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Enhanced perceptual priming for neutral stimuli occurring in a traumatic context: Two experimental investigations

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Abstract

Intrusive memories in posttraumatic stress disorder are often triggered by stimuli that are perceptually similar to those present shortly before or during the trauma. The present study aims to examine the possible role of perceptual priming in this phenomenon. It further investigates whether the degree of perceptual priming is associated with dissociation and whether both perceptual priming and intrusive memories can be reduced through elaboration.

Two experiments measured perceptual priming for neutral stimuli that immediately preceded a "traumatic" event. Volunteers ($N = 46$, 92) watched a series of "traumatic" and neutral picture stories, and completed a blurred object identification (perceptual priming) memory task, and a recognition memory task. Participants in Experiment 1 were selected to score either high or low on the Trait Dissociation Questionnaire [Murray, Ehlers, & Mayou (2002). Dissociation and posttraumatic stress disorder: Two prospective studies of motor vehicle accident survivors. *British Journal of Psychiatry*, *180*, 363–368]. They also completed a state dissociation measure in the session. Experiment 2 randomly allocated participants to an experimental condition designed to increase elaboration or to a control condition. This experiment also included a measure of intrusive memories.

Both experiments found enhanced perceptual priming for the stimuli that immediately preceded the "traumatic" stories compared to those preceding neutral stories. Participants with high trait dissociation showed relatively stronger perceptual perceptual priming. The degree of perceptual priming for stimuli from the "traumatic" stories also correlated with state dissociation (Experiment 1). Experimental manipulation of the elaboration of the stories showed that elaboration reduced the enhanced perceptual priming effect and the relative probability of reexperiencing symptoms (Experiment 2). The results support the role of perceptual priming in intrusions after traumatic events.

Keywords: Trauma memories; Perceptual priming; Posttraumatic stress disorder; Data-driven processing; Dissociation; Elaboration

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Introduction

Intrusive memories are considered the hallmark symptom of PTSD. They usually consist of brief sensory fragments of the traumatic event, and are accompanied by high emotional distress (e.g., Ehlers & Steil, 1995; Holmes, Grey, & Young, 2005; van der Kolk & Fisler, 1995). Even though it is not uncommon for intrusive memories to have several sensory components, studies investigating the modalities of intrusive memories have repeatedly shown that visual sensations seem to be the most common form (Ehlers et al., 2002; Hackmann, Ehlers, Speckens, & Clark, 2004; Mellman & Davis, 1985; Michael, Ehlers, Halligan, & Clark, 2005). Furthermore, intrusive memories in PTSD are accompanied by a sense of "nowness", i.e., the impression that the sensations are happening now rather than stemming from the past (e.g., Ehlers, Hackmann, & Michael, 2004; Hackmann et al., 2004; Michael, Ehlers, Halligan, & Clark, 2005).

Cognitive theories of PTSD concur in assuming that intrusive memories are due to the way the trauma memories are encoded, organized in memory, and retrieved (Brewin, Dalgleish, & Joseph, 1996; Conway & Pleydell-Pearce, 2000; Ehlers & Clark, 2000; Foa, Steketee, & Rothbaum, 1989). However, surprisingly little is known about the mechanisms that lead to intrusive memories. The clinical and theoretical literature on PTSD has emphasized the remarkably wide range of external and internal triggers of reexperiencing (Brewin et al., 1996; Foa et al., 1989). Only some of these triggers seem to be semantically linked to the traumatic event, such as TV or newspaper reports about similar events. Interestingly, triggers are often stimuli that are perceptually similar to the stimuli featuring in the intrusion (Ehlers & Clark, 2000; Ehlers et al., 2004). For example, a car crash survivor kept reexperiencing the bright headlights that were coming towards him before the accident. In therapy, it became clear that bright patches of light on a darker background (e.g., sunlight on a lawn) triggered this intrusive memory. Frequently, trauma survivors are not aware which stimuli trigger their intrusive memories and thus experience them as coming out of the blue. Thus, the triggering of intrusive memories appears to be mainly cue-driven.

Ehlers and colleagues observed that the content of intrusive memories is also somewhat surprising. They asked patients with PTSD who had experienced a range of different traumas to describe the content of their intrusive memories. Interestingly, most participants reported that they had sensory memories of stimuli that were present immediately before the traumatic event happened or immediately before the moment that had the largest emotional impact (Ehlers et al., 2002). For example, a man who witnessed the suicide of a person who jumped in front of a train had intrusive images of the sight of the railway tracks as he had seen them just before the person jumped. A subsequent study, in which two independent raters judged the content of participants' intrusive memories, corroborated these findings. The majority of intrusions ($>80\%$) did not represent the worst moment of the trauma. The most common intrusive memories were stimuli signalling the onset of the event, followed by stimuli that signalled a particularly upsetting moment during the trauma (Hackmann et al., 2004).

