Intrusive Memories Following Disaster: Relationship with Peritraumatic Responses and

Later Affect

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Abstract

Cognitive theories of PTSD suggest that intrusive memories result from disrupted information processing during traumatic memory encoding and are characterized by fear, helplessness, and horror at recall. Existing naturalistic studies are limited by the absence of direct comparisons between specific moments that do and do not correspond to intrusive memories. We tested predictions from cognitive theories of PTSD by comparing peritraumatic responses during moments experienced as intrusive memories versus distressing moments of the same traumatic event from the same individual not experienced as intrusive memories. A further comparison was with highly distressing moments experienced during the same event by individuals without intrusive memories. We utilized a psychometrically generated model to distinguish different peritraumatic reactions. Moments experienced as intrusive memories were characterized by higher peritraumatic distress, immobility, cognitive overload, and somatic dissociation when compared both to distressing moments from the same individual that did not intrude, and to the most distressing memories of individuals without intrusions. Exploratory analyses indicated that at recall intrusive memories were characterized by higher levels of primary traumatic emotions such as anxiety, fear, and helplessness in comparison with non-intrusive memories. Findings from this novel naturalistic design support predictions made by cognitive theories of PTSD and have implications for research and preventative interventions targeting intrusive memories.

Keywords: intrusive memories, disaster, earthquakes, peritraumatic, PTSD

General scientific summary

Cognitive theories of post-traumatic stress disorder (PTSD) suggest that later intrusive memories of a traumatic event are partly caused by specific changes in how people felt, thought, and behaved during the event, *i.e.,* peritraumatic reactions. We provide support for this hypothesis by showing that the specific moments of the traumatic event later experienced as intrusive memories are characterized by different peritraumatic reactions to those moments from the same trauma that did not intrude later. Additionally, we show that, when experiencing an intrusive memory, the person relives the same types of emotions likely experienced during the actual traumatic event.

Intrusive trauma memories are highly sensory and emotional, and are triggered involuntarily by external or internal reminders of a distressing event (Ehlers et al., 2004). They are a hallmark symptom of posttraumatic stress disorder (PTSD). According to prominent cognitive theories of PTSD, intrusive memories are the result of disruptions in information processing produced by various peritraumatic responses that occur during traumatic memory encoding (Brewin et al., 2010; Ehlers & Clark, 2000). These theories also suggest that the recall of intrusive memories is accompanied by emotions that resemble those experienced during the traumatic event. In this article we test these theories by comparing reported peritraumatic responses during moments that are or are not experienced as intrusive memories as well as the affective phenomenology of such memories at recall.

According to the revised dual representation theory of PTSD (Brewin et al., 2010), intrusive memories are the result of a disrupted relationship between two types of memory, sensory representations and contextual representations. Consistent with evidence that negative content can reduce associative binding and the coherence of episodic memories (Bisby et al., 2020), peritraumatic responses are held to be an important mechanism responsible for altering consciousness during encoding. As a result, contextual representations are weakened, leaving the person vulnerable to intrusive memories driven by sensory and affective representations corresponding to those moments. Similarly, the cognitive model of PTSD (Ehlers & Clark, 2000) hypothesizes that re-experiencing symptoms and the sense of current threat experienced by people with PTSD result from individuals engaging disproportionately in bottom-up sensory and affective information processing, *i.e.* data-driven processing, to the detriment of encoding conceptual information at the time of the trauma. In contrast, the mnemonic model of PTSD (Rubin et al., 2008) does not specify a causal role for peritraumatic emotions and responses. It considers that

retrospective reports of such reactions can be more parsimoniously explained in terms of general reconstructive memory processes at the time of recall.

The behavioral, cognitive, and affective phenomena taking place during traumatic memory encoding have been collectively termed peritraumatic reactions (Gorman et al., 2016). They include peritraumatic dissociation, both in its psychic (Cardeña, 1994) and somatoform[1] presentations (Nijenhuis, 2004), peritraumatic distress (Brunet et al., 2001), tonic immobility (Marx et al., 2008), mental defeat (Ehlers et al., 2000), and data-driven processing (Ehlers & Clark, 2000). However, many existing measures of these concepts demonstrate some conceptual overlap and not all correspond to distinct peritraumatic processes. In a recent study that aimed to identify the factor structure of the most commonly administered peritraumatic scales we identified five psychometrically distinct factors, which were labelled mental defeat, somatoform dissociation, cognitive overload, immobility, and distress (Massazza et al., 2021).

