they experienced an involuntary cognition *that was related to the photos* when completing the vigilance task (e.g.,

[36] We determined valence ratings using the Affective Norms for English Words database (Bradley & Lang, 1999). For words not included in the ANEW database *(N*=154), we had 50 participants on Mechanical Turk rate their valence and arousal, following Bradley and Lang's (1999) method. We used words with a mean valence rating of less than four as cues.

[37] Participants (*N*=54) who did not view cue words experienced significantly fewer involuntary cognitions (*M*= 2.11, *SD*=1.60) than participants shown cue words (*N*=54; *M*=3.00, *SD*=1.79), *p*=.031, *d*=0.52 [0.14, 0.90]).

Kubota, Nixon, & Chen, 2015; Takarangi, Strange, & Lindsay, 2014) Participants then completed the task. Each time participants pressed the "x" key—to indicate they experienced an involuntary cognition— the task paused and a black screen appeared with text instructing participants to fill out the monitoring booklet provided.

8.2.2.11. Monitoring Booklet. Within the monitoring booklet, participants described the content of the involuntary cognitions and indicated (yes/no) whether: all details of the cognition were from a single photo, the cognition contained details from several different photos, the cognition was a memory of some other experience from the past, the cognition contained some details from the photos but also other (imagined) details, or if all details of the cognition were imagined (i.e., did not appear in the photos). After filling out the booklet, participants resumed the task by pressing the "n" key. The time participants spent recording their cognitions in the booklet was included within the 10-minute time limit of the vigilance task. Thus, the line pattern slides stopped appearing after 10 minutes, regardless of how many trials participants had completed.

8.2.2.12. Intrusion Diary. Participants recorded intrusions in a paper booklet for 24-hours after the conclusion of the intrusion provocation task. For each intrusion, participants described the intrusion's content and indicated its type (image, thought or combination). Participants also rated (1= *not at all*, 5=*extremely/completely*) the degree 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.

8.2.2.13. Experience of Intrusions Scale (EIS). We used the 5-item EIS (Salters-Pedneault, Vine, Mills, Park, & Litz, 2009) to measure the frequency, unwantedness and unpredictability of participants' intrusions for the 24-hour period after leaving the lab. Participants rated items (e.g., "*On average, when you've had these thoughts, how unwanted were they?*") from 0 (*not at all/almost never*) to 4 (*extremely/very frequently*). The EIS has good test-retest reliability and

convergent validity with other measures of intrusions, including the White Bear Suppression Inventory intrusions subscale (Wegner & Zanakos, 1994).

8.2.3. Procedure. We preregistered this study on the Open Science Framework. Our registration form and data file can be found here: https://osf.io/vy3t8/. The Flinders University Social and Behavioural Research Ethics Committee approved this research. The study advertisement and information form stated that participation would involve answering potentially distressing questions about past trauma and viewing potentially disturbing, graphic photos. We told participants that the study investigated the effect of self-relevance on responses to emotional material, to minimize the likelihood of participants guessing the study aims.

After informed consent procedures, participants responded to demographics questions and then completed the THS, PCL-5, STAI-T, GRS, BDI-II, and PANAS, respectively. Next, participants read that they were about to view photos showing various negative scenes that have actually occurred throughout the world and to closely concentrate on the photographs. The buffer and target IAPS photos the appeared on the screen. After the photos finished displaying, participants responded to the photo rating questions and then completed the PANAS again.

Next, all participants worked on a series of easy crossword puzzles for 10 minutes. We included this delay to ensure memory performance would not be at ceiling for the first recognition test. After this period, participants completed the recognition test, followed by the PCL-5. Participants then completed the intrusion monitoring and vigilance task. After the monitoring period, participants rated their involuntary cognitions (overall) on vividness, emotional intensity and associated distress (1=*not at all*, 5=*extremely*). We also asked participants how hard they tried to push intrusions out of their mind and how much the experience felt as though it was happening "right now". Finally, we asked participants whether the majority of the involuntary cognitions they experienced were thoughts, images, or a combination of both. We included these measures because research suggests that involuntary cognitions in PTSD are typically vivid and experienced in the "here and now", often visually-based, and tend to elicit strong emotions and distress. Moreover,

people with PTSD often attempt to suppress involuntary cognitions (e.g., Ehlers & Clark, 2000; Ehlers et al., 2002; Hackmann et al., 2004; Steil & Ehlers, 2000). We thus wanted to determine how comparable the intrusions elicited in this study were to intrusions in PTSD. After participants provided these ratings they were given the intrusion diary and accompanying instructions.

Twenty-four hours after the lab session, participants received an email containing a survey link that contained the PANAS, the second recognition test, the EIS and PCL, respectively. We also asked participants whether they had voluntarily thought or spoken about the photos during the 24-hour period in the survey. If so, participants indicated frequency (1 = *not at all*, 5 = *nearly all the time*). Participants then read debriefing information.

8.3. Results

8.3.1. Sample Characteristics. We first compared conditions on demographics, trauma history and existing symptomology. There were no significant differences for age, gender and ethnicity (all *ps*>.05). Table 8-1 displays descriptive and inferential statistics for existing symptomology measures and trauma history. There were no significant differences between conditions.

Table 8-1.

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

	Control	Intrusion Provocation	Statistic
HMS	5.63 [3.76, 7.49]	5.27 [3.34, 7.20]	$t(94)=0.27$, $p=.79$, $d=.05$ [-.35, .45]
TS	1.35 [1.10, 1.61]	1.65 [1.26, 2.04]	$t(81.39)=1.25$, $p=.21$, $d=.25$[-.15, .66]
PPD	.71 [.48, .93]	.81 [.49, 1.13]	$t(94)=.54$, $p=.59$, $d=.11$[-.29, .51]
PCL-5	27.29 [21.45,33.13]	24.63 [19.94, 29.31]	$t(89.81)=0.72$, $p=.48$, $d=.15$[-.26, .55]
STAI-T	48.50 [45.19, 51.81]	49.23 [46.66, 51.79]	$t(94)=0.35$, $p=.73$, $d=.07$ [-.33, .47]
BDI-II	16.83 [13.38, 20.28]	16.00 [13.30, 18.70]	$t(88.89)=0.38$, $p=.70$, $d=.08$ [-.32, .48]
GRS	50.13 [47.69, 52.56]	50.08 [48.03, 52.14]	$t(94)=0.03$, $p=.98$, $d=.01$ [-.40, .41]

Note. HMS =High Magnitude Stressor Exposure, 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

8.3.2. Reactions to Photos. To determine whether the photos were an effective trauma analogue, we analyzed participants' photo ratings, positive and negative affect and analogue PTSD symptoms. Table 8-2 shows descriptive statistics. Replicating results from Studies 1, 2, 4 and 5 of this thesis, participants rated the photos as very disgusting and unpleasant, moderately distressing, and reported paying close attention to the photos. None of these ratings significantly differed between conditions, all *p*s>.05.

Next, we compared positive and negative affect scores before and after photo exposure[38], using 2 (Intrusion Provocation, Control) x 2 (Time 1, Time 2) mixed ANOVAs. There were no significant main effects of condition or interactions between condition and time, all *ps*>.05. However, there were significant main effects of time for positive ($F(1, 94)=207.26$, $p<.001$, $\eta_p^2=.69$, 95% *CI* [.58, .76]) and negative affect ($F(1, 94)=125.23$, $p<.001$, $\eta_p^2=.57$ [.44, .66]). Consistent

[38] We also compared positive affect and negative affect prior to the second memory test. There were no significant differences between conditions, all *ps*>.05.

with our expectations, positive affect significantly decreased (*d*=0.92 [0.74, 1.11]), and negative affect significantly increased following encoding, *d*=1.14 [0.88, 1.39].

Table 8-2.

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

	Control	Intrusion Provocation
Photo Ratings		
Unpleasant	5.81[5.40, 6.22]	5.81[5.40, 6.23]
Distress	4.85[4.42, 5.29]	4.75[4.32, 5.18]
Disgust	5.46[4.99, 5.93]	5.40[4.91, 5.88]
Attention	5.92[5.66, 6.18]	5.79[5.50, 6.08]
Affect		
PA before photos	26.23[23.85, 28.61]	25.35[23.50, 27.21]
PA after photos	19.58[17.67, 21.50]	19.25[17.43, 21.07]
NA before photos	17.33[15.51, 19.15]	15.58[13.96, 17.21]
NA after photos	25.75[22.95, 28.55]	24.44[22.04, 26.83]
PCL Time 1		
Total	18.00[14.84, 21.16]	17.31[14.34, 20.29]
Re-experiencing	5.56[4.43, 6.70]	5.71[4.49, 6.93]
Avoidance	1.65[1.27, 2.02]	1.38[1.04, 1.71]
Cognition & Mood Change	6.88[5.56, 8.19]	6.46[5.43, 7.49]
Arousal	3.92[3.06, 4.78]	3.77[2.78, 4.77]
PCL Time 2		
Total	15.02[10.92, 19.12]	14.46[10.52, 18.39]
Re-experiencing	3.79[2.68, 4.90]	3,81[2.65, 4.98]
Avoidance	2.60[1.83, 3.38]	2.50[1.76, 3.24]
Cognition & Mood Change	4.63[3.18, 6.07]	4.67[3.11, 6.22]
Arousal	4.00[2.73, 5.27]	3.48[2.40, 4.56]

Finally, we compared PCL scores—i.e., our measure of analogue PTSD symptoms in relation to the photos—after the first test and after the second test[39], using a 2 (Intrusion Provocation, Control) x 2 (Time 1, Time 2) mixed ANOVA. There was a significant main effect of

time: PCL scores were higher at T1 (M=17.66, *95% CI* [15.52, 19.79]) compared to T2[40] (M=11.89 [9.77, 14.01]), $F(1, 94)=38.09$, $p<.001$, $\eta_p^2=.29$ [.14, .42]. It is likely that the first PCL captured initial symptoms and reactions, which later subsided. We also examined whether condition and time interacted in their effect on PCL scores. One possibility is that the cue words had a carryover effect on subsequent PTSD symptoms, whereby participants who saw cues experienced more analogue PTSD symptoms over the 24-hour period. Inconsistent with this proposal, there was no significant main effect of condition ($F(1, 94)=0.11$, $p=.74$, $\eta_p^2<.01$[.00, .05] or interaction between condition and time ($F(1, 94)=.002$, $p=.97$, $\eta_p^2<.01$ [.00, .05], suggesting that viewing cues did not affect subsequent analogue PTSD symptoms.

8.3.3. Manipulation Check. Next, we examined whether the cue words successfully elicited involuntary cognitions about the photos. We expected that exposure to cues would encourage involuntary cognitions about the photos. Consistent with this hypothesis, the intrusion provocation condition experienced significantly more involuntary cognitions about the photos (M=5.85, *95% CI* [4.59, 7.12]) than the control condition (M=2.65 [1.85, 3.44]), $t(94)=4.33$, $p<.001$. The size of this effect was large, according to Cohen's benchmarks (Cohen, 1981), d=0.88 [0.46, 1.30]. Interestingly, although the intrusion provocation condition reported more intrusions, intrusions were comparable between conditions for overall vividness, emotional intensity, associated distress, "here and nowness" and attempt to suppress their occurrence, all *ps*>.05. The proportion of cognitions that were either images, thoughts, or a combination of both also did not significantly differ conditions, $\chi^2(1)=1.70$, $p=.43$, $\varphi=.15$. Thus, the presence of cue words did not appear to affect the qualities of the intrusions experienced. Descriptive and inferential statistics for these ratings appear in Table 3.