Ehlers and Clark (2000) suggested that the easy triggering of intrusive memories in PTSD by perceptually similar cues is a function of strong perceptual priming for stimuli that occurred shortly before or during the traumatic event. The authors propose that perceptual priming, together with strong associative links between these stimuli (S–S associations), and between the stimuli and strong affective responses (S–R associations) (see also Foa et al., 1989; Keane, Zimering, & Caddell, 1985), facilitates cue-driven retrieval of corresponding aspects of the trauma memory.

Cue-driven activation of autobiographical memories is usually inhibited when the memory becomes incorporated into the autobiographical knowledge base (Conway & Pleydell-Pearce, 2000). On the basis of these findings, Ehlers and Clark (2000) suggested that in PTSD there is poor inhibition of cue-driven retrieval of aspects of the trauma because the memory for the traumatic event is poorly elaborated. In particular, it is insufficiently linked with its context, i.e. with things that happened shortly before or afterwards, and with other autobiographical information. The three memory processes (perceptual priming, associative learning, and poor elaboration) are thought to work in conjunction in producing reexperiencing symptoms, i.e., poor memory elaboration in itself is not sufficient for producing intrusive memories (Ehlers & Clark, 2000).

Perceptual priming is a form of implicit memory that refers to the facilitated identification of perceptual objects as a consequence of prior exposure. Many laboratory experiments have demonstrated perceptual priming by showing that degraded perceptual stimuli of words or objects are more easily identified if the

person has previously been exposed to the stimuli (Schacter, 1992). Importantly, perceptual priming can occur independently of any conscious recollection of a previous encounter with the stimuli (Schacter, 1992). Hence perceptual priming is thought to be responsible for certain mind-popping phenomena in which perceptual fragments of experience spontaneously materialize in awareness (Schacter, 1996). With respect to the above-mentioned example of the car crash survivor, it thus seems probable that the triggering of the "headlight intrusion" by patches of light reflects the influence of perceptual priming.

The perceptual priming hypothesis received indirect empirical support from studies showing enhanced implicit memory for trauma-related material for people with PTSD compared to those without PTSD (Amir, McNally, & Wiegatz, 1996; Michael, Ehlers, & Halligan, 2005; but see Golier, Yehuda, Lupien, & Harvey, 2003; McNally & Amir, 1996). However, these studies have the limitation that they investigated perceptual priming for words or sentences, which are related to, but dissimilar to the sensory impressions that are reexperienced after trauma. As visual intrusive memories seem to be the most common form of intrusive memories, it would be desirable to study perceptual priming for visual stimuli from the traumatic context that trigger intrusions. This is, however, difficult to achieve in trauma survivors for several reasons. First, traumatized people are often not aware which stimuli trigger their intrusive memories. Second, even if the triggers are identified in therapy, it would be extremely hard to bring them under experimental control, especially as the stimuli differ from one trauma survivor to the other and as it would be next to impossible to match a control group to the traumatized group with respect to duration of initial exposure and the time between initial exposure and the perceptual priming task.

Ehlers, Michael, Chen, Payne, and Shan (2006) therefore developed an experimental paradigm to study visual perceptual priming for stimuli that occur in a traumatic context. The paradigm investigates perceptual priming for neutral objects that occur just before something "traumatic" happens, as clinical observations showed that intrusive memories often feature such stimuli (see the headlights and railway track examples above). Participants watched a series of "traumatic" and neutral picture stories. The content of the first picture is unemotional. It contains neutral preceding stimuli (e.g. a cushion) for which memory is later tested. During the second picture, either something "traumatic" (e.g., a man being attacked with a knife) or something neutral happens. The last picture focuses on the outcome of the story for the main character (e.g., the attacked man is being decapitated). In accordance with the enhanced perceptual priming hypothesis, the results showed that neutral stimuli preceding a "traumatic" event showed enhanced perceptual priming and predicted intrusive memories (Ehlers et al., 2006).

At this stage, it remains unclear how a subsequent "traumatic" event can produce enhanced perceptual priming for previously encountered stimuli. One possible explanation may be that the distress brought on by the "traumatic" event produces an encoding style that favors perceptual processing (e.g., Siegel, 1995). This change in encoding might affect the encoding and storage of previously encountered information, as this is held in consciousness for some time in order to help the organism to connect and make sense of subsequent events.

Further support for the enhanced perceptual priming hypothesis stems from a recent study about emotional memory by Arntz, de Groot, and Kindt (2005). Participants watched a series of slides that were accompanied by a spoken story, which was either neutral or emotional (distressing). A subsequent memory test revealed that participants in the emotional condition performed better on a perceptual identification and on a perceptual recognition task than participants in the neutral condition.

Although the above results point to enhanced perceptual priming as one mechanism underlying intrusions, they need to be extended in order to address several important issues that remain unanswered. It is, for example, not yet known if the encoding style during a traumatic event influences the extent of perceptual priming and if perceptual priming and reexperiencing can be reduced through elaboration, as has been suggested (Conway & Pleydell-Pearce, 2000; Ehlers & Clark, 2000). The present series of experiments aims to investigate these questions by using a modified version of the Ehlers et al. (2006) paradigm.