The relationship between intrusive memories and peritraumatic reactions has primarily been investigated using the trauma film paradigm whereby healthy participants are exposed to traumatic images and resulting intrusive memories occurring over the following days are captured using a diary (James et al., 2016). Results from studies using this approach have been mixed (Marks et al., 2018). Some found a positive relationship between higher levels of self-reported peritraumatic reactions during exposure to analogue trauma and later intrusive memories (Holmes et al., 2004; Hall and Berntsen, 2008; Morina et al., 2013; Kuiling et al., 2019). However, attempts to manipulate dissociation have largely been unsuccessful in demonstrating any effects on intrusive memories (Hagenaars et al., 2008; Dorahy et al., 2016).

A few naturalistic studies focused on the ability of peritraumatic responses to predict later PTSD symptom clusters, but in these analyses intrusive memories were not

distinguished from other forms of re-experiencing such as nightmares and arousal on reminders (Massazza et al., 2021; Simeon et al., 2003; van der Velden et al., 2006; see Evans et al., 2007, for an exception). Another limitation in the literature is that studies have generally measured peritraumatic reactions experienced during the *whole* traumatic event, even though intrusive memories generally represent only fractions of the entire trauma (Holmes et al., 2005; Brewin, 2016). It remains unclear why only certain moments of a trauma are encoded as intrusive memories while other moments from the same trauma are encoded as normal autobiographical memories. The cognitive models of intrusive memory development would suggest that fluctuations in peritraumatic reactions during the same traumatic event might be responsible for the differential encoding of memories determining which moments will later intrude and which will not (Chou et al., 2014).

Cognitive models of intrusive memory development also suggest that the disruptions in memory encoding experienced during the peritraumatic phase are responsible for the highly affective nature of intrusive memories. In particular, intrusive memories are posited to be accompanied by strong emotions that were experienced at the time of the trauma (Brewin et al., 1996; Kvavilashvili, 2014). This contributes to the feeling of re-experiencing (Bryant et al., 2011) and to the maintenance of a sense of current threat (Ehlers & Clark, 2000).

Emotions such as fear, helplessness, and horror that are often felt during a traumatic event were described as 'primary emotions' by Brewin et al. (1996) to distinguish them from emotions such as anger, guilt, and sadness that are more likely to arise from later appraisals when the person reflects on the traumatic events and their causes. To date only one study has tested the prediction that involuntary memories, compared to ordinary autobiographical memories, should be accompanied by different sorts of emotion. Hellawell and Brewin (2004) found, as predicted, that involuntary memories were more likely to be accompanied

by primary emotions and less likely to be accompanied by secondary emotions. A more detailed study is now required to examine the nature of the specific emotions involved.

We therefore investigated whether specific moments of a traumatic event that corresponded to an intrusive memory would be characterized by different levels of peritraumatic reactions than moments experienced as normal autobiographical memories. We also investigated whether intrusive memories at recall would be characterized by different types of emotion in comparison with normal autobiographical memories. In response to the concern that retrospective reports of peritraumatic responses could be influenced by current levels of symptoms (Candel & Merckelbach, 2004; Rubin et al., 2008), we adopted two strategies. The first was to compare intrusive and non-intrusive distressing memories of the same severe traumatic event in the same individuals so that symptom levels would be constant. The second was to compare, while controlling for PTSD symptom levels, the same intrusive memories with the most distressing memories reported by a separate sample of individuals exposed to the same event who did not develop intrusive memories. Our hypotheses were that moments experienced as intrusive memories would be characterized by higher levels of peritraumatic reactions in comparison to moments that did not later intrude and that, at recall, intrusive memories would be accompanied by an excess of primary, relative to secondary, emotions.

Methods

Participants and Recruitment

All 104 participants were survivors of the 2016-2017 Central Italy earthquakes. The 104 participants were selected for interview building on a previous study conducted by the authors (Massazza, Joffe, & Brewin, 2019) through the help of local health services and the local municipality. The purposive sampling strategy was aimed at reproducing the

approximate demographic distribution of the population of Amatrice as a whole in terms of

age and gender as per 2016 census (Istituto Nazionale di Statistica, 2016).