Next, we analysed the content of these involuntary cognitions. Specifically, we analyzed how frequently participants assigned cognitions to each category. We were particularly interested

[40] The PCL we administered at T2 contained 6 more items than the modified PCL administered at T1. Thus, we excluded these 6 additional items when computing total PCL scores at T2 for this analysis.

in whether the cues encouraged *both* involuntary memories about the photos *and* involuntary cognitions with imagined details.

Overall, participants categorized 62.6% of cognitions as containing details exclusive to a single photo they viewed (e.g., "*decomposed body viewed earlier"*), and 15.1% of cognitions as containing details from several different photos (e.g., *"photos of serious burns or wounds to the face"*). A further subset (8.2%) of cognitions were categorized as memories of another past experience related to the theme of the photos (e.g., "*first sexual assault as adult"*). For involuntary elaborative cognitions, participants labelled 11.1% of their cognitions as containing both imagined details and details from the photos viewed (e.g., *"image of dead person with some details from previous images"*), and 8.7% as consisting entirely of imagined details[41] (e.g., "*Pictured the aftermath of an earthquake-rubble, broken buildings etc*."). Finally, for a small proportion of cognitions (1.4%) participants selected the "other" category.

We compared the mean number of cognitions in each of the categories between conditions. There were no significant differences for memories of another past experience, cognitions with imagined details and cognitions consisting entirely of imagined details between conditions, all *p*s>.05. Indeed, contrary to expectations, the mean frequency of cognitions consisting either partially or entirely of imagined details was less than one in both conditions (Control: *M*=.83 [.49, 1.18], Intrusion Provocation: *M* =.79 [.32, 1.27]). However, the intrusion provocation condition experienced significantly more cognitions consisting of details from a single photo they viewed (*t*(94)=4.45, *p*<.001, *d*=.90 [.49, 1.33]) and cognitions containing details from several photos (*t*(94)=2.50, *p*=.01, *d*=.51 [.10, .92]) than controls. Thus, contrary to predictions, cue-exposed participants experienced more involuntary *memories* about the photos, but not more involuntary elaborative cognitions, compared to controls.

[41] These rates were comparable to those observed in Chapter 7 (Study 5): participants categorised 13.6% cognitions as containing both imagined details and details from the photos viewed and 7.0% of cognitions as consisting entirely of imagined details.

8.3.4. Re-experiencing Symptoms. Next, we examined involuntary cognition frequency *after* leaving the lab. We were specifically interested in whether provoking involuntary cognitions in the lab would lead to more involuntary cognitions during the 24-hour delay period. Thus, we compared conditions on our involuntary cognition measures for the delay period: i.e., the intrusion diary and the EIS. Descriptive and inferential statistics appear in Table 8-3. There was no significant effect of condition on any of these measures. These findings suggest the cue words did not affect participants' re-experiencing symptoms after leaving the lab.

Table 8-3.

Intrusion measures by experimental condition, including means (with 95% confidence intervals), and inferential statistics.

	Control	Intrusion Provocation	Statistic
Frequency (MP)	2.65 [1.85, 3.44]	5.85 [4.59, 7.12]	$t(94)=4.33$, $p<.001$, $d=0.88$[0.46, 1.30]
Characteristics (MP)			
Distress	3.11 [2.82, 3.41]	3.05 [2.73, 3.37]	$t(74)=.30$, $p=.77$, $d=.07$[-.38, .52]
Vividness	3.57 [3.26, 3.89]	3.46 [3.14, 3.79]	$t(74)=.48$, $p=.63$, $d=.11$[-.34, .56]
Suppression	3.94 [3.59, 4.30]	3.49 [3.07, 3.91]	$t(74)=1.65$, $p=.10$, $d=.38$ [-.07, .83]
Here and Now	2.11 [1.68, 2.55]	2.39 [1.99, 2.79]	$t(74)=.94$, $p=.35$, $d=.22$[-.24, .67]
Emotion	3.00 [2.61, 3.39]	3.10 [2.71, 3.29]	$t(74)=.36$, $p=.72$, $d=.08$[-.37, .53]
Frequency (D)	1.48[.99, 1.97]	1.54[1.01, 2.08]	$t(94)=.17$, $p=.86$, $d=.04$[-.37, .44]
Characteristics (D)			
Distress	2.83[2.49, 3.17]	3.00[2.61, 3.39]	$t(60)=.66$, $p=.51$, $d=.17$[-.33,.67]
Vividness	3.13[2.78, 3.48]	3.60[3.22, 3.97]	$t(60)=1.85$, $p=.07$, $d=.47$[-.04, .97]
Suppression	3.40[3.03, 3.78]	3.88[3.49, 4.26]	$t(60)=1.78$, $p=.08$, $d=45$[-.05, .96]
Here and Now	1.97[1.60, 2.34]	2.24[1.81, 2.66]	$t(60)=.95$, $p=.35$, $d=.24$[-.26, .74]
Aware	3.67[3.35, 3.99]	3.33[2.93, 3.73]	$t(60)=1.35$, $p=.18$, $d=.34$[-.16,.84]
Out of the blue	3.33[3.01, 3.64]	3.71[3.40, 4.02]	$t(60)=1.75$, $p=.09$, $d=.44$[-.06, .95]
Emotional	2.93[2.60, 3.27]	3.02[2.63, 3.41]	$t(60)=.34$, $p=.73$, $d=.09$[-.41, .59]
EIS score	5.90[4.75,7.04]	6.65[5.67, 7.62]	$t(94)=1.00$, $p=.32$, $d=.20$[-.20, .61]

Note. MP: Monitoring Period, D: Diary, EIS: Experience of Intrusions Scale.

We also compared how frequently participants *voluntarily* thought or spoke about photos between conditions. The proportion of participants who voluntary thought or spoke about the photos did not significantly differ between the intrusion provocation condition (46.8%) and the

control condition (53.2%), $\chi^2(1)=.52$, $p=.47$, $\varphi= .07$. Further, how often participants indicated voluntarily thinking or talking about the photos was not significantly correlated with any dependent variables of interest, all *ps*>.05.

8.3.5. Memory Accuracy and Response Bias. Recall our main aim was to test whether provoking intrusions would *increase* participants' tendency to respond "old" to test items over time (i.e., memory amplification) and *decrease* their capacity to discriminate between old and new photos over time (i.e., sensitivity). To separate sensitivity from response bias, we used a signal detection method (Stainslaw & Todorov, 1999). We classified old (i.e., previously seen) photos as signal events. We classified new (i.e., previously unseen photos), negative photos[42] 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 measure *d'*—which represents sensitivity—and *c*—which represents response bias. Increasing *d'* values indicate an increased ability to discriminate between old and new photos. Further, $c < 0$ indicates a response bias toward answering "old," and $c > 0$ indicates a response bias toward answering "new". We compared sensitivity and response bias before and after the intrusion provocation manipulation, using 2 (Intrusion Provocation, Control) x 2 (Time 1, Time 2) mixed ANOVAs.

For sensitivity, participants were poorer at discriminating between old and new photos at T2 (*M*=1.57, *95% CI* [1.44, 1.70]) compared to T1, *M*=2.13 [1.95, 2.30]), a significant main effect of time, $F(1, 94)=52.94$, $p<.001$, $\eta_p^2=.36$ [.21, .48]. There was no significant main effect of condition ($F(1, 94)=.60$, $p=.44$, $\eta_p^2=.01$ [.00, .07]). Inconsistent with our hypothesis, there was no significant interaction between condition and time ($F(1, 94)=1.83$, $p=.18$, $\eta_p^2=.02$ [.00, .10]). That is, the intrusion provocation condition showed a comparable reduction in sensitivity over time (Time 1: *M*=2.13[1.85, 2.41] Time 2: *M*=1.67 [1.48, 1.87], *d*=.54 [.26, .85]) compared to control participants (Time 1: *M*=2.13 [1.91, 2.35] Time 2: M=1.46 [1.28, 1.65], *d*=.94 [.60, 1.29]). A Bayesian repeated

[42] We also examined participants' memory accuracy for new neutral (control) photos. On average, participants incorrectly identified 2.7% and 3.8% of control photos at T1 and T2, respectively. These proportions did not significant differ between conditions, all *ps*>.05.

measures ANOVA (Rouder, Speckman, Sun, Morey, & Iverson, 2009) revealed only anecdotal evidence for the interaction hypothesis, BF_{10}=1.89. That is, these data are merely 1.89 times more likely under the alternative hypothesis (i.e., that the reduction in sensitivity over time depends on experimental condition) than under the null hypothesis (i.e., that the effect of time on sensitivity does not depend on condition).

For response bias, participants were *less* biased to answer "old" to the photos at T2 (*M*=.14 [.03, .25]) compared to T1 (*M*=-.26 [-.35, -.17]), a significant main effect of time, *F*(1, 94)=62.97, *p*<.001, η_p^2=.40, *95% CI* [.24, .52]. This finding is consistent with normal forgetting. There was no significant main effect of condition (*F*(1, 94)=1.72, *p*=.19, η_p^2=.02 [.00, .10]). Inconsistent with our hypothesis, there was no significant interaction between condition and time (*F*(1, 94)=0.27, *p*=.61, η_p^2<.01 [.00, .06]): the intrusion provocation condition showed a comparable change in response bias over time (Time 1: *M* =-.21 [-.33, -.10], Time 2: *M*=.21 [.03, .39], *d* =.80 [.48, 1.14]) relative to the control condition (Time 1: *M*=-.30 [-.44, -.17], Time 2: *M*=.07 [-.07, .20], *d*=.79 [.47, 1.10]). A Bayesian repeated measures ANOVA (Rouder et al., 2009) revealed substantial evidence for the null hypothesis (i.e., that the effect of time on response bias does not depend on condition), BF_{10}=0.24. These findings suggest that our provoking intrusions did not contribute to memory amplification for the trauma analogue.

8.3.6. Confidence. We compared mean confidence scores for Old and New test items before and after the intrusion provocation manipulation, using 2 (Intrusion Provocation, Control) x 2 (Time 1, Time 2) mixed ANOVAs. Confidence significantly reduced over time for old photos (T1: *M*=9.04, *95% CI* [8.87, 9.21], T2: *M*=8.22 [7.98, 8.46]), a significant main effect of time, *F*(1, 94)=92.86, *p*<.001, η_p^2=.50 [.35, .60]. Participants became more confident when identifying new photos over time (T1: *M*=7.45 [7.17, 7.73], T2: *M*=7.66 [7.34, 7.98], *d*=.14 [.02, .26]), a significant main effect of time, *F*(1, 94)= 5.81, *p* =.02, η_p^2=.06 [.00, .17] . Indeed, there was non-significant trend for participants to be more accurate at identifying new photos over time (*t*(95)=1.92, *p*=.058, *d*=.17 [-.01, .35], which may explain their increased confidence over time. Critically there were no

significant main effects of condition or interactions between condition and time for both old and new photos (all *ps*>.05), suggesting our manipulation did not affect confidence in memory.