Experiment 1

Dissociation is a multifaceted concept, which describes "a disruption in the usually integrated functions of consciousness, memory, identity, or perception of the environment" (American Psychiatric Association, 1994,

p. 766). It includes a range of cognitive phenomena such as derealization, depersonalization, a distorted sense of time, being dazed, and emotional numbing. Peritraumatic dissociation has consistently been found to predict subsequent PTSD (for a meta-analysis see Ozer, Best, Lipsey, and Weiss (2003)). It has been suggested that dissociation during a traumatic event decreases focal attention, thereby interfering with a conceptual processing of the traumatic event and promoting a nonverbal, perceptual processing style that is characteristic for PTSD (Brewin et al., 1996; Siegel, 1995).

As the performance on a perceptual priming task relies heavily on perceptual, unconscious operations, we assumed that it might vary as a function of dissociation. Therefore, Experiment 1 investigated the association between enhanced perceptual priming and dissociation. As previous research investigating the role of processing styles during analogue "traumatic" events did not succeed in manipulating the processing style during the experiment (Halligan, Clark, & Ehlers, 2002; Murray, 1997), we selected participants who scored either high or low on trait dissociation. People with high dissociation scores might habitually encode information in a relatively rich perceptual way and thus show enhanced perceptual priming. Further, a prospective study on dissociation in PTSD showed that a pre-trauma tendency to dissociate correlated with peritraumatic dissociation (Murray et al., 2002). Thus, one may assume that participants high in trait dissociation show particularly high levels of state dissociation when watching "traumatic" picture stories. The experiment included a measure of state dissociation in order to explore its relationship with trait dissociation and perceptual priming.

In summary, Experiment 1 addressed the following hypotheses:

(1) There is greater perceptual priming for neutral stimuli that immediately precede a "traumatic" event than for neutral stimuli that precede a neutral event (replication of Ehlers et al.'s (2006) earlier results).
(2) People high in trait dissociation show more perceptual priming than people low in trait dissociation.
(3) State dissociation while encoding the "traumatic" picture stories is associated with perceptual priming.

Method

Participants

Participants were recruited from 253 students at Oxford and Oxford Brookes Universities, UK, who had completed the Trait Dissociation Questionnaire (TDQ) (Murray et al., 2002). In order to qualify for the study, participants had to score either in the upper (65 and above, high dissociation group, $N = 25$) or in the lower quartile (32 and below, low dissociation group, $N = 25$) of this scale. Participants received £5 travel expenses. Four students were excluded because a screening questionnaire indicated that they had a history of trauma, suffered from current blood/injury phobia or severe depression. The final sample comprised 46 students (28 female, 18 male). Ages ranged from 18 to 48 years, $M = 22.6$, SD = 5.6.

Materials

The experimental software for all parts of the experiment was programmed with SuperLab. Picture stories and memory tests were presented on a 15″ screen of an APPLE Macintosh computer.

Picture stories

Participants saw eight analogue "traumatic" and eight neutral picture stories, each consisting of three pictures. One additional neutral story (of a man getting drunk) was used to familiarize the participants with the task. The first picture (presented for 20 s) introduced the main character. It is always neutral so that it is not possible to conclude from this picture whether the story is unpleasant or neutral. The first picture contains two neutral objects in the background that are unimportant for the course of the story (*preceding* objects). The second picture (presented for 20 s) depicts the plot of the story and shows something traumatic or neutral happening. It contains one *central* object that is important for the course of the story, and determines whether the content is traumatic or neutral. The third and last picture (presented for 15 s) shows the final outcome for the main character of the story. It focuses on and underlines the traumatic vs. neutral content of the story.

	Unpleasant Story	Neutral Story
PICTURE 1: Main character in neutral setting	A man is watching TV	A man is entering the kitchen
preceding stimuli	*bottle, cushion*	*spatula, frying pan*
PICTURE 2: Main character experiences "traumatic" or neutral event	The man is attacked with a knife by an intruder	The man notices that his wife is repairing an old boot on the kitchen table
central stimuli	*knife*	*boot*
PICTURE 3: "Traumatic" versus neutral outcome	decapitated man	puzzled man

Fig. 1. Story structure, example of one "traumatic" and one parallel neutral story. The objects for which perceptual priming and recognition memory were later tested are in italics.

In order to make the material as realistic as possible, the stories were made up from feature films in which not well-known actors and actresses starred or documentaries. The cultural background of the stories was embedded in a "western" context so that the participants (who all lived in a similar context) could easily identify with the main characters.

The unpleasant and neutral picture stories were matched for the number of males, females, and objects occurring in them, and whether the event happened indoors or outdoors. For example, one unpleasant story contains a dog killing a man and the matching story depicts a cat stealing the sandwich from its owner. A list of the contents of all stories is presented in Appendix.