Measures

In a previous article we reported an analysis, utilising exploratory structural equation

modeling (ESEM), to determine the structure of 63 items representing the entire content of

six standard peritraumatic questionnaires: the Mental Defeat Questionnaire (MDQ)

(Dunmore et al., 2001), the Somatoform Peritraumatic Dissociation Questionnaire (SDQ-P)

(Nijenhuis et al., 2001), the Peritraumatic Dissociative Experiences Questionnaire (PDEQ)

(Marmar, Weiss and Metzler, 1997), the Tonic Immobility Scale (TIS) (Forsyth, Marx, Fusé,

Heidt & Gallup, 2000), the Peritraumatic Distress Inventory (PDI) (Brunet et al. 2001), and

the Data-Driven Processing Scale (DDPS) (Halligan et al., 2002). Details of the scales and of

translation procedures are reported in Massazza et al. (2021). All items were answered in

respect of the overall traumatic exposure. This resulted in five peritraumatic factors, i.e.,

Mental Defeat, Somatoform Dissociation, Cognitive Overload, Immobility, and Distress.

Separately from this, a smaller selection of 33 conceptually representative items taken

from the same set of standard peritraumatic questionnaires was administered in respect of

intrusive and non-intrusive distressing memories during the course of the earthquake. This

subset consisted of five items from the Mental Defeat Questionnaire, three items from the

Somatoform Peritraumatic Dissociation Questionnaire, eight items from the Peritraumatic

Dissociative Experiences Questionnaire, six items from the Tonic Immobility Scale, seven

items from the Peritraumatic Distress Inventory, and four items from the Data-Driven

Processing Scale. Participants rated how much they recalled experiencing such reactions

from 0 ("not at all") to 5 ("extremely"). Additionally, participants were asked to rate how

much they experienced ten negative emotions during recall of the intrusive and non-intrusive

distressing memories on a scale from 0 ("*not at all*") to 10 ("*extremely*"). The 10 emotions

were: anxiety, anger, sadness, guilt, shame, helplessness, numbness, fear, horror, and disgust.

Participants also completed the PTSD Checklist for DSM-5 (PCL-5: Weathers et al.,

2013), a 20-item questionnaire investigating how much the individual was bothered by

symptoms in the last month from 0 "*not at all*" to 4 "*extremely*". The PCL-5 has been shown

to have high total internal reliability (α = .90) and acceptable to good internal reliability for

its subscales (α range = .57 – .78) (Sveen et al., 2016). Internal reliability in the current study

was high with Cronbach's α = .91. Finally, participants completed a series of demographic

questions on gender, age, and education level.

Procedure

To investigate the presence of intrusive memories of the earthquake the first author

began by reading out to the participant a description of what an intrusive memory is (adapted

from Hackmann, Ehlers, Speckens, and Clark, 2004, and Evans et al., 2007, reported in full

in the Supplementary Materials) and asking whether they had persistently experienced such a

type of memory in the months following the earthquakes. If they experienced more than one

intrusive memory, they were asked to select the one they found most distressing and to state

if they were still experiencing intrusions at the time when the interview was conducted.

Following identification and description of the memory they were asked to complete the 33

peritraumatic questions and asked to answer each item only in relation to the *specific*

moments corresponding to that intrusive memory rather than for the trauma as a whole.

Participants with intrusions were then asked to identify and describe another memory

of the earthquakes that was just as distressing as the intrusive memory they had previously

identified but that had never spontaneously intruded. They then completed the same 33

peritraumatic items in relation to the specific moments corresponding to this non-intrusive

control memory (script reported in Supplementary Materials). Participants who had never

experienced intrusive memories were asked to identify and describe the most distressing memory they had of the earthquake events and to complete the peritraumatic items in relation to these specific moments.

Data collection took place for three months in May, June, and July 2018. This was 20 months following the earthquake in August 2016 and 15 months following the last major earthquake in January 2017. The UCL Research Ethics Committee approved this research with the project ID: 10517/001. Prior to taking part participants read an information sheet and provided written informed consent.