8.3.7. Intrusion Measures and Memory Amplification. Finally, we examined the relationships between our intrusion measures and memory amplification. We were specifically interested in whether increasing intrusion frequency in the lab would predict both a reduction in sensitivity and an increase in memory amplification, consistent with the reality-monitoring explanation. Unexpectedly, intrusion frequency in the lab was not significantly correlated with change in response bias (*r*=-.04, *95% CI* [-.24, .16], *p*=.72) or change in sensitivity (*r*=.03 [-.17, .23], *p*=.80). The same was true when we focused on intrusions with imagined details exclusively: frequency of intrusions that contained imagined details (or were entirely imagined) was not significantly related to change in response bias (*r*=.02 [-.18, .22] *p*=.82) or change in sensitivity (*r*= -.07 [-.27, .13], *p*=.49).

Given intrusion frequency was not related to memory amplification, we decided to explore whether other measures associated with intrusions (aside from frequency) affected amplification. Interestingly, we observed several significant relationships between intrusion characteristics—as measured in the diary—and memory amplification. In particular, we found that memory amplification was significantly associated with the degree of distress associated with intrusions reported in the diary (*r*=-.26, *95% CI* [-.48, -.01], *N*=62, *p*=.04), the degree to which participants tried to suppress intrusions reported in the diary (*r*=-.32 [-.53, -.08], *N*=62, *p*=.011) and how much the intrusions' accompanying emotions reflected the emotions experienced at the time they viewed the photos (*r*=-.26 [-.48, -.01], *N*=62, *p*=.042). Furthermore, there was a small positive association between vividness of intrusions as reported in the diary and memory amplification, which approached statistical significance (*r*=-.22 [-.45, .03], *N*=62, *p*=.08). However, how much the intrusion felt as though the experience was happening "right now", how aware participants were of current surroundings when the intrusion occurred, and how "out of the blue" the intrusion was, did not significantly relate to memory amplification, *p*s>.05. Furthermore, we did not observe any

significant correlations between characteristics of intrusions reported in the monitoring period (e.g., vividness, emotional intensity and associated distress) and memory amplification, all *ps*>0.05.

Finally, we correlated frequency of diary intrusions, the re-experiencing subscale of the PCL and EIS scores with memory amplification and change in sensitivity. All results were non-significant with the exception of the PCL: replicating our prior research (Oulton et al., 2016), increasing re-experiencing symptoms on the PCL was related to an increase in response bias toward responding "old" to photos over time (*r*=-.22 [-.40, -.02], *p*=.028). All other PCL subscales were not significantly related to these variables, all *ps*>.05.

8.4. Discussion

Our goal in this study was to examine whether participants gradually incorporate imagined details about a trauma analogue—generated via involuntary cognitions—into their memory, leading to memory amplification. To this end, we attempted to manipulate the presence of both involuntary memories *and* involuntary elaborative cognitions between subjects using cue words. Our findings suggest that we were only successful in manipulating *memories* of the photos and not elaborative cognitions. Furthermore, the presence of cue words did not affect the characteristics of the intrusions experienced. Interestingly, we observed no significant effect of this intrusion frequency manipulation on participants' ability to distinguish between old and new photos over time (i.e., sensitivity) or their bias to respond "old" to photos over time (i.e., response bias). Taken together, our findings do not provide evidence that intrusive *memory* frequency is causally related to memory amplification for a trauma analogue. Thus, our results do not support the proposal that intrusions enhance accessibility to memories of trauma, therefore causing an increase in endorsements of trauma exposure over time. However, because we were unable to manipulate the rate of involuntary elaborative cognitions in this paradigm, we are limited in our ability to test the reality-monitoring explanation with these data.

When considering our findings it is important to note the low rate of involuntary elaborative cognitions experienced (*M*=.81 [.52, 1.10]. We initially anticipated that cues would encourage these

cognitions because prior research using written cues (e.g., Plimpton, Patel, & Kvavilashvili, 2015; Mazzoni, Vannucci, & Batool, 2014) has successfully encouraged both involuntary memories and other types of cognitions, including imagined events. One potential explanation for this discrepancy is that previous studies have asked participants to report any involuntary cognition—regardless of content—when completing the vigilance task. In contrast—because we were exclusively interested in trauma-related cognitions—we asked participants to indicate when they experienced involuntary cognitions *about the photos*. By restricting participants to only report cognitions related to a specific, past experience, we likely affected the observed frequency of involuntary elaborative cognitions. It should be acknowledged, however, that this aspect of our procedure was necessary because we were exclusively interested in how trauma-related cognitions influence memory, to test the reality-monitoring proposal.

Interestingly, we also found that written cues only encouraged memories about the trauma analogue, but not involuntary elaborative cognitions. The finding that cues encouraged involuntary memories about the trauma analogue is unsurprising based on existing theory. Indeed, according to theories of involuntary autobiographical memory retrieval, cues resembling features of past events encourage a spreading of activation of the memory network, leading to involuntary autobiographical memories: i.e., memories of personal experiences that arise spontaneously (e.g., Berntsen, 2009; Mace, 2007). Importantly however, theorists have also argued that the same process underlies the construction of other types of involuntary cognitions, including imagined future events (Berntsen & Jacobsen, 2008). Yet our data suggests that written cues that overlap with a trauma analogue do not provoke involuntary elaborative cognitions. One potential explanation for this finding may be that the trauma analogue was not immersive or distressing enough to promote these elaborative cognitions. Indeed, involuntary elaborative cognitions often include a sense of ongoing threat and a perception that "worse is to come". For example, trauma victims experience "worst case scenario intrusions", where the cognition represents an exaggerated version of the trauma happening in the present. These cognitions are similar to future-based images experienced in

anxiety disorders, such as panic disorder (see Clark, 1999, for a review). One possibility, therefore, is that the trauma analogue did not encourage these types of cognitions because it did not provoke the same anxiety and threat to life or safety experienced during real-life trauma exposure. Indeed, supporting this proposal, we found that analogue PTSD arousal symptoms (e.g., "*being "super alert" or watchful or on guard"*) experienced in the lab were significantly associated with the frequency of involuntary elaborative cognitions experienced in the lab (r=.21, p=.039). Future research might therefore consider using a different trauma analogue that elicits stronger feelings of anxiety. However, for ethical reasons, we are of course constrained in how much we can provoke such emotional states. Thus, it may not be possible to answer our research question with experimental methods. Alternatively, future studies might elect to use real-life scenarios where people have already chosen to perform a highly arousing activity (e.g., skydiving) to investigate this proposal further (e.g., Cavenett & Nixon, 2006).

Although we encouraged intrusive memories about the trauma analogue, this enhancement did not affect memory accuracy or response bias. Some researchers have proposed that memory amplification may reflect a rehearsal effect. According to this proposal, PTSD sufferers are more equipped to easily recall previous stressor exposure because trauma memories are more frequently rehearsed via intrusive memories (Litz & Keane, 1989). Similarly, other authors argue that memory amplification reflects an availability heuristic, whereby trauma survivors make estimates about prior trauma exposure on the basis of how frequently they can recall similar examples (Roemer et al., 1998). When a survivor experiences intrusions frequently, such examples will presumably be easier to recall. However, conflicting with these proposals, we found no evidence of a causal relationship between intrusive memories and memory amplification. Interestingly, these results are thus somewhat inconsistent with our observations in Study 4. In Study 4, we observed that manipulating the frequency of involuntary cognitions—via our elaboration instructions—led to changes in memory amplification. One potential reason for this discrepancy is that, unlike Study 4, in this study our conditions experienced a comparable number of intrusions during the 24-hour delay

period. That is, exposure to written cues did not affect how often the photos intruded after leaving the lab. Thus, perhaps our manipulation was not strong enough to detect observable differences in response bias between our conditions. Indeed, although intrusion frequency—both in the lab and during the 24 hour delay—was not significantly related to changes in response bias or sensitivity, we observed a significant relationship between re-experiencing symptoms on the PCL and an increase in response bias toward responding "old" to photos over time, consistent with Study 4. Future research might therefore consider developing stronger manipulations of intrusion frequency to provide a more powerful test of these availability proposals.

When considering our correlational findings, however, it is important to note that many of our intrusion measures were not significantly related to memory amplification. Indeed, the only significant relationship was between the re-experiencing subscale of the PCL and memory amplification. One possible explanation for this discrepancy across different measures is that the PCL captures other qualities of intrusions that contribute to memory amplification beyond mere frequency (e.g., "*having strong physical reactions when something reminded you of the stressor (for example, heart pounding, trouble breathing, sweating)*", *"repeated, disturbing, and unwanted memories of the photos*). Indeed, perhaps the disturbing nature of intrusions determines memory amplification more than the frequency of those intrusions; presumably, the more distressing and emotional an intrusion is, the more likely it will resemble a true memory of trauma, and therefore the more likely it will become incorporated into memory. Supporting this explanation, memory amplification was significantly associated with intrusion related distress, how much participants tried to suppression intrusions and how much the intrusions' accompanying emotions reflected the emotions experienced when viewing the photos. Interestingly, research suggests that intrusion characteristics (e.g., associated distress, "here and nowness") are more predictive of PTSD than intrusion *frequency* (e.g., Michael, Ehlers, Halligan, & Clark, 2005). Thus, PTSD sufferers may be susceptible to memory amplification not because they experience intrusions more regularly, but because their intrusions have qualities that emulate real-life exposure to trauma. Future research

should investigate this proposal further by experimentally manipulating intrusion-related distress and examining how this affects memory. For example, priming participants to interpret intrusions as negative could potentially assist in manipulating intrusion-related distress.

Nevertheless, we found no significant relationships between intrusion characteristics during the monitoring period and memory amplification, contradicting this proposal that intrusion characteristics predict memory amplification. However, this discrepancy may be because less time had passed since encoding in the monitoring period. Therefore, participants likely had a clearer memory of the photos viewed and consequently may have easily detected discrepancies between the content of their intrusions and the photos themselves. Furthermore, participants rated intrusions *overall* on their characteristics at the end of the monitoring period, unlike in the intrusion diary where participants rated each intrusion individually after it occurred. Thus, the intrusion diary may have provided a more valid measure of intrusion characteristics, because this measure was less contaminated by retrospective biases and potential guessing.

Our study has limitations. First, the photos likely failed to provoke the same stress experienced during a real-life trauma and thus may not generalize to real-world trauma. Second, our rate of involuntary elaborative cognitions was low. Thus, despite our best efforts, we were unable to experimentally test the reality-monitoring proposal. Future research should try to develop effective methods to encourage involuntary elaborative cognitions and therefore examine the reality-monitoring explanation.

Overall, our findings showed that provoking intrusions did not significantly affect response bias or sensitivity for a trauma analogue. However, because we did not manipulate intrusions containing imagined details, we are unable to make firm conclusions about the reality-monitoring proposal from these data. Therefore, an important direction for future research is to examine what causes involuntary elaborative cognitions after trauma and thus develop new ways to experimentally manipulate these cognitions. Furthermore, our data make an important contribution to the literature by suggesting that intrusion-related characteristics may be more predictive of

memory amplification, relative to intrusion frequency. Thus, future studies should consider developing methods to experimentally manipulate intrusion characteristics to more closely examine how these characteristics affect memory amplification.