Fig. 1 illustrates the structure of one unpleasant (a man being stabbed and decapitated) and one neutral picture story (a man coming home and seeing his wife repairing a boot on the dining table), and lists what objects occur in these stories.

Participants were told that it was the purpose of the experiment to test how pictures affect people's emotions. They were asked to watch the pictures closely and to imagine that they were present at the scene. After each picture story, they were asked to rate the pictures for pleasantness and arousal. There was no indication that memory for the pictures would be tested later.

Picture stories were presented in two blocks of "traumatic" and neutral stories, in counterbalanced order. Blockwise presentation was chosen to prevent crossover of negative emotions produced by unpleasant picture stories to neutral ones. Order of presentation did not influence the results. Between blocks participants had a 5-min break. The order of the stories within each block was randomized and different for every participant.

Memory measures

Memory for objects shown in the picture stories was tested with a blurred object identification task (assessing perceptual priming) and a recognition task (assessing explicit memory). In designing the memory tests, objects from the picture stories were isolated and edited using Adobe PhotoShop. All objects were left in their original size. As each participant completed both memory tests, two equivalent sets (sets 1 and 2) of objects were created for each task. Each set contained one of the preceding objects from each story and, in the recognition task, half of the central objects from unpleasant and neutral scenes. Half of the participants saw objects from set 1 in the perceptual priming task and objects from set 2 in the recognition task. For the other half of the participants, sets were reversed. Picture set did not influence the results.

Perceptual priming task. Visual perceptual priming leads to an enhanced identification rate for previously seen objects. Perceptual priming was assessed with a blurred object identification task. In order to decrease the chance that participants noticed that the task was a memory test, only the preceding objects from the stories (8

from "traumatic" and 8 from neutral stories) were included. Furthermore, the majority of items ($N = 24$) were unprimed objects that had not featured in the picture stories (e.g., a hole punch, scissors). These unprimed objects were matched for size to the primed objects from the picture stories.

Participants were told that they were now doing a different task that was unrelated to the picture stories. They were informed that the task was about how easy it is for people to identify blurred pictures. They were instructed to look at the pictures and guess what the object might be, working as quickly and as accurately as possible. The experimenter wrote down the answers, which were later coded for accuracy. If participants could not guess what the object might be, they indicated that they did not know. After their answer, participants moved on to the next object by pressing the space bar.

The preceding objects from the picture stories were blurred with a Gaussian filter to a degree which allowed approximately 50% correct identification in pilot participants with no prior exposure to the picture stories; objects from unpleasant stories: $M = 51.3\%$, $N = 40$; objects from neutral stories: $M = 49.8\%$, $N = 40$. The unprimed items were blurred slightly less so that their baseline identification rate was $M = 59.7\%$. This was done to ensure that each participant would identify at least a few unprimed objects, thus reducing the chance that participants would notice that the identification task tests performance for stimuli from picture stories.

The objects were presented in successive, random order on the computer screen that varied with each participant.

As the baseline identification rates for the individual objects varied substantially, we calculated the incremental identification probability for each object compared to its baseline identification rate. This method allowed us to obtain for each object a precise measure how much its identification rate has been increased through prior exposure. If the baseline identification rate for an object were, for example, .4, then the incremental identification rate would be .6 in the case of correct identification and $-.4$ in the case of non-identification. For objects from picture stories, perceptual priming from prior exposure would show in positive incremental identification probability, whereas unprimed objects (no prior exposure) should be identified at baseline rates, resulting in a mean incremental identification probability of 0.

Recognition task. The recognition task tested explicitly memory performance for objects from the picture stories. It was incorporated into the study as one way to estimate possible influences of explicit memory on the results of the perceptual priming task. It included both central and preceding objects from the picture stories. For each "old" object from the picture stories, a parallel new object was chosen that looked somewhat different in appearance. These parallel new objects matched the objects from the picture stories in size and object type (e.g., if the object from the picture story was a watch, another watch of approximately the same size was used as the parallel object). Objects were presented on a computer screen in a successive, random order, which was different for each participant. Participants were asked to indicate whether or not they had seen the object previously in the stories by pressing the corresponding keys on the computer keyboard.

Comparability of the material used in the memory tasks. The preceding objects shown in the "traumatic" and neutral stories did not differ in baseline identification rates. However, this is not a sufficient test of comparability, as one also needs to verify that the salience of the preceding objects in the two story types does not differ. A pilot study ($N = 20$) was therefore designed to rule out the hypothesis that preceding objects from one story type are more noticeable than objects from the other story type and that subsequent differences in memory are due to object salience. The procedure and memory measures of this pilot investigation were identical to the main experiment except that not the complete picture stories were presented, but only the first pictures of the stories (which were always neutral). When the preceding objects were presented without their emotional context, the objects from the "traumatic" stories did not differ in incremental identification rates, $M = .08$, $SD = .17$, from those that occurred in neutral stories, $M = .14$, $SD = .19$, $t\ (19) = 1.56$, $p = .14$. There were no differences in recognition sensitivity, $t\ (19) = -.24$, $p = .81$, "traumatic" stories: $M = 1.75$, $SD = 1.39$, neutral stories: $M = 1.85$, $SD = 1.32$, or response bias, $t\ (19) = 1.56$, $p = .14$, "traumatic" stories: $M = .32$, $SD = .40$, neutral stories: $M = .58$, $SD = .70$. As none of the memory measures indicated differences in memory when the objects were presented without their emotional context, one can attribute possible memory differences in the main experiment to the emotional character of the stories.