Data Analysis

From the 33 items of the shortened peritraumatic questionnaire, we initially selected 3 items to represent each of the five peritraumatic factors derived from the ESEM. Items with the highest loadings on each factor were selected provided that they also had high internal consistency. Two additional items were added to the mental defeat scale and three to the distress scale in order to improve internal reliability. These items, their factor loadings from the original exploratory factor analysis, and the coefficient alphas corresponding to each abbreviated scale in the current sample, are given in Supplementary Table A. Peritraumatic factor sub-scores were calculated by summing the scores from each of the items.

Descriptive statistics were calculated across the entire sample. We investigated differences in PTSD symptoms, age, gender, and education between participants with and without intrusions using independent samples t-tests and chi-squared tests of independence. Next, we ensured that all events took place during the peritraumatic timeframe, *i.e.* either during the earthquakes or during key distressing events such as corpse recognition in the days immediately after. Events that did not take place during this timeframe, corresponding to 11 non-intrusive control memories from the within-subjects analysis and one most distressing memory from the between-subjects analysis, were removed. One participant reported they

could not identify a control memory and was also removed from the analysis. All trauma memories were however retained for the analyses investigating differences in emotions experienced at recall, as this prediction did not depend on the specific timeframe of events. There were no other missing data.

As the peritraumatic factors were expected to be all positively inter-related (Massazza et al., 2021), we conducted three different multivariate analyses in order to test for overall differences in peritraumatic reactions across memory types. In the first within-subjects MANOVA moments experienced as intrusive memories were compared with non-intrusive moments among the same participants. The groups with and without intrusions were then compared. Since the group with intrusions reported more PTSD symptoms and were younger (details in Results section), two between-subjects MANCOVAs compared intrusive or control memories (in the group reporting intrusions) with most distressing memories reported by those who did not experience intrusions, controlling for PTSD symptoms and age. Using G*Power (Faul et al., 2007), power was estimated to be .99 for the within-subject MANOVA and .98 for the between-subject MANCOVAs, assuming a moderate effect size, alpha = .05, and the observed correlation of .22 among the repeated measures. Following significant multivariate effects, individual one-way ANOVAs and ANCOVAs were conducted for each peritraumatic reaction. Levene's test for homogeneity of variance was employed. Effect size for all these analyses was reported using partial eta-squared. Conventionally a value of .01 is defined as a small effect, .06 as a medium effect, and .14 as a large effect.

Unlike the peritraumatic factors, we had no reason to expect all the different emotions experienced at recall to be positively inter-related. Rather than use multivariate analyses we therefore conducted individual paired-sample t tests to assess differences in emotions experienced at recall between intrusive memories and non-intrusive control memories among the same participants. Effect size for these analyses was reported using Cohen's *d*.

Conventionally a value of .02 is defined as a small effect, .05 as a medium effect, and .08 as a large effect. We used individual ANCOVAs to compare intrusive and control memories (in the group reporting intrusions) with the most distressing memories reported by those who did not experience intrusions, controlling for levels of PTSD and age. No overall correction for multiple comparisons was applied as some individual emotions (e.g., anxiety and fear, guilt and shame) were expected to be correlated, and correction could have introduced Type II errors. The analyses should therefore be regarded as exploratory.

Presence of outliers was assessed through visual examination of box plots and none were identified. Due to the skewed distributions of the PCL scores, the value used in the analyses was square root transformed and achieved normal distribution.

Results

Demographic Details

Forty-five percent of the sample were men (mean age = 44.23, range = 19-72) and 55% women (mean age = 43.04, range = 18-74). Seventy-four percent of the sample identified as Catholic with the remaining 26% identifying with other religious or spiritual groups. Twenty-one percent held a university degree, 51% had completed secondary school, 26% had completed middle school, and 2% had completed only primary school.

The mean untransformed PCL-5 score was 20.98 ($SD = 15.03$). Fifty-one participants (49%) reported having experienced intrusive memories following the earthquakes. Of these participants, 44 (86%) were still experiencing these intrusive memories at the time the interview was conducted. Participants with intrusions reported significantly higher PCL-5 scores ($M = 28.01$, $SD = 16.09$) in comparison with participants without intrusions ($M = 14.21$, $SD = 10.17$), $t(102) = -5.25$, $p < .001$, $d = 1.01$, 95% CI [0.59, 1.42]. Participants with intrusions were younger ($M = 37.94$, $SD = 16.09$) than those without intrusions ($M = 49.00$, $SD = 15.23$), $t(102) = 3.60$, $p < .001$, $d = 0.68$, 95% CI [0.27, 1.08]. The presence of

intrusive memories was independent of gender ($\chi^2(1) = .04$, $p = .829$, $\varphi = .04$) and of

education level ($\chi^2(2) = 1.19$, $p = .550$, Cramer's V = .10).