9. General Discussion

9.1. Summary of key aims and findings

The aim of this thesis was to examine one recently proposed explanation for why victims of trauma exhibit memory amplification. Specifically, my goal was to determine whether memory amplification occurs because people confuse imagined trauma-related details with their true experience (i.e., the 'reality-monitoring account'). This explanation has never been empirically tested. I addressed this gap in the literature by testing several key assumptions that underlie the reality-monitoring proposal. In particular, I tested whether: (1) intrusive symptoms are related to an enhancement in *false* memories of trauma and a tendency to endorse trauma exposure over time, (2) victims of real-life trauma experience involuntary cognitions that contain imagined details and are experienced similarly to memories of experienced events, and (3) whether experimentally manipulating the imagination of details related to trauma has a causal effect on memory amplification. Taken together, the findings from my thesis provide some preliminary support for the reality-monitoring explanation for memory amplification.

After reviewing the relevant literature and establishing my key objectives in Chapters 2 and 3, in Chapter 4, the first empirical chapter, I developed a novel laboratory-based paradigm to address whether the re-experiencing symptoms of PTSD are associated with a tendency to endorse more trauma exposure and an enhancement in memory distortion over time, consistent with the reality-monitoring explanation (Studies 1 and 2). To my knowledge these studies are the first to investigate the memory amplification effect in a controlled environment that permitted me to examine memory accuracy and response bias for trauma exposure over time. Using this paradigm, I showed that, among participants who showed memory amplification, analogue re-experiencing symptoms were positively related to a tendency to endorse exposure to more graphic photos over time (memory amplification). The effect sizes I observed were comparable to effects from the field research (Giosan et al., 2009; Engelhard et al., 2008; King et al., 2000; Southwick et al., 1997). Furthermore, in line with the assumption that involuntary cognitions lead to source misattribution

and therefore false memories, I also found that analogue re-experiencing symptoms at the later time point (T2)—one week later—were associated with an increase in false memories of the photos over time. These findings therefore conflict with prior proposals that memory amplification may reflect a repression mechanism (e.g., Southwick et al., 1997) and, instead, suggest that people become worse at remembering the trauma and become more biased to endorse trauma exposure.

In Chapter 5 (Study 3) I addressed a different yet related key assumption underlying the reality-monitoring explanation: that people with heightened PTSD symptoms are more prone to involuntary cognitions that include imagined details, compared to healthy, trauma-exposed people. In this study I aimed to gain a better insight of how frequently people with heightened PTSD symptoms experience involuntary elaborative cognitions—i.e., cognitions that include imagined details related to trauma—relative to healthy, trauma exposed people, and how these cognitions are experienced. Importantly, no prior research had investigated the characteristics of the *experience* of involuntary elaborative cognitions among victims of trauma (e.g., associated distress and vividness) and therefore it was unclear whether these cognitions could be mistaken for memories due to shared characteristics. Further, although one study had addressed whether people with PTSD experience involuntary elaborative cognitions more frequently than trauma-exposed controls (Reynolds & Brewin, 1998), due to small sample size this study may have lacked sufficient power to detect effects. I therefore investigated these questions in a large US adult sample (N=1,215). Most involuntary content that participants reported was categorized as memories, however a subset (18.8%) of content was categorized as non-memories (trauma-related cognitions that were not memories of the past). Although some of these non-memories were evaluative cognitions—i.e., verbally-based cognitions, such as thoughts about who is to blame—a subset were elaborative non-memories (also referred to as "elaborative cognitions" in this thesis), such as future-based images related to the trauma. Importantly, involuntary elaborative non-memories were more frequent among participants with probable-PTSD (based on the cut-off of the PCL; Weathers et al., 2013) compared to non-PTSD participants. Critically, memories and non-memories were indistinguishable

on many phenomenological characteristics, including vividness and associated distress. Study 3's findings are therefore consistent with one assumption underlying the reality-monitoring explanation for memory amplification. Specifically, according to the source monitoring framework, vivid and emotional memories lacking information about cognitive operations (e.g., records of imagining and retrieving) are typically judged as originating from true experience (e.g., Lindsay, 2008). My data showed that non-memories about trauma encompass all of these characteristics. Nevertheless, due to the non-experimental nature of this study, these findings do not allow conclusions regarding whether people mistake non-memories for real memories.

Given the evidence from Study 3 that victims of trauma do experience involuntary elaborative cognitions about their experience, my goal in the subsequent chapters was to investigate whether these cognitions are causally related to memory amplification, in line with the reality-monitoring account. Indeed, although data from Studies 1 and 2 suggested that re-experiencing measures and memory amplification are related, these data did not provide insight regarding this relationship's direction or what precise mechanism underlies this association. Thus, in Chapters 6, 7 and 8, I reported the findings from experimental paradigms that I used to more rigorously test the reality-monitoring explanation.

In Chapter 6 (Study 4), I investigated whether instructing participants to imagine new details and expand upon their intrusions of a trauma analogue would affect their memory for that trauma analogue. I was primarily interested in whether internally generating new details would cause people to endorse exposure to more trauma over time, consistent with a reality-monitoring error mechanism. Interestingly, contrary to predictions, I found that instructing participants to elaborate on their intrusions actually led to those participants experiencing *fewer* involuntary cognitions about the photos and endorsing exposure to negative photos *less frequently* over time, compared to control participants who did not elaborate on their involuntary cognitions. These results may reflect elaboration instructions enhancing conceptual processing of the trauma. More specifically, elaboration perhaps assisted participants with processing the meaning of the photos in an organized

way and placing the photos into context, therefore causing a reduction in involuntary cognitions about the photos. Alternatively, elaboration might have encouraged more specific memories, causing less sensitivity to trauma-related cues and therefore fewer intrusions. Importantly, given that *both* intrusion frequency and elaboration differed between conditions, the study design unfortunately did not provide an appropriate test of the realty-monitoring proposal. More specifically, we cannot confidently conclude that the reduction in intrusions *caused* less memory amplification among elaboration participants.

Considering that intentional and deliberate elaboration did not enhance memory amplification in Study 4, one possibility I considered is that the spontaneous and non-deliberate nature of elaborative cognitions—and, particularly, the lack of context associated with their experience—is essential for amplification to occur; because these qualities may inhibit people from conceptual processing the event, thereby maintaining re-experiencing symptoms. Chapters 7 (Study 5) and 8 (Study 6) were targeted towards investigating this proposal. In Study 5, my primary goal was to develop an effective manipulation of *spontaneous* elaborative cognitions to determine how involuntary elaborative cognitions affect memory amplification. To this end, in Study 5 I tested whether presenting participants with written cues would provoke involuntary elaborative cognitions related to negative photos. Current theory suggests that involuntary elaborative cognitions are constructed using details from different memories (Berntsen & Jacobsen, 2008). Thus, I investigated whether multiple, unrelated cues presented *together* would enhance involuntary elaborative cognitions relative to *isolated* cues, therefore allowing us to provoke elaborative cognitions in the lab and examine how this manipulation affects memory amplification. I therefore manipulated the number of cues presented together between-participants: participants completed a vigilance task for 10-minutes where they saw triplet cues, single cues, or no cues. Each time participants reported an involuntary cognition—by pressing a computer key—they answered questions in a booklet about that cognition's content and characteristics. Encouragingly, consistent with the findings from Study 3, I found that over 20% of cognitions elicited in this paradigm

consisted either wholly or partially of imagined trauma-related details. However, contrary to predictions, whether cues were presented in isolation or in triplets did not affect how frequently participants experienced involuntary elaborative cognitions. One explanation for this finding is that multiple cues do not encourage involuntary elaborative cognitions more than singularly presented cues. Another potential explanation for this finding is that participants were reluctant to report cognitions because doing so meant responding to multiple questions about the content of those cognitions. Moreover, because time spent filling out the booklet was included within the 10-minute time limit, participants could feasibly record only a small number of cognitions. I therefore wondered whether the effect size I observed for cue presence was weaker than reality, due to a ceiling effect.

Indeed, my findings from Study 6 confirmed this speculation that the difference in intrusion frequency between conditions was influenced by a ceiling effect. I found that when participants did not have to rate cognitions during the monitoring phase, there was a larger difference in involuntary cognition frequency between participants shown cues and participants not shown cues in Study 6 (d=.88) relative to Study 5 (d =.52). I subsequently examined how this stronger manipulation of cognition frequency affected memory amplification. Importantly however, my findings from Study 6 suggested that cues only encouraged involuntary *memories* of the photos and not involuntary elaborative cognitions. Unexpectedly, there was no significant effect of this manipulation of intrusive memories on participants' ability to distinguish between old and new photos over time or their bias to respond "old" to photos over time. The findings from Study 6 therefore did not provide evidence that intrusive *memories* are causally related to memory amplification for a trauma analogue. Interestingly however, although there was no significant relationship between intrusion frequency and memory amplification, there was a significant relationship between re-experiencing symptoms—as measured by the PCL—and memory amplification, consistent with findings from Studies 1, 2, and 4. Furthermore, several measures of intrusion *characteristics* were related to memory amplification, including associated distress, the degree to which participants tried to

suppress intrusions and how much the intrusions' accompanying emotions reflected the emotions experienced at the time they viewed the photos. One possibility that arises from these findings is that the distress associated with intrusions is more critical in determining memory amplification than intrusion frequency; following the reality-monitoring account, the more distressing and emotional an intrusion is, the more likely it will resemble a memory for a perceived event, and therefore the greater likelihood it will be incorporated into a person's memory. Nevertheless, because the number of involuntary elaborative cognitions did not significantly differ between the cued condition and control condition, I was unfortunately unable to directly test the reality-monitoring explanation with these data. Considered together, however, the findings from this thesis make several important theoretical contributions to the literature, which I explore in the following section.

9.2. Theoretical Contributions

As discussed in Chapter 1, many clinicians and theorists assume our memories for trauma are 'special', because they are frequently buried in the unconscious by special processes (such as repression) and can later be recovered with *negligible distortion* (e.g., Bass & Davis, 1988; Fredrickson, 1992; Herman, 1992; Terr, 1994; van der Kolk & Fisler, 1995). Importantly, although some theorists acknowledge that trauma memories are not immune from distortion (e.g., Ehlers et al., 2002), several current PTSD models reflect an underlying assumption that traumatic memory is special: many authors conceptualize PTSD as an autobiographical memory disorder, in which the trauma memory is fragmented and difficult to integrate with the person's life story (e.g. Brewin et al., 1996; Van der Kolk & Fisler, 1995). For example, Brewin and colleagues (1996) present a dual processing model of PTSD, arguing that traumatic memories are often represented non-verbally because people non-consciously process certain details present during the event, including sensory and perceptual information. These memories may include images and noises that people processed too quickly to give much conscious attention, or information regarding the bodily response to the trauma, such as changes in heart rate. Importantly, according to this model, this information is not

consciously retrieved and is only accessible when a person encounters trauma reminders in their environment. Critically, the authors assume that when this information is retrieved it is *completely accurate*.