Cognitive processing style measures

Trait dissociation. The *TDQ* (Murray et al., 2002) is a 38-item questionnaire that measures several aspects of habitual dissociation such as detachment from others, sense of spilt self, emotional numbing, amnesia for important life events. Murray et al. (2002) found that the internal consistency of the total score was above Cronbach's $\alpha = .90$, and the retest reliability above $r = .80$ in a range of samples. Furthermore, TDQ scores predicted chronic PTSD in motor vehicle accident (Murray et al., 2002) and assault survivors (Halligan, Michael, Clark, & Ehlers, 2003). The internal consistency score for the TDQ in the present sample was Cronbach's $\alpha = .87$.

State dissociation. Dissociation during the block of traumatic and the block of neutral stories was measured with the *State Dissociation Questionnaire (SDQ)* (Murray et al., 2002), a 9-item scale assessing different aspects of dissociation such as derealization, depersonalization, detachment, altered time sense, emotional numbing, and reduction of awareness in surroundings. The SDQ was given twice, after the block of "traumatic" stories, and after the block of neutral stories. The SDQ showed good reliability and validity in traumatized and nontraumatized samples (Halligan et al., 2002, 2003; Murray et al., 2002). It correlates strongly with the Peritraumatic Dissociation Scale (Marmar, Weiss, & Metzler, 1997) $r = .79$ (Rosario, Ehlers, Williams, & Glucksman, submitted). The internal consistency in the present sample was Cronbach's $\alpha = .83$.

Further measures

The *Past Experience Questionnaire* screens participants for a trauma history, blood/injury phobia, and severe depression. Participants who met any of these criteria were excluded from the study at the request of the Oxfordshire Psychiatric Research Ethics Committee.

Participants rated each picture story in terms of pleasantness and arousal on two rating scales, each on a scale from −10 to 10. The *Pleasantness Rating* was labeled "extremely unpleasant" to "very pleasant" and the *Arousal Rating* "very relaxing" to "very activating (e.g., pounding heart, tense muscles)".

Procedure

Participants received an information sheet about the study and were given further information on the telephone when arranging the appointment. They were informed in writing and verbally that the study involved watching some unpleasant pictures, and that they could drop out of the study at any point without having to give a reason. On arrival at the laboratory, participants gave written consent. They then completed the Past Experience Questionnaire. Participants were then given oral and written instructions for watching the picture stories, and watched the two blocks of picture stories, each followed by the cognitive processing questionnaires.

After a 10-min break, the perceptual priming task was given, followed by the object recognition task.

The experimenter made sure that participants felt well before leaving and gave participants her contact details, encouraging them to get in touch if they felt in any way distressed about the experiment. However, none of the participants took up this offer and none reported that they found the experiment too distressing.

Data analysis

Picture ratings and state dissociation. Before examining the hypotheses, we checked whether participants perceived the "traumatic" stories as unpleasant and the neutral stories as neutral. Pleasantness and Arousal Ratings and SDQ scores were analyzed with 2×2 repeated measures ANOVAs, with dissociation group (high versus low) as the between-subject factor and story context ("traumatic" versus neutral) as the within-subject factor.

Perceptual priming task. To test whether watching the picture stories led to perceptual priming, incremental identification rates (adjusted for baseline identification rates, see above) for the objects from picture stories (primed) and unprimed objects were compared with a 2×2 repeated measures ANOVA, with dissociation group (high versus low) as the between factor and previous exposure (primed versus unprimed) as the within factor. Greater priming in the dissociation group (Hypothesis 2) would show in a significant interaction of the group and exposure factors.

Once a general perceptual priming effect was established, the priming index was computed to compare priming for objects from "traumatic" versus neutral stories. The priming index was the difference between the incremental identification rates for primed minus unprimed objects. The priming index was analyzed with a 2×2 repeated measures ANOVA, with trait dissociation group (high versus low) as the between-subject factor and story context ("traumatic" versus neutral) as the within-subject factor. This ANOVA allowed us to test Hypothesis 1 (greater perceptual priming for neutral stimuli that occur in a traumatic context than for neutral stimuli that occur in a neutral context), and to explore whether the enhanced priming effect was greater in the high dissociation group.