Peritraumatic Reactions and Memory Type

In the within-subjects analysis the repeated-measures MANOVA on intrusive

memories and non-intrusive control memories was significant, Wilks' $\Lambda = .56$, $F(5, 34) =$

5.14 , $p = .001$, $\eta^2_p = .43$, 90% CI [.14, .52]. Separate univariate repeated-measures ANOVAs

were then conducted for each peritraumatic factor sub-score and results are shown in Table 1.

Intrusive memories were characterized by higher levels of somatoform dissociation, cognitive

overload, immobility, and distress, but not by more mental defeat.

A corresponding between-subjects MANCOVA was conducted between moments

corresponding to intrusive memories and most distressing memories among those not

reporting any intrusions. Transformed PCL-5 scores and age were included as covariates.

This was also significant, Wilks' $\Lambda = .69$, $F(5, 95) = 8.50$, $p < .001$, $\eta^2_p = .31$, 90% CI [.15,

.39]. The individual ANCOVAs are shown in Table 2. Once again intrusive memories were

characterized by higher scores on all peritraumatic factors except for mental defeat, which

showed a marginally significant effect. After corrections required following homogeneity of

variance tests[2], the effect for mental defeat weakened and was no longer marginally

significant, whereas all other results remained similar. In a post-hoc analysis we investigated

the effect of omitting the two covariates. Results were again very similar except that intrusive

memories were now characterized by higher scores on mental defeat[3].

The between-subjects MANCOVA comparing distressing control memories among

participants with intrusions and most distressing memories among participants without

intrusions was not significant after controlling for transformed PCL-5 scores and age, Wilks'

$\Lambda = .94$, $F(5, 83) = 1.06$, $p = .387$, $\eta^2_p = .06$, 90% CI [.00, .10].

Emotions at Recall and Memory Type

Emotions experienced at recall of intrusive memories and non-intrusive control memories among participants with intrusions are reported in Table 3. In these within-subject analyses intrusive memories at recall were characterized by higher levels of anxiety, fear, and helplessness.

One-way between-subjects ANCOVAs were conducted to test for differences in emotions experienced at recall of intrusive memories and at recall of most-distressing memories among participants without intrusions. Age and transformed PTSD symptoms were included as covariates. Results are shown in Table 4. Once again intrusive memories were characterized by higher levels of anxiety and fear at recall. A post hoc analysis investigating the effect of omitting the covariates again found significant effects for anxiety and fear, but also significant effects for guilt and numbness[4].

Finally, one-way between-subjects ANCOVAs were conducted to test for differences in emotions experienced at recall of non-intrusive distressing memories among participants with and without intrusions, controlling for age and PTSD symptoms. No significant difference in emotions at recall was found between the two groups, largest $F(1, 102) = 1.02$, $p = .314$. A post hoc analysis investigating the effect of omitting the covariates found a significant effect for guilt only[5].

Discussion

This study tested the predictions from cognitive theories of intrusive memory development and phenomenology (Brewin et al., 1996, 2010; Ehlers & Clark, 2000) using a novel naturalistic design and a psychometrically validated model of peritraumatic reactions. As hypothesized, moments experienced as intrusive memories were associated with higher

levels of all peritraumatic reactions except for mental defeat, when compared to moments from the same trauma experienced as distressing, but non-intrusive, by the same participants. Additionally, moments experienced as intrusive memories were characterized by higher scores on all peritraumatic reactions, except for mental defeat, in comparison with the moments experienced as most distressing memories among participants without intrusions.

These findings support the importance of peritraumatic encoding for intrusive memories, and answer the valid concerns raised that retrospective reports of these reactions could be biased by current symptom levels (Candel & Merckelbach, 2004; Rubin et al., 2008). As symptom levels were controlled in our analyses they cannot account for the different pattern of responding. Moreover, as intrusive and non-intrusive trauma memories are argued to be essentially the same by Rubin et al. (2008), differing only in their method of retrieval, there would seem to be no reason to reconstruct them differently.