Taken together, the findings from this thesis are inconsistent with this special mechanism proposal. Instead, the research presented in this thesis adds to a large body of literature highlighting that trauma memory is both dynamic and highly malleable—even when people do not receive explicit misinformation about their experience. Indeed, across all of the experiments assessing memory, participants falsely remembered graphic photos that they had never seen before, and failed to remember stimuli that they had actually seen, making decisions with a high degree of confidence. Importantly, these stimuli were rated as highly distressing, unpleasant and disgusting, ruling out the possibility that the trauma analogue represented a neutral, ordinary experience for participants that was not memorable. Furthermore, in Studies 1, 2, 4 and 6 this difficulty in distinguishing between seen and unseen stimuli *exacerbated* over time. Thus, the findings from this thesis make a significant contribution to the literature by showing that memories for traumatic experiences—like memories for everyday experiences—tend to become less accurate as time passes. Previous field studies on memory amplification have not been able to verify trauma exposure and have therefore not been able to determine which time point represents a more accurate account of what actually happened. More specifically, field studies have only been able to examine how *consistently* people remember their trauma over time, and not how *accurately* they remember their experience, because true trauma exposure is unknown. Through the use of a tightly controlled trauma analogue design, I was able to address this limitation. By controlling participants' exposure to a trauma analogue, I could assess both how accurate people are when remembering trauma over time and how biased they are to endorse trauma exposure. Importantly, based on the field research, some researchers within the memory amplification literature have proposed that memory amplification could reflect victims of trauma either repressing or actively suppressing their trauma memories initially and the memories being brought to consciousness as time elapses (e.g., Southwick et al., 1997). However,

my research directly contradicts this proposal by showing that people become *less* accurate when remembering their experience over time.

Also conflicting with the special mechanism view, in Study 3 I found that victims of real-life trauma with probable PTSD commonly experienced involuntary cognitions about their trauma that were not an accurate representation of what truly happened to them—contradicting previous speculation that PTSD intrusions are always veridical (e.g., van der Kolk & Fisler, 1995). Importantly, prior to this research, minimal empirical work had investigated the occurrence of these cognitions among people with PTSD. This gap in the literature may partly reflect PTSD commonly being considered a disorder caused by *past* events and researchers therefore focusing their attention on how the trauma is *remembered* rather than how trauma-related details are *imagined* (Berntsen & Rubin, 2015). Critically, my findings suggest that people with probable PTSD (based on the cut-off of the PCL; Weathers et al., 2013) are susceptible to involuntary elaborative cognitions and that these cognitions are experienced similarly to involuntary memories of trauma. The findings from Study 3 have at least two important theoretical implications. First, the findings are consistent with the proposal that involuntary elaborative cognitions assist in developing and/or maintaining PTSD symptoms, by contributing to an ongoing sense of threat (Ehlers & Clark, 2000) and an inability to put the trauma in the past. Second, my findings align with the idea that people with PTSD could mistake involuntary elaborative memories for genuine memory traces, consistent with the reality-monitoring proposal. Indeed, we know that source-monitoring errors are more likely when real and imagined memories share phenomenological characteristics (e.g., Lindsay, 2008).

This thesis also adds to a growing body of literature showing that PTSD symptomology and memory amplification are significantly related. It is important to consider, however, that my methodology differs from prior studies showing this relationship. Specifically, previous research has used verbal checklists to assess trauma exposure, whereby participants read trauma *descriptions* (e.g., *"seeing human remains"* and *"death of a close friend"*) and then either indicate (yes/no) whether they have been exposed, or how frequently they have been exposed to that event on a

Likert Scale (e.g., Roemer et al., 1998). Some authors have noted that these items are often general enough to be considered subjective (e.g., "*witnessing violence"*) and have concluded that these assessment methods may be vulnerable to re-interpretation over time (e.g., Engelhard et al., 2000). Indeed, Engelhard and McNally (2015) found that when they asked Dutch soldiers why their responses were inconsistent on these assessments over time, the most common explanation was that they had interpreted the item differently. For example, participants interpreted "seeing human remains" as seeing blood on one occasion but not the other occasion. Importantly, researchers have proposed that PTSD symptoms cause the trauma victim to re-interpret trauma descriptions, due to a motivation to justify distress (e.g., Engelhard et al., 2000). Furthermore, laboratory-based research suggests that description-based test formats encourage a liberal response bias for graphic photos (Takarangi, Oulton, & Strange, in press). Critically however, the studies presented in this thesis removed any potential influence of this testing format on memory: during the recognition tests, participants actually viewed photos they had seen before and simply had to indicate whether they had seen those photos previously or not. Further, test items were always completely different on each administration. Thus, this research was a purer assessment of participants' actual memory for events. Interestingly, when I used this test format, I still observed a significant relationship between PTSD symptoms and memory amplification. Therefore, my findings suggest how the trauma memory is typically assessed in the field and, particularly, its vulnerability to reinterpretation, cannot entirely account for the relationship between PTSD and memory amplification. My research therefore extends prior research by suggesting that other underlying mechanisms, aside from victims merely reinterpreting items, must contribute to amplification.

When considering the correlational findings from this thesis, however, it is important to acknowledge that many intrusion measures were not significantly associated with memory amplification across our different studies. Indeed, the only significant relationship we consistently observed across studies was between the re-experiencing subscale of the PCL and memory amplification. One possible explanation for this discrepancy across different measures is that the

PCL captures other qualities of intrusions that contribute to memory amplification beyond mere frequency, including associated negative reactions (e.g., *"feeling very upset when something reminded you of the stressful experience"*). Indeed, Study 6's findings suggest that the distress associated with intrusions may be more critical in determining memory amplification compared to intrusion frequency. Interestingly, we know that intrusion characteristics (e.g., associated distress, "here and nowness") are a stronger predictor of PTSD, relative to how *frequently* intrusions are experienced (e.g., Michael, Ehlers, Halligan, & Clark, 2005). Thus, one possibility is that people with PTSD are prone to memory amplification not because they experience intrusions more regularly, but because their intrusions typically have qualities that emulate real-life exposure to trauma (e.g., they are distressing, emotional and vivid) and therefore these cognitions are susceptible to source confusion. The findings from my thesis support this theoretical assumption.

Importantly, regardless of whether intrusion frequency or intrusion characteristics play a more important role in contributing to memory amplification, this relationship between re-experiencing symptoms and memory amplification has important theoretical implications. Within the PTSD literature, an underlying theoretical assumption is that the magnitude of the stressor the person is exposed to predicts the PTSD symptom severity—referred to as the "dose-response" model (March, 1993). More specifically, it is proposed that increasing severity of trauma—in terms of threat to life and safety—exacerbates PTSD symptomology (e.g., Dohrenwend & Dohrenwend, 1974). Researchers have often explained this model in terms of conditioning theory (Keane et al., 1985). Specifically, the traumatic stressor, which is considered an unconditioned stimulus, causes an unconditioned response of fear and terror. However, the traumatic stressor becomes associated with other neutral stimuli present during the trauma, which also elicit fear. Critically, the more severe the traumatic stressor, the greater the conditioned response to these stimuli, and therefore the more PTSD symptoms the trauma victim will experience. Indeed, this dose-response model is reflected in the DSM-5 diagnostic criteria for PTSD: in order to receive a PTSD diagnosis, a person must have been exposed to actual or threatened death, serious injury or sexual violence (APA,

2013). There is support for the dose-response model in the literature. For example, we know that people who are *directly* exposed to a stressor are more likely to later develop PTSD, relative to people who only witness a stressful event (Hoge et al., 2004). Critically, however, my findings suggest that this dose-response relationship may actually be inflated. For example, my results imply that if a trauma victim experiences severe re-experiencing symptoms (e.g., nightmares and flashbacks), then that person is more likely to over-report what actually happened when asked about their experience. A clinician or researcher might interpret this scenario as strong evidence for the dose-response model, because the severity of (reported) trauma exposure aligns with the degree of reported symptoms. Importantly, however, the true degree of trauma exposure might be less than what the victim reported. Thus, the relationship between *objective* trauma exposure and symptom severity is weaker. Taken together, the view that PTSD is merely an outcome of objective trauma exposure may be oversimplified. Although the presence of PTSD obviously does not change what actually happened in someone's past, my findings suggest that these symptoms can "work backwards" and alter how one *remembers* their past, which is certainly noteworthy.

Considered together, the findings from this thesis support Rubin, Berntsen, and Bohni's (2008) memory-based PTSD model. According to this model, a person's current memory of a traumatic event, and not the traumatic event per se, predicts their symptomatology and neither voluntary nor involuntary trauma memories are consistent over time. Instead, Rubin et al. (2008) suggest that trauma memories will be influenced and essentially distorted by many factors, such as current emotions, expectations and feedback from other people. My thesis therefore supports this model and extends it by suggesting that re-experiencing symptoms in particular can influence trauma memories. Specifically, my data lend preliminary support to the contention that people can confuse internally generated details about their trauma with what actually happened to them, causing changes in the trauma memory over time.

9.3. Practical Implications

One assumption underlying the diagnosis of PTSD is that clients' memories of trauma

exposure are accurate (Rubin,Bernsten, & Bohni, 2008). Indeed, PTSD is a somewhat unique disorder in that its diagnosis is dependent on a person reporting exposure to an event that qualifies as traumatic. Even if a person presents with severe PTSD symptomology, they cannot be diagnosed with PTSD unless they have been exposed to a Criterion A stressor. Considering the research from this thesis, it is important to understand that a person's memory of a trauma may not necessarily be an accurate representation of what happened. In particular, when clients report on trauma retrospectively, current PTSD symptoms—and particularly re-experiencing symptoms—may lead the client to overestimate their true trauma experience. Similarly, with regard to the involuntary cognitions, it is important to recognize that these cognitions are reconstructive, can include imagined details, and can change how a person remembers their experience. Given these cognitions can potentially affect memory, clinicians might consider identifying and exploring the meaning and function of these cognitions with clients, and target these cognitions using established therapy techniques (e.g., cognitive-behavioural).

When evaluating the findings from this thesis, however, it is important to acknowledge that in several studies I found that re-experiencing symptoms were associated with a change in response bias, but not a change in sensitivity. Put differently, how frequently participants re-experienced the trauma analogue was positively associated with a tendency to endorse trauma exposure but not a reduction in *memory accuracy* per se. Thus, it might be that the re-experiencing symptoms of PTSD cause trauma survivors to require less "evidence" that they have been exposed—e.g., a feeling of familiarity, or a distinct recollection of the event—to endorse a traumatic event as something they experienced. Consider, for example, a war veteran who frequently experiences involuntary elaborative cognitions that include details the veteran imagined but did not experience during service. Over time, these cognitions may lead to an overall impression that the veteran experienced many distressing experiences during service. Consequently, when asked about their trauma exposure, the veteran might endorse exposure to events that are only vaguely familiar to them. Put differently, the veteran might lower their response criterion (i.e., how much evidence they require to

say they experienced an event) because they assume that the probability of exposure is higher than it truly is. This process is of course distinct from the veteran confusing an involuntary elaborative cognition for a true memory of their experience and therefore responding that they experienced the event depicted in that cognition.