Hypothesis 3 stipulated an association between state dissociation and perceptual priming for objects in these stories. Pearson's correlation coefficients were computed to test this hypothesis (one-tailed as we expected only positive correlations on the basis of prior research). Scatter plots confirmed a linear association between the variables.

Recognition memory. Data analysis of the object recognition task followed signal detection theory (SDT) (MacMillan & Creelman, 1991). This analysis allows computing of sensitivity (d') and response bias (c) scores. Sensitivity measures how well participants discriminated between objects from the stories and parallel objects that they had not seen before. Response bias assesses participants' implicit readiness to identify or reject objects as being from the stories. Sensitivity and response bias were analyzed using $2 \times 2 \times 2$ repeated measures ANOVAs, with dissociation group as the between factor, and story context ("traumatic" versus neutral) and object importance (central versus preceding) as within-subject factors.

Effect size. Following the recommendations of Rosenthal (1995), measures of effect size were computed as partial η^2, which reflects the proportion of total variability attributable to a factor (and reported here as effect size ES, percentage of explained variance). According to Cohen (1988), effects are considered as small when ranging from 2% to 12%, as medium when ranging from 13% to 44%, and as large when the explained variance is more than 45%.

Results

Validity of picture stories

Pleasantness Ratings showed a main effect of story type, the "traumatic" stories, $M = -6.35$, SD = 2.15, were rated as more unpleasant that the neutral stories, $M = .93$, SD = 1.47, F (1, 44) = 294.10, $p < .001$, ES = 87%. The "traumatic" stories, $M = 4.36$, SD = 2.60, were also rated as more arousing than the neutral stories, $M = -.22$, SD = 1.70, F (1, 44) = 133.04, $p < .001$, ES = 75.1%. There were no main effects or interactions for trait dissociation group on these variables.

The means for state dissociation whilst watching the picture stories were as follows. High dissociation group: "traumatic" stories, $M = 1.31$, SD = .736; neutral stories, $M = .807$, SD = .774. Low dissociation group: "traumatic" stories, $M = .304$, SD = .393; neutral stories, $M = .168$, SD = .228. The high trait dissociation group reported greater state dissociation than the low trait dissociation group, $F(1, 44) = 35.29$, $p < .001$, ES = 44.5%. Participants reported greater state dissociation during the "traumatic" stories than during the neutral stories, $F(1, 44) = 12.04$, $p = .001$, ES = 21.5%. There was a trend for the high dissociation group to report greater increases in state dissociation with the "traumatic" stories compared to the neutral stories than the low dissociation group, $F(1, 44) = 3.42$, $p = .071$, ES = 7.2%.

Perceptual priming task

The comparison of the incremental identification rates of primed and unprimed objects showed a main effect of prior exposure, means for "traumatic" and neutral stories, $M = .089$, SD = .151, and $M = -.012$, SD = .153. The objects from the picture stories had greater incremental identification rates than unprimed objects, F (1, 44) = 20.93, $p < .001$, ES = 32.2%, demonstrating a general perceptual priming effect. A significant interaction between trait dissociation group and prior exposure, F (1, 44) = 7.28, $p = .010$, ES = 14.2%, indicated a greater difference between primed and unprimed objects in the high dissociation

Table 1
Perceptual priming for preceding objects from picture stories, Experiment 1

Story context	Dissociation group	Perceptual priming: *M* (SD)
"Traumatic"	High ($n = 23$)	.24 (.21)
	Low ($n = 23$)	.07 (.17)
Neutral	High	.09 (.15)
	Low	.02 (.22)

Priming is quantified by difference in incremental identification rate between primed and unprimed objects.

group, $M = .16$, SD = .14, than in the low dissociation group, $M = .04$, SD = .16. There was no main effect of trait dissociation group, $F(1, 44) = 1.82$, $p = .18$, ES = 4%.

Table 1 presents the results for Hypothesis 1 (greater perceptual priming for preceding stimuli that occur in a traumatic context than for those that occur in a neutral context) and Hypothesis 2 (greater perceptual priming in the high dissociation group). As expected, the priming index was greater for objects from "traumatic" stories than for objects from neutral stories, $F(1, 44) = 8.33$, $p = .006$, ES = 15.9%. As before, people high in trait dissociation had more perceptual priming than people low in trait dissociation, $F(1, 44) = 7.28$, $p = .01$, ES = 14.2%, but there was no significant interaction between trait dissociation group and story context, $F(1, 44) = 1.98$, $p = .17$, ES = 4.3%, i.e., trait dissociation did not differentially affect perceptual priming for the two story types.

Associations between perceptual priming for objects from traumatic stories and cognitive processing. In accordance with Hypothesis 3, perceptual priming for objects from "traumatic" picture stories correlated with state dissociation whilst watching these stories, $r(46) = .27$, $p = .03$. Perceptual priming for objects in the "traumatic" context also correlated with the degree to which participants rated the picture stories as unpleasant, $r = -.31$, $p = .02$ (Pleasantness Rating), but not with Arousal Ratings. However, the association between state dissociation and perceptual priming was not explained by correlations with Pleasantness Ratings, as it remained significant when Pleasantness Ratings were partialled out, $r = -.24$, $p = .05$.