Replicating Hellawell and Brewin (2004), our exploratory analyses indicated that recall of intrusive memories was associated with higher levels of "primary" traumatic emotions such as fear, anxiety, and helplessness in comparison with non-intrusive autobiographical memories in the within-subject analyses. Fear and anxiety were also higher in the comparison between individuals with and without intrusions. Unlike in the earlier study by Hellawell and Brewin, there were no differences in levels of "secondary" emotions such as anger, sadness, or shame that might emerge during the appraisal phase of the trauma rather than during the traumatic event itself. This may be due to the very extended nature of the exposure provided by the series of earthquakes which, in comparison to briefer traumatic events, may have permitted a greater degree of appraisal to occur while the events were unfolding.

The results concerning primary emotions nevertheless strengthen earlier reports suggesting a specific link between fear and intrusive memories (Reynolds & Brewin, 1999).

The finding that intrusive memories, relative to non-intrusive memories, are characterized by those emotions that predominate during the trauma itself is also consistent with the predictions of dual representation theory of PTSD (Brewin et al., 1996, 2010). In contrast, there is less basis in the mnemonic theory (Rubin et al., 2008) for this pattern of results.

The key strength of the current design was the focus on peritraumatic reactions during *specific moments* of the trauma that were later experienced as different types of memory, rather than on reactions occurring during the trauma as a whole. Our results suggest that variation within the same individual in levels of peritraumatic reactions could be a meaningful determinant of intrusive memory development. This confirms, in a naturalistic setting, results from the experimental literature showing that momentary decreased heart rate, used as a proxy measure of dissociation, was associated with the specific moments of a trauma film that later intruded (Holmes et al., 2004; Chou et al., 2014). The association between heart rate and dissociation in the real world is likely to be complex, however, and dependent on the nature of the situation (Sterlini & Bryant, 2002).

In many circumstances the notion of a "traumatic event" may therefore be better understood as a collection of micro-events associated with different peritraumatic features (Ehlers, 2010), as supported by qualitative work conducted with this sample (Massazza et al., 2020). These observations raise questions about the precision of peritraumatic measures that in some circumstances require respondents to summarize their response over a very extended period of time. We should acknowledge, however, that although our design reduced this period considerably, some summarizing undoubtedly occurred in our study, particularly in the case of memories selected for being the most distressing. Our observations also support the argument of Marks et al. (2018) that one of the main limitations of the trauma film paradigm is that by using a rapid-fire series of distressing film clips, researchers might be

artificially truncating the peritraumatic variation which characterizes the chronology of a

real-life trauma.

A second strength of the current design is the use of a psychometrically validated

model of peritraumatic reactions which distinguished five distinct dimensions (Massazza et

al., 2021). Participants reported higher levels of peritraumatic distress, immobility, cognitive

overload, and somatoform dissociation in moments experienced as intrusive memories

compared to moments that did not intrude. These findings support the hypothesis that

intrusive memory might correspond to "hotspot" moments of peak emotional distress

(Holmes et al., 2005). Additionally, they provide support in a naturalistic setting to

experimental findings concerning the role of peritraumatic arousal (Hall & Berntsen, 2008),

cognitive load (Nixon et al., 2007), immobility (Kuiling et al., 2019), data-driven processing

(Morina et al., 2013), and somatoform dissociation (Hagenaars et al., 2008) in the

development of intrusive memories.

Interestingly, mental defeat did not differ significantly between intrusive and non-

intrusive memories in the within-subjects analysis, nor between intrusive and most

distressing memories in the between-subject analysis once age and PTSD symptoms were

controlled for. In our exploratory structural equation modelling (Massazza et al., 2021), the

mental defeat factor was one of two with the strongest associations to all four PTSD

subscales. This may indicate that mental defeat contributes to overall PTSD via pathways

other than memory encoding. For example, it might affect a more global appraisal of how one

reacted during the overall event, leading to feelings of guilt or shame for feeling helpless or

failing to react (Ehlers & Clark, 2000).