Practically speaking, however, even if inconsistencies in reporting do not always reflect an explicit change in a person's memory of what happened, a liberal response bias for trauma still has important implications in the real world. In legal settings, for example, victims of trauma with heightened PTSD symptomology might exhibit a tendency to over-report their actual experience, due to a response bias. It is not hard to imagine how this tendency to over-report could have very significant and real consequences for the outcome of court proceedings. Consider, for example, an assault victim being questioned about what happened during the assault at trial. A plaintiff who has a liberal response bias when being questioned about the attack—therefore endorsing events that they are not completely sure happened—may sway a jury's decision towards a guilty verdict more than a plaintiff with a conservative response bias. Similarly, in the clinical realm, clinicians in most cases are entirely reliant on the client in determining their trauma history, often using checklist methods. Thus, when a client is highly symptomatic these reports may be unreliable. Further, it is conceivable that a bias to endorse trauma exposure in therapy could indirectly lead to false memories. For example, a client who merely endorses exposure to a certain event may come to imagine the endorsed event and perhaps even discuss the event with their therapist to assist in "piecing together" what happened. As discussed in Chapter 1, we know that both of these factors drastically enhance the likelihood of false memories (e.g., Heaps & Nash, 2001).

9.4. Limitations and Future Directions

I must acknowledge several limitations of the studies presented. First, when interpreting these results it should be noted that I used a trauma analogue to investigate my research question. Clearly, viewing a series of negative photos is a very different experience from the types of experiences assessed in standard memory amplification studies (e.g., "sitting with the dead", "being

shot at" etc.). Indeed, participants generally rated the photos as being low on self-relevance and exposure to the photos had no serious and lasting consequences for the participants, whereas this is clearly not the case for real-life traumatic experiences. This difference could mean that effortful avoidance and thought suppression is much more likely for real-life trauma compared to photos. Differences in degree of avoidance may also affect how an event is remembered. For example, purposeful avoidance of trauma memories might lead to a paradoxical enhancement of intrusions (e.g., Wegner et al., 1997), which may in turn cause less memory decay over time. Given these differences, our results of course have no *direct* bearing on how victims of real-life traumatic experiences remember their experiences over time and our results should not be generalized to victims of real-life traumatic experiences. However, it is worth nothing that the DSM-5 (APA, 2013) is now explicit that a Criterion A stressor can be repetitive exposure to graphic media, including photos as part of someone's occupation (e.g., police work). Moreover, our results do show that memories for graphic material become more distorted with the passage of time and that a bias to endorse exposure to such material is associated with symptoms akin to the re-experiencing symptoms of PTSD.

Related to this point, the trauma analogue was markedly different to real-life trauma because there was no coherent narrative linking the content of the photos together. Indeed, the images participants saw often depicted dissimilar and unconnected traumatic scenes (e.g., burn victims, physical violence and death). This lack of continuity may have implications for memory performance in the current paradigm. For example, some authors propose that victims of trauma may attempt to "fill gaps" in their memory for traumatic experiences—by imagining new experiences—because their memory feels incomplete or fragmented (e.g., Strange & Takarangi, 2012). However, because photos were distinct and unconnected, this gap filling process to complete the narrative may have been unlikely, because no obvious narrative existed. Similarly, memory amplification may have been less likely in this research because we did not repetitively expose participants to photos depicting very similar content. Within the field research, memory

amplification is studied almost exclusively among veterans, where participants are asked about their experiences during deployment. Given people on deployment may experience many similar events on a daily basis; it is possible that the potential for amplification is higher because there is more opportunity for source confusion. It is important to note, however, that there is evidence memory amplification extends to other non-repeated traumas, including 9/11 (Giosan et al., 2009) and a school shooting (Schwarz et al.,1993).

Despite these limitations, the stimuli I used allowed me to: (1) ethically assess memory accuracy for a stressful experience and (2) use the signal detection framework to measure sensitivity and response bias in a standard recognition paradigm, both of which are methodological strengths of this thesis. Furthermore, IAPS photos elicit consistent fear-related physiological and behavioural responses (Hairi et al., 2002; Smith, Bradley, & Lang, 2005) and involuntary cognitions for negative IAPS stimuli can occur up to a year after initial viewing (Bywaters et al., 2004). Moreover, we know that exposure to disturbing media can lead to secondary traumatic stress if a person is repeatedly exposed in their line of work (Bourke & Craun, 2013). Thus, this paradigm is a useful tool to investigate potential mechanisms underlying memory amplification in an ethical and externally valid way. Future research should, however, investigate whether the effects I observed replicate using different trauma analogue stimuli, including stimuli with an underlying narrative, such as a trauma film. Investigating the reality-monitoring proposal among a PTSD population would also be an important future step to draw firm conclusions about the theory's plausibility.

For practical reasons, the paradigm I used was also very different to previous research with regard to the delay between trauma exposure and the first memory test. For example, in Chapters 4, 6 and 8, the first memory test was administered just 20 minutes after encoding. This aspect of the procedure means that the recognition test fell within the memory consolidation phase which occurs between 10 minutes and 6 hours after encoding (e.g., Walker, Brakefield, Hobson, & Stickgold, 2003). Thus, it is possible that the recognition test interfered with encoding. Note, however, that a delay period of 20 minutes or less is common practice within laboratory based recognition

paradigms (e.g., Huppert & Piercy, 1976; Shepard, 1967). Nevertheless, this aspect of our procedure limits the ecological validity of this research because the memory amplification effect in field studies concerns memories retrieved from long-term memory. Thus, it is unclear whether the relationships I observed in these studies would replicate in the field.

The paradigm I used also differed quite drastically from the field research where memory assessments are typically administered several years apart. In contrast, the delay period was 1 week in Chapter 4 (Study 1 & 2) and a mere 24 hours in Chapters 6 and 8 (Study 4 & 6). Again, this delay period potentially influenced my findings. My goal in this thesis was to determine whether memory amplification reflects involuntary elaborative cognitions gradually becoming incorporated into memory. Although we observed a significant relationship between re-experiencing symptoms and an increase in false memories in Study 1, one possibility is that the shorter delays used in subsequent studies meant that source confusion was unlikely. In particular, although my data suggests participants experienced involuntary elaborative cognitions, it may be that participants could easily distinguish between details they had imagined and details they actually witnessed because not enough time had elapsed for their memories of the photos to decay.

Similarly, perhaps the delay was not long enough for traces of cognitive operations—a characteristic associated with imagined information (Johnson et al., 1993)—to fade. Indeed, these factors may partly explain why I observed no relationship between re-experiencing symptoms and change in sensitivity across all studies and, why in some cases, other measures of involuntary cognitions (e.g., diary entries, EIS scores) were not associated with my primary dependent measures. Maybe if the delay was longer participants would forget or lose source information that the new details originated from their imagination and people would be more likely to mistake such details as genuine memory traces. Extending the delay between tests would therefore be an interesting avenue for future research. However, when designing such studies with IAPS stimuli, it would be important to consider the potential for floor effects for memory performance. Indeed, in several studies, participants made multiple errors during the memory tests a mere 20 minutes after

encoding. Alternatively, it may be fruitful to conduct longitudinal research with victims of real-life trauma examining whether cognitions that participants previously interpret as elaborative later become labelled as memories for perceived events, consistent with the reality-monitoring proposal. Another clear limitation of this thesis is that I was unable to experimentally manipulate the occurrence of involuntary elaborative cognitions. Thus, my ability to provide a more rigorous test of the reality-monitoring proposal was limited. I anticipated that verbal cues associated with photos would elicit involuntary elaborative cognitions. Yet data from Study 5 and Study 6 did not support this prediction. One explanation for this finding may be that the trauma analogue was not threatening or distressing enough to encourage these cognitions. Indeed, previous research shows that involuntary elaborative cognitions often include a sense of ongoing threat and a perception that "worse is to come". Thus, it might be that participants were not susceptible to involuntary elaborative cognitions because the photos did not promote an ongoing sense of threat. Consistent with this proposal, our results showed that analogue PTSD arousal symptoms (e.g., "*being "super alert" or watchful or on guard"*) were significantly associated with frequency of involuntary elaborative cognitions. Thus, future research should perhaps consider using a different trauma analogue that elicits heightened anxiety and a perception of ongoing threat. However, this limitation is of course a difficult hurdle to overcome ethically in experimental studies.

Although the findings from Study 4 suggested a relationship between re-experiencing symptoms and memory amplification among control participants, I cannot draw conclusions about the precise mechanism underlying this relationship. For example, it may be that it is not the intrusions themselves that lead to memory amplification, but rather the inferences or beliefs that arise from these intrusions. More specifically, the distress caused by the experience of many intrusions may contribute to a belief that the trauma was particularly severe, therefore leading to a liberal response bias. Another possibility is that people who are symptomatic and therefore experience intrusions regularly may be less inclined to search their memory of the trauma when responding to test items—because doing so might elicit involuntary cognitions. Indeed, we know

that symptomatic trauma survivors are typically motivated to try to avoid the occurrence of involuntary cognitions (Ehlers & Steil, 1995). Thus these participants may endorse any item that seems relatively familiar to them. Alternatively, it may be that the relationship reflects mood congruent recall: when people experience intrusions regularly they might also experience negative affect, leading to greater recall of negatively-valenced events. Note however, that across all studies we found no evidence that intrusions were related to more accurate responses to the negative photos presented at test. Another explanation is that the relationship reflects generalization of fear. According to the fear conditioning literature (e.g., Vervilet, Baeyens, Van den Bergh, & Hermans, 2013), conditioned (or learned) fear responses can generalize or spread to related stimuli that are more and more removed from the original unconditioned stimulus (e.g., the trauma). Put differently, people can experience negative reactions following exposure to a broad range of stimuli that possess little resemblance to the trauma itself, particularly if those people experience anxiety. This generalization of fear may result in the person being over-inclusive when deciding whether a negative event actually happened to them or not. Alternatively, these findings may reflect an availability heuristic. For example, when deciding whether an event was either experienced or not experienced, people might base their decision on how frequently they can bring similar examples to mind. Of course, if a person experiences intrusions regularly, such examples will be more accessible, and therefore the person will be more likely to endorse trauma exposure.

Note, however, the findings from Study 6 did not support the availability heuristic proposal: intrusion frequency was not significantly related to memory amplification. There were, however, small significant relationships between intrusion characteristics and memory amplification. These relationships are consistent with the reality-monitoring account: intrusions that share characteristics with real memories of trauma are presumably more likely to become incorporated into memory. However, one clear limitation of this study is that we cannot draw conclusions about causality based on these correlational relationships. It is also important to note that many of the results and effects I found in these studies were small, absent or even opposite to predictions (e.g., Study 6). This

pattern may have arisen because the relationship between re-experiencing and memory amplification is typically small in the field; thus, it is very difficult to find strong effects in the first place.