Further analyses

Recognition memory. There were no effects of dissociation group or story context on recognition sensitivity. The only significant effect was that central objects were better discriminated than preceding objects, as indicated by a main effect of object importance, $F(1, 44) = 13.46$, $p = .001$, ES = 23.4%. Regarding response bias, the analysis revealed a significant main effect of story context, $F(1, 44) = 7.14$, $p = .01$, ES = 14%, indicating that participants had a more liberal response criterion for objects from the unpleasant stories. No other effects reached significance.[2]

Discussion

The results of the perceptual priming task replicate our earlier findings that neutral stimuli that immediately precede a "traumatic" event are more strongly primed than comparable stimuli that precede a neutral event (Ehlers et al., 2006). They are further in line with studies of trauma survivors that found evidence for a relationship of enhanced perceptual priming for trauma-related stimuli and PTSD symptoms (Amir et al., 1996; Michael, Ehlers, & Halligan, 2005). The current findings add to this emerging literature as the enhanced perceptual priming effect was experimentally induced by embedding the neutral pictures that included the neutral objects in a context of either "traumatic" or neutral picture stories. When presented without this context, the degree of perceptual priming for the objects from these scenes did not differ (and means were in the opposite direction to those in the Experiment). Thus, the differences in perceptual priming can be attributed to the different emotional context in which the objects occurred.

[2]A full description of the recognition memory results can be requested from the authors.

There has been a debate in the literature on the influence of explicit memory on the performance in implicit memory tasks such as perceptual priming tests (e.g., Jacoby, Toth, & Yonelinas, 1993; Tulving, Schacter, & Stark, 1982). The present study was not designed to address this issue so that we cannot conclude with certainty that a pure implicit memory effect was observed. However, the pattern of findings make it very unlikely that the enhanced perceptual priming effect for objects from the traumatic stories stemmed from the intentional search for these objects and the use of explicit knowledge. There was no indication of any effect of story context on recognition (sensitivity) rates. The only difference that emerged in recognition memory performance was a higher recognition rate for central objects compared to preceding objects. This result is consistent with eyewitness research, which shows that central information from traumatic and neutral events is better remembered than neutral information (Christianson, 1992), and with clinical observations that PTSD patients remember the central aspects clearly. Analysis of the response bias in the object recognition task revealed that participants used a more liberal response criterion for objects belonging to the "traumatic" stories than for those from the neutral stories. This result is in line with a stronger implicit memory for objects from "traumatic" stories. Perceptual priming increases the feeling of familiarity, which can be expected to generalize to the similar objects presented in picture stories, as previous research has shown that implicit memory traces are poorly distinguished from other traces (Baddeley, 1997). Thus, a sense of familiarity is likely to increase the tendency to report having seen the object before.

Dissociation has repeatedly been shown to be associated with PTSD (e.g., Bremner & Brett, 1997; Halligan et al., 2003; Murray et al., 2002; Spiegel & Cardena, 1990; see Ozer et al., 2003, for a meta-analysis). The current study tested whether dissociation modulates the strength of perceptual priming. People high in trait dissociation indeed showed stronger perceptual priming for the objects from the picture stories than those low in trait dissociation. Thus, people who have a habitual tendency to dissociate seem to be characterized by a perceptual processing style. The main effects for dissociation group and for story context meant that the highest perceptual priming scores were found in the condition "high dissociation and 'traumatic' story context". Furthermore, there was a trend for the high dissociation group to report greater increases in state dissociation with the "traumatic" stories compared to the neutral stories than the low dissociation group. State dissociation during the "traumatic" picture stories was related to the degree of perceptual priming for objects from these stories. Together, these effects indicate that people high in dissociation are at risk for strong implicit memory representations of "traumatic" material. The current experiment did not show a significant interaction between the factors dissociation and story context ($p = .17$), but this may be due to low statistical power. Taken together, the findings on dissociation are in line with the hypothesis that dissociation promotes a perceptual processing style, as well as with previous findings showing that trait dissociation may make people more vulnerable to experience dissociation during traumatic events, and that the development of posttraumatic symptoms depends on the degree to which people actually dissociate during the event (e.g., Halligan et al., 2003; Murray et al., 2002).