A third strength in the current design is that the time-lag between trauma and data

collection allowed us to investigate many intrusive memories that persisted 15-20 months

after trauma. In contrast to experimental studies, where intrusions rarely last more than a few

days, these long-lasting intrusions are what clinicians are likely to encounter in therapy since many patients will access treatment for post-trauma psychopathology months, if not years, following exposure (Maguen et al., 2012).

Our findings have a number of practical implications for the prevention and management of intrusive memories. Firstly, individuals who are likely to be exposed to trauma, such as firefighters or disaster first responders, might receive training in the management of their own peritraumatic reactions prior to exposure (Wild et al., 2018). Secondly, interventions might be devised to reduce certain peritraumatic reactions in survivors immediately after trauma exposure (Iyadurai et al., 2018), such as using dual-task interventions (Mertens et al., 2020) like Tetris to reduce excessive sensory-based processing of the traumatic memory (Horsch et al., 2017). Thirdly, simple screening instruments measuring particularly harmful peritraumatic phenomena might be administered to trauma survivors soon after exposure as a tool to identify individuals at increased risk of developing PTSD.

The main limitation of the current study is the retrospective nature of the description of peritraumatic reactions. Findings concerning the accuracy and consistency of retrospective recall of peritraumatic reactions are mixed (Ouimette et al., 2005; David et al., 2010). While peritraumatic ratings are by nature retrospective, future studies might collect data closer to exposure. Additionally, the cross-sectional nature of the study hinders precise causal inference concerning the relationship between peritraumatic reactions and intrusions with possible reverse causality and third variable issues. For example, it could be argued that differences in the severity of particular incidents led both to greater peritraumatic reactions and to a greater likelihood of intrusions occurring. However, there are no reliable objective indices of severity in such an overwhelming natural disaster, and severity is closely tied to the individual reactions that make up our peritraumatic measures. Thus we do not believe

there is a clearly identifiable "third variable" that could be assessed. Personality traits have also been linked to peritraumatic reactions and might influence memory (Jaycox et al., 2003). These alternative explanations are less likely given the combination of within-subjects and between-subjects findings. Future longitudinal designs will be necessary to expand upon and confirm the current results.

This study tested, in a sample exposed to the same real-life trauma, the predictions made from theoretical models of intrusive memory development and phenomenology (Brewin et al., 1996; Ehlers & Clark, 2000). Our findings support these predictions and add to numerous results suggesting that intrusive trauma memories are underpinned by different processes than ordinary autobiographical memory (Bisby & Burgess, 2017; Chou et al., 2018; Kleim et al., 2012; Kroes et al., 2011; Sierk et al., 2019; Whalley et al., 2013). Improvements in the treatment of PTSD, and psychiatric disorders in general, will follow from a better understanding of the mechanisms that underpin the development and phenomenological characteristics of specific symptoms. The current work contributes to this endeavor by using a novel, theory-driven, naturalistic design, shedding more light on one of the hallmark symptoms of PTSD.

Footnotes

1. Psychic dissociation refers to mental experiences such as amnesia, depersonalization, derealization, and fragmentation of identity, whereas somatic dissociation refers to bodily experiences such as analgesia, perceptual changes, or loss of motor control. The assumption that these sets of experiences are related to exactly two corresponding distinct latent variables is as yet unproven.
2. In the case of mental defeat, somatic dissociation, and immobility, Levene's test for homogeneity of variance was significant. Scores on each peritraumatic measure were therefore adjusted for age and level of PTSD symptoms, and the between-subject analyses repeated using Welch's F test which is robust to group differences in variance. Similar results were obtained for mental defeat, $F(1, 89) = 2.98$, $p = .088$, somatic dissociation, $F(1, 80) = 10.00$, $p = .002$, and immobility, $F(1, 97) = 12.08$, $p = .001$.
3. Mental defeat, Welch's $F(1, 82) = 17.91$, $p < .001$.
4. Anxiety, $F(1, 102) = 22.98$, $p < .001$; fear, $F(1, 102) = 7.96$, $p = .006$; guilt, $F(1, 102) = 0.37$, $p = .002$; numbness, $F(1, 102) = 4.34$, $p = .040$.
5. Guilt, $F(1, 102) = 4.19$, $p = .043$.