Given the limitations of Study 4 and 6, I have several suggestions for future research in this research area. First, determining the strategies that participants adopt when determining whether events are experienced or not experienced would be particularly useful. For example, it may be beneficial to use remember-know judgments at test to examine whether participants endorse trauma because they can actually remember the event, or simply because the event is familiar or similar to the gist of *other* events they remember witnessing. Second, future studies should consider examining how motivation affects memory performance more closely. Determining whether the relationship between re-experiencing and memory amplification remains when there are incentives for correct decisions at test would perhaps assist in determining whether motivation plays a role in memory amplification. Third, I believe it would useful to examine how manipulations designed to affect discrepancy detection influence memory amplification in this paradigm. For example, researchers could examine whether warnings about the potential for involuntary cognitions to become incorporated into memory affect test decisions. Fourth, I believe it is important to study how individual difference factors affect memory amplification. For example, examining whether participants' trait ability or proneness to internally-generate vivid mental images influences memory amplification could assist in further testing of the reality-monitoring proposal. Finally, given findings from Study 6, researchers should consider experimentally manipulating intrusion characteristics—such as associated distress—and examine how this manipulation affects memory. For example, priming participants to interpret intrusions as negative could potentially assist in manipulating intrusion-related distress and thus determining whether it is causally related to memory amplification.

9.5. Conclusion

Taken together, the findings from this thesis provide preliminary support for the reality-

monitoring explanation for memory amplification. In particular, I found that (1) re-experiencing symptoms are associated with a tendency to endorse trauma exposure over time, (2) people experience involuntary cognitions about their trauma—both in the lab and in the real-world—that possess imagined details, (3) experimentally manipulating elaboration of intrusions affects memory amplification. Although we were unsuccessful in manipulating the occurrence of involuntary elaborative cognitions, findings from this research suggest that the reality-monitoring proposal certainly affords further empirical attention and this paradigm appears to be a viable tool to investigate the proposal further.

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Appendix A-IAPS numbers for photos used

IAPS numbers for negative images used (including buffer images)

2703, 3000, 3001, 3005.1, 3110, 3131, 3261, 3350, 3530, 6021, 6212, 6350, 6563, 9253, 9413, 9433, 9570, 9571, 9910, 2800, 3016, 3030, 3053, 3063, 3064, 3068, 3071, 3100, 3120, 3191, 6520, 6540, 6570, 9040, 9163, 9187, 9220, 9560, 9921, 2095, 2205, 2811, 3059, 3069, 3080, 3101, 3168, 3170, 3180, 3266, 3500, 6313, 9140, 9183, 9252, 9405, 9414, 9421, 9635.1, 3010, 3015, 3060, 3062, 3102, 3103, 3130, 3140, 3195, 3225, 3230, 3301, 6022, 6415, 6560, 9075, 9185, 9254, 9410, 9412, 9181, 9902, 6821, 9050, 9435, 9332, 9911, 9420, 3400, 2900, 6315, 9901, 9908, 9903, 3017, 3181, 3061, 2799, 2730, 3150

IAPS number for control (neutral) images used

2002, 2038, 2214, 2220, 2396, 2397, 2411, 2484, 2749, 2840, 2890, 6150, 7000, 7002, 7003, 7004, 7009, 7010, 7012, 7020, 7034, 7035, 7041, 7045, 7050, 7056, 7160, 7161, 7179, 7185, 7187, 7233, 7235, 7247, 7255, 7476, 7484, 7487, 7950, 9070

Appendix B-Examples of involuntary elaborative non-memories

I just get an image of defibrillator and someone grabbing it - the actual image is probably from a television show because I wasn't there when it happened, but it just comes to mind whenever I think about what happed to my sister.
I was in the kitchen getting a glass of water when I saw my father sitting in my dining room in the chair he used to use when he was visiting me. Instead of being pleasant and healthy, he was in pain and crying out. / It only lasted a second. I sat down and cried and sipped my water. I was alone.
I sometimes see the mangled car in my mind even though I only saw a Picture once and only drove by the wreckage after being released from the hospital at a distance. I can't recall specific details It just pops into my head sometimes, maybe when I see pictures of other accidents on-line.
I keep imagining my husband with his affair partner. I also discovered that he had had a total of seven affairs while we wre together so I imagine those people with him as well, even though I don't know what they look like.
I constantly put myself in the apartment where my niece was when she passed away. I wasn't there when it happened but I imagine seeing my sister go into my niece's room to check on her. When she leans into the crib my niece is face down and she turns her over. Her face isn't there and my sister drops her screaming.
I was walking home after doing homework at the library. It was late out, and I began to worry that someone will come and sexually assault me like that man did. I had an image of someone grabbing both of my arms and then forcing themselves on me, with a knife in hand. It was night time and I couldn't shake the thought, so I practically ran home.
The other image was that someone was breaking into my apartment at night when I am home alone and then breaking into my room to rape me and kill my dog. It happens right as a I lay down for bed and it doesn't go away until I hold my dog for a while. I feel as though a panic attack will happen when It comes to mind.
I see myself passed out on the ground. This is where people told me I was after the incident occurred. One guy had to turn me over on my stomach because I started vomiting and would choke on it. So I see this happening.
…Part of the memory is of the owner's wife pounding on the door, and my daughter panicking on the other side, even though I wasn't there for that part. But it's part of the memory anyway...

Appendix C-Elaboration instructions

"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 D-Examples of elaboration task descriptions

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.

Appendix E-IAPS numbers for photos shown

Set 1:

2352, 2703, 3000, 3001, 3005, 3110, 3131, 3261, 3350, 3530, 6021, 6212, 6350, 6563, 9253, 9413, 9433, 9570, 9571, 9910

Set 2:

2800, 3016, 3030, 3053, 3063, 3064, 3068, 3071, 3100, 3120, 3191, 6520, 6540, 6570, 9040, 9163, 9187, 9220, 9560, 9921

Set 3:

2095, 2205, 2811, 3015, 3059, 3069, 3080, 3101, 3168, 3170, 3180, 3500, 6313, 9140, 9183, 9252, 9405, 9414, 9421, 9635

Set 4:

3010, 3060, 3062, 3102, 3103, 3130, 3140, 3195, 3225, 3230, 3266, 3301, 6022, 6415, 6560, 9075, 9185, 9254, 9410, 9412

Buffers:

2900, 3400, 6821, 9050, 9181, 9332, 9420, 9435, 9902, 9911, 2730, 2799, 3017, 3061, 3150, 3181, 6315, 9901, 9903, 9908

Appendix F-Supplementary Table for Chapter 7

Table S1.

Comparison of mean [and 95% CIs] characteristic ratings for intrusive memories and involuntary elaborative cognitions.

Rating	Intrusive Memories	Involuntary Elaborative Cognitions	Inferential Statistics
Distress	3.08 (1.16)	2.84 (1.21)	$t(430)=1.79$, $p=.08$, $d=0.21$ [-.02, .44]
Vividness	3.57 (1.03)	3.32 (1.08)	$t(429)=2.02$, $p=.044$, $d=.24$ [.01, .47]
Suppression	3.36 (1.27)	3.17 (1.36)	$t(429)=1.29$, $p=.20$, $d=.15$ [-.08, .39]
"Right now"	2.26 (1.17)	2.31 (1.23)	$t(429)=0.36$, $p=.72$, $d=.04$ [-.19, .27]
Emotional Intensity	4.25 (1.69)	4.12 (1.69)	$t(430)=0.65$, $p=.52$, $d=.08$ [-.15, .31]

Note. For distress, vividness, suppression and right now scales, 1 = *not at all* and 5= *extremely/completely*. For emotional intensity scale, 1=*not at all*, 7=*very strongly*.

Appendix G-Trauma History Screen

The events below may or may not have happened to you. Circle “YES” if that kind of thing has happened to you or circle “NO” if that kind of thing has not happened to you. If you circle “YES” for any events: put a number in the blank next to it to show how many times something like that happened

A. A really bad car, boat, train, or airplane accident YES NO _____ times

B. A really bad accident at work or home YES NO _____ times

C. A hurricane, flood, earthquake, tornado, or fire YES NO _____ times

D. Hit or kicked hard enough to injure - as a child YES NO _____ times

E. Hit or kicked hard enough to injure - as an adult YES NO _____ times

F. Forced or made to have sexual contact - as a child YES NO _____ times

G. Forced or made to have sexual contact - as an adult YES NO _____ times

H. Attack with a gun, knife, or weapon YES NO _____ times

I. During military service - seeing something horrible or being badly scared YES NO _____ times

J. Sudden death of close family or friend YES NO _____ times

K. Seeing someone die suddenly or get badly hurt or killed YES NO _____ times

L. Some other sudden event that made you feel very scared, helpless, or horrified YES NO _____ times

M. Sudden move or loss of home and possessions YES NO _____ times

N. Suddenly abandoned by spouse, partner, parent, or family YES NO _____ times

Did any of these things really bother you emotionally? NO YES If you answered “YES”, fill out one or more of the boxes on the next pages to tell about EVERY event that really bothered you

Letter from above for the type of event: _____ Your age when this happened: _____ Describe what happened:

When this happened, did anyone get hurt or killed? NO YES

When this happened, were you afraid that you or someone else might get hurt or killed? NO YES

When this happened, did you feel very afraid, helpless, or horrified? NO YES

When this happened, did you feel unreal, spaced out, disoriented, or strange? NO YES

After this happened, how long were you bothered by it? not at all / 1 week / 2-3 weeks / a month or more

How much did it bother you emotionally? not at all / a little / somewhat / much / very much

Appendix H- PTSD Checklist for DSM-5

Instructions: Below is a list of problems that people sometimes have in response to a very stressful experience. Please read each problem carefully and then circle one of the numbers to the right to indicate how much you have been bothered by that problem in the past month.

In the past month, how much were you bothered by:	Not at all	A little bit	Moderately	Quite a bit	Extremely text
1. Repeated, disturbing, and unwanted memories of the stressful experience?	0	1	2	3	4
2. Repeated, disturbing dreams of the stressful experience?	0	1	2	3	4
3. Suddenly feeling or acting as if the stressful experience were actually happening again (as if you were actually back there reliving it)?	0	1	2	3	4
4.Feeling very upset when something reminded you of the stressful experience?	0	1	2	3	4
5. Having strong physical reactions when something reminded you of the stressful experience (for example, heart pounding, trouble breathing, sweating)?	0	1	2	3	4
6. Avoiding memories, thoughts, or feelings related to the stressful experience?	0	1	2	3	4
7. Avoiding external reminders of the stressful experience (for example, people, places, conversations, activities, objects, or situations)?	0	1	2	3	4
8. Trouble remembering important parts of the stressful experience?	0	1	2	3	4
9. Having strong negative beliefs about yourself, other people, or the world (for example, having thoughts such as: I am bad, there is	0	1	2	3	4

something seriously wrong with me, no one can be trusted, the world is completely dangerous)?					
10. Blaming yourself or someone else for the stressful experience or what happened after it?	0	1	2	3	4
11. Having strong negative feelings such as fear, horror, anger, guilt, or shame? 0	0	1	2	3	4
12. Loss of interest in activities that you used to enjoy?	0	1	2	3	4
13. Feeling distant or cut off from other people?	0	1	2	3	4
14. Trouble experiencing positive feelings (for example, being unable to feel happiness or have loving feelings for people close to you)?	0	1	2	3	4
15. Irritable behavior, angry outbursts, or acting aggressively?	0	1	2	3	4
16. Taking too many risks or doing things that could cause you harm?	0	1	2	3	4
17. Being “superalert” or watchful or on guard?	0	1	2	3	4
18. Feeling jumpy or easily startled?	0	1	2	3	4
19. Having difficulty concentrating?	0	1	2	3	4
20. Trouble falling or staying asleep?	0	1	2	3	4

Appendix I-State Trait Anxiety Inventory-Trait Subscale

A number of statements which people have used to describe themselves are given below. Read each statement and then select the appropriate number to the right of the statement to indicate how you generally feel.