Experiment 2

Experiment 2 was designed to replicate the finding from Experiment 1 that neutral objects from a traumatic context are more strongly primed than those objects from a neutral context. It further tested whether the enhanced perceptual priming enhances the probability that the traumatic event is reexperienced (as a sensation with a "nowness" quality) rather than remembered as an ordinary memory, as Ehlers and Clark (2000) predicted. The experiment further studied the effects of elaboration on perceptual priming and subsequent rexperiencing symptoms. Elaboration is thought to lead to inhibition of cue-driven retrieval (Conway & Pleydell-Pearce, 2000; Ehlers & Clark, 2000), and we thus expected an elaboration manipulation to reduce the enhanced perceptual priming effect and to protect against subsequent reexperiencing symptoms. Experiment 2 randomly allocated participants to one of two experimental conditions: (1) an experimental condition which was designed to increase elaboration and (2) a control condition that involved a series of cognitive tasks unrelated to the picture stories. The experimental condition was modeled on aspects of cognitive therapy for PTSD (Ehlers, Clark, Hackmann, McManus, & Fennell, 2005) in that it aimed at elaborating the participants' experience of taking part in the experiment and at facilitating the integration of this experience into the participants' autobiographical memories. This is meant to lead to an inhibition of cue-driven retrieval of

memories. The control group completed tasks that required verbal processing, like the elaboration condition, while at the same time preventing participants from thinking about the picture stories. This group was expected to show the enhanced perceptual priming effect, as in Experiment 1, and to be more likely to remember the experiment in form of reexperiencing, rather than ordinary memories, than the elaboration group.

Thus, Experiment 2 examined to test the following hypotheses:

(1) there is enhanced perceptual priming for neutral stimuli preceding a traumatic context compared to those that precede a neutral context (control condition only);
(2) the degree of perceptual priming for stimuli from a traumatic context predicts subsequent reexperiencing symptoms;
(3) elaboration after exposure to traumatic material reduces the enhanced perceptual priming to a greater extent than a cognitive control task designed to prevent processing of the picture stories;
(4) elaboration after exposure leads to fewer reexperiencing symptoms (i.e., unwanted images, feelings and dreams), but not to fewer thoughts about the experiment (e.g. "This cat looks just like the one I saw in the experiment"), than a cognitive control task.

Method

Participants

One hundred students from Oxford and Oxford Brookes University were recruited for this experiment. Eight students were excluded because they met at least one of the exclusion criteria (trauma history, current blood phobia or severe depression). The final sample consisted of 92 people. Sixty participants were female and 32 male. Ages ranged from 18 to 42 (mean age 23.5, SD = 7.1). Participants were paid £5 for their travel expenses.

Materials

The picture stories, perceptual priming task and recognition task were the same as in Experiment 1. The only difference was that for some objects in the perceptual priming task the degree of blurredness was changed somewhat with the goal to bring their baseline identification rate closer to 50%. A new pilot study ($N = 40$) showed that this adjustment was successful. Mean baseline identification rates were $M = .49$, $SD = .16$ for "traumatic" stories, and $M = .49$, $SD = .15$ for neutral stories. We used the baseline identification rates established in the new pilot study to calculate the incremental identification increase rates for Experiment 2.

Experimental manipulation

Elaboration group. Half of the participants were asked to answer five questions in writing, which were designed to facilitate elaboration. The participants received a sheet of paper with the five questions, as well as oral instructions.

The first question was what the participants had done before they came to the experiment and how they had felt. The second question was whether the experiment had matched the participant's expectations. In the third and fourth questions the participants were asked to think back to the stories and to indicate which ones they liked/disliked most, and whether the stories reminded them of things that had happened in their own lives. The final question asked about any plans that participants had for the rest of the day and how they felt about them. The experimenter reassured the participants that their answers would be treated with the strictest confidentiality. The participants had 20 min to answer the questions, and were instructed to spend the same amount of time on each of the questions. When the time for one question was up, the experimenter told participants to move on to the next question.

Control group. The other half of the participants were told that the experiment dealt not only with the processing of pictures but also with the processing of words. They were given several sheets that each contained a different word task, and were told that they should try to complete as many of these tasks as

possible in the next 20 min. The first task contained a list of neutral words and participants had to explain the meaning of these words (e.g. "connect" means "join together"). The second task contained phrases, and participants had to identify words that were not correctly spelled given the context of the phrase ("a honey be"). The third task was to identify which word of a group of four was misspelled (investigation, *readilly*, examined, assuming). The fourth task comprised groups of words, and participants had to find the word that was closest in meaning to a word typed above the group (malaria: basement, fever, theatre, fruit, ocean, tune). No task contained trauma-related words.

Measures

Pleasantness and Arousal Ratings. These were the same as in Experiment 1.

Past Experience Questionnaire. Participants were screened for exclusion criteria with the same questionnaire as in Experiment 1.

Mood Ratings. On four different occasions during the experiment, participants rated how happy, angry, depressed and anxious they felt on scales from 0 (not at all) to 100 (extremely).

Memories and Thoughts Questionnaire. Participants received this questionnaire by mail one month after the experiment. It asks whether the participants had intrusive memories about the picture stories seen in the experiment in the week before the questionnaire was received, in the form of images, feelings, and dreams (e.g., a spontaneously occurring mental image of the cat that featured in one story). Participants indicated also how many thoughts about the experiment they had in the preceding week (e.g., a verbal reflection, such as "This cat looks like the one I saw in the psychology