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Table 1

Peritraumatic Reactions During Moments Experienced as Intrusive Memories and Control Memories (Same Participants)

Peritraumatic factors	Intrusive memories		Non-intrusive control memories					
	M	SD	M	SD	$F(1, 38)$	p	Partial η^2	90% CI
Mental defeat	8.85	7.03	6.95	6.29	3.55	.067	.09	[.00, .24]
Somatoform dissociation	3.64	3.46	2.07	3.17	6.27	.017	.14	[.01, .30]
Cognitive overload	9.64	4.44	7.53	4.12	8.60	.006	.18	[.03, .35]
Immobility	6.25	4.81	3.38	3.58	10.92	.002	.22	[.05, .38]
Distress	14.46	5.68	10.67	5.63	16.72	.000	.31	[.11, .46]

Table 2

Peritraumatic Reactions During Moments Encoded as Intrusive Memories and Most Distressing Memories (Different Participants)

Peritraumatic factors	Intrusive memories		Most distressing memories					
	M	*SD*	*M*	*SD*	*F*(1, 99)	*p*	Partial η^2	90% CI
Mental defeat	9.22	6.98	4.38	4.25	3.95	.050	.04	[.00, .12]
Somatoform dissociation	3.35	3.54	0.73	1.95	13.61	.000	.12	[.03, .22]
Cognitive overload	9.39	4.45	4.88	4.27	15.28	.000	.13	[.04, .23]
Immobility	5.96	4.88	2.10	3.96	16.46	.000	.14	[.05, .24]
Distress	14.78	5.78	8.60	5.79	16.76	.000	.15	[.05, .25]

Note. Analyses controlled for age and transformed PCL-5 scores.

Table 3

Emotions Experienced at Recall of Intrusive Memory Versus Control Non-Intrusive Memory (Same Participants)

	Intrusive memories		Non-intrusive control memories					
	M	*SD*	*M*	*SD*	*t*(49)	*p*	*D*	95% CI
Anxiety	7.38	2.76	4.94	3.92	4.51	.000	0.71	[0.40, 1.06]
Anger	6.52	3.78	6.46	3.62	0.10	.915	0.02	[-0.29, 0.32]
Sadness	8.52	2.36	8.34	2.61	0.39	.696	0.07	[-0.29, 0.44]
Guilt	4.42	4.01	3.46	3.85	1.50	.140	0.24	[-0.08, 0.57]
Shame	0.86	2.25	0.94	2.53	-0.21	.832	0.03	[-0.28, 0.34]
Helplessness	8.48	2.71	7.30	3.47	2.37	.022	0.38	[0.07, 0.70]
Numbness	2.78	3.77	2.20	3.33	1.08	.282	0.16	[-0.13, 0.46]
Fear	6.46	3.36	4.72	3.89	2.62	.011	0.48	[0.12, 0.85]
Horror	4.28	4.26	4.00	4.05	0.47	.638	0.07	[-0.22, 0.35]
Disgust	1.68	3.13	2.62	3.82	-1.65	.105	0.27	[-0.05, 0.60]

Table 4

Emotions Experienced at Recall of Intrusive Memories Versus Most Distressing Memories
(Different Participants)

	Intrusive memories		Most distressing memories					
	M	*SD*	*M*	*SD*	*F*(1, 103)	*p*	Partial η^2	90% CI
Anxiety	7.43	2.76	4.30	3.79	12.64	.001	.11	[.03, .20]
Anger	6.58	3.77	5.52	4.02	1.17	.280	.01	[.00, .06]
Sadness	8.54	2.35	8.67	2.19	0.01	.902	.00	[.00, .00]
Guilt	4.33	4.01	2.01	3.28	2.67	.105	.02	[.00, .09]
Shame	0.84	2.23	0.58	1.76	0.00	.956	.00	[.00, .00]
Helplessness	8.50	2.69	7.45	3.53	1.16	.284	.01	[.00, .06]
Numbness	2.72	3.75	1.39	2.68	1.85	.176	.01	[.00, .07]
Fear	6.52	3.36	4.49	3.96	4.33	.040	.04	[.00, .11]
Horror	4.39	4.29	3.67	4.08	0.67	.414	.00	[.00, .05]
Disgust	1.84	3.31	2.33	3.48	0.22	.633	.00	[.00, .03]

Note. Analyses controlled for age and transformed PCL-5 scores.