	Almost Never	Sometimes	Often	Almost Always
I feel pleasant	○	○	○	○
I feel nervous and restless	○	○	○	○
I feel satisfied with myself	○	○	○	○
I wish I could be as happy as others seem to be	○	○	○	○
I feel like a failure	○	○	○	○
I feel rested	○	○	○	○
I am 'calm, cool and collected'	○	○	○	○
I feel that difficulties are piling up so that I cannot overcome them	○	○	○	○
I worry too much over something that really doesn't matter	○	○	○	○
I am happy	○	○	○	○
I have disturbing thoughts	○	○	○	○
I lack self-confidence	○	○	○	○

I feel secure	○	○	○	○
I make decisions easily	○	○	○	○
I feel inadequate	○	○	○	○
I am content	○	○	○	○
Some unimportant thought runs through my mind and bothers me	○	○	○	○
I take disappointments so keenly that I can't put them out of my mind	○	○	○	○
I am a steady person	○	○	○	○
I get in a state of tension or turmoil as I think over my recent concerns and interests	○	○	○	○

Appendix J-Beck Depression Inventory-II

This next block consists of 21 groups of statements. Please read each group of statements carefully, and then pick out the ONE STATEMENT in each group that best describes the way you have been feeling during the PAST TWO WEEKS, INCLUDING TODAY. If several statements in the group seems to apply equally well, select the highest number for that group. Be sure you do not choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

Sadness

- ○ 0. I do not feel sad.
- ○ 1. I feel sad much of the time.
- ○ 2. I am sad all the time.
- ○ 3. I am so sad or unhappy that I can't stand it.

Pessimism

- ○ 0. I am not discouraged about my future.
- ○ 1. I feel more discouraged about my future than I used to be.
- ○ 2. I do not expect things to work out for me.
- ○ 3. I feel my future is hopeless and will only get worse.

Past Failure

- ○ 0. I do not feel like a failure.
- ○ 1. I have failed more than I should have.
- ○ 2. As I look back, I see a lot of failures.
- ○ 3. I feel I am a total failure as a person.

Loss of Pleasure

- 0. I get as much pleasure as I ever did from the things I enjoy.
- 1. I don't enjoy things as much as I used to.
- 2. I get very little pleasure from the things I used to enjoy.
- 3. I can't get any pleasure from the things I used to enjoy.

Guilty Feelings

- 0. I don't feel particularly guilty.
- 1. I feel guilty over many things I have done or should have done.
- 2. I feel quite guilty most of the time.
- 3. I feel guilty all of the time.

Punishment Feelings

- 0. I don't feel I am being punished.
- 1. I feel I may be punished.
- 2. I expect to be punished.
- 3. I feel I am being punished.

Self-Dislike

- 0. I feel the same about myself as ever.
- 1. I have lost confidence in myself.
- 2. I am disappointed in myself.
- 3. I dislike myself.

Self-Criticalness

- 0. I don't criticise or blame myself more than usual.
- 1. I am more critical of myself than I used to be.
- 2. I criticise myself for all of my faults.
- 3. I blame myself for everything that happens.

Suicidal Thoughts or Wishes

- 0. I don't have any thoughts of killing myself.
- 1. I have thoughts of killing myself, but I would not carry them out.
- 2. I would like to kill myself.
- 3. I would kill myself if I had the chance.

Crying

- 0. I don't cry any more than I used to.
- 1. I cry more than I used to.
- 2. I cry over every little thing.
- 3. I feel like crying, but I can't.

Agitation

- 0. I am no more restless or wound up than usual.
- 1. I feel more restless or wound up than usual.
- 2. I am so restless or agitated that it's hard to stay still.
- 3. I am so restless or agitated that I have to keep moving or doing something.

Loss of Interest

- 0. I have not lost interest in other people or activities.
- 1. I am less interested in other people or things than before.
- 2. I have lost most of my interest in other people or things.
- 3. It's hard to get interested in anything.

Indecisiveness

- 0. I make decisions about as well as ever.
- 1. I find it more difficult to make decisions than usual.
- 2. I have much greater difficulty in making decisions than I used to.
- 3. I have trouble making any decisions.

Worthlessness

- 0. I do not feel I am worthless.
- 1. I don't consider myself as worthwhile and useful as I used to.
- 2. I feel more worthless as compared to other people.
- 3. I feel utterly worthless.

Loss of Energy.

- 0. I have as much energy as ever.
- 1. I have less energy than I used to.
- 2. I don't have enough energy to do very much.
- 3. I don't have enough energy to do anything.

Changes in Sleeping Pattern.

- 0. I have not experienced any change in my sleeping pattern.
- 1a. I sleep somewhat more than usual.
- 1b. I sleep somewhat less than usual.
- 2a. I sleep a lot more than usual.
- 2b. I sleep a lot less than usual.
- I wake up 1-2 hours early and can't get back to sleep.

Irritability

- 0. I am no more irritable than usual.
- 1. I am more irritable than usual.
- 2. I am much more irritable than usual.
- 3. I am irritable all the time.

Changes in Appetite

- 0. I have not experienced any change in my appetite.
- 1a. My appetite is somewhat less than usual.
- 1b. My appetite is somewhat greater than usual.
- 2a. My appetite is much less than before.
- 2b. My appetite is much greater than usual.
- 3a. I have no appetite at all.
- 3b. I crave food all the time.

Concentration Difficulty

- 0. I can concentrate as well as ever.
- 1. I can't concentrate as well as usual.
- 2. It's hard to keep my mind on anything for very long.
- 3. I find I can't concentrate on anything.

Tiredness or Fatigue

- 0. I am no more tired or fatigued than usual.
- 1. I get more tired or fatigued than usual.
- 2. I am too tired or fatigued to do a lot of the things I used to do.
- 3. I am too tired or fatigued to do most of the things I used to do.

Loss of Interest in Sex

- 0. I have not noticed any recent change in my interest in sex.
- 1. I am less interested in sex than I used to be.
- 2. I am much less interested in sex now.
- 3. I have lost interest in sex completely.

Appendix K-Depression Anxiety Stress Scale-21

Please read each statement and select the number 0, 1, 2, or 3 which indicates how much the statement applied to you over the past week. There are no right or wrong answers. Do not spend too much time on any statement. The rating scale is as follows:

0 Did not apply to me at all.
1 Applied to me to some degree, or some of the time.
2 Applied to me to a considerable degree, or a good part of the time.
3 Applied to me very much, or most of the time.

	0	1	2	3
1. I found it hard to wind down	○	○	○	○
2. I was aware of dryness of my mouth	○	○	○	○
3. I couldn't seem to experience any positive feelings at all	○	○	○	○
4. I experienced breathing difficulty (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion)	○	○	○	○
5. I found it difficult to work up the initiative to do things	○	○	○	○
6. I tended to over-react to situations	○	○	○	○
7. I experienced trembling (e.g. in the hands)	○	○	○	○
8. I felt that I was using a lot of nervous energy	○	○	○	○
9. I was worried about situations in which I might panic and make a fool of myself	○	○	○	○

10. I felt that I had nothing to look forward to	○	○	○	○
11. I found myself getting agitated	○	○	○	○
12. I found it difficult to relax	○	○	○	○
13. I felt down-hearted and blue	○	○	○	○
14. I was intolerant of anything that kept me from getting on with what I was doing	○	○	○	○
15. I felt I was close to panic	○	○	○	○
16. I was unable to become enthusiastic about anything	○	○	○	○
17. I felt I wasn't worth much as a person	○	○	○	○
18. I felt that I was rather touchy	○	○	○	○
19. I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat)	○	○	○	○
20. I felt scared without any good reason	○	○	○	○
21. I felt that life was meaningless	○	○	○	○

Appendix L-Global Rumination Scale

Indicate how well each of the statements below describes you using a 7 point scale (1 - does not describe me well to 7 - describes me well).

	Does not describe me well						Describes me well
I seldom think about things that happen in the past.	1	2	3	4	5	6	7
I often get distracted from what I am doing with thoughts about something else.	1	2	3	4	5	6	7
If I don't want to think about something, I'm able to just stop thinking about it.	1	2	3	4	5	6	7
I often think about what my life will be like in the future.	1	2	3	4	5	6	7
When I have a problem, I tend to think about it a lot of the time.	1	2	3	4	5	6	7
I often become "lost in thought".	1	2	3	4	5	6	7
When I know that I am going to have an important talk or an argument with someone in the near future, I rehearse in my mind what I will say and what they will probably say in response.	1	2	3	4	5	6	7
Sometimes I feel like I have no control over my thoughts.	1	2	3	4	5	6	7
I have no trouble focusing all of my attention on one thing.	1	2	3	4	5	6	7

When I don't understand something that happens, I tend to run it over in my mind until I can make sense out of it.	1	2	3	4	5	6	7

Appendix M- Positive Affect Negative Affect Schedule

This scale consists of a number of words that describe different feelings and emotions. Read each item and then select the appropriate answer next to that word. Indicate to what extent you feel this way right now.

	Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
Interested	1	2	3	4	5
Distressed	1	2	3	4	5
Excited	1	2	3	4	5
Upset	1	2	3	4	5
Strong	1	2	3	4	5
Guilty	1	2	3	4	5
Scared	1	2	3	4	5
Hostile	1	2	3	4	5
Enthusiastic	1	2	3	4	5
Proud	1	2	3	4	5
Irritable	1	2	3	4	5
Alert	1	2	3	4	5
Ashamed	1	2	3	4	5
Inspired	1	2	3	4	5
Nervous	1	2	3	4	5
Determined	1	2	3	4	5
Attentive	1	2	3	4	5
Jittery	1	2	3	4	5
Active	1	2	3	4	5
Afraid	1	2	3	4	5

Appendix N- Response to Intrusions Questionnaire

Please rate how often you have engaged in the following strategies when experiencing intrusive memories about the photos. Select "0" if you did not experience any intrusive memories.

	0 I did not experience any intrusions	1 Never	2	3	4	5	6	7 Very Often
I dwell on them								
I worry that something like that could happen to me or my family.								
I think about what could have been done differently to prevent the event form happening								

Appendix O-Experience of Intrusions Scale

Yesterday in session 1, you viewed a series of graphic photographs. Please select the answer that corresponds with your experience since first viewing the photos.

	almost never	infrequently	occasionally	frequently	very frequently
How often have you found yourself thinking to any degree about the photographs since seeing them?	○	○	○	○	○

Please select the answer that corresponds with your experience since first viewing the photos.

	not at all	a little	moderately	quite a bit	extremely
On average, how distressed were you when these thoughts came to mind?	○	○	○	○	○
On average, to what degree did the thoughts about the photographs come out of the blue?	○	○	○	○	○
On average, when you had these thoughts, how unwanted were they?	○	○	○	○	○
On average, when you had these thoughts, how much did they interfere with what you were doing at the time?	○	○	○	○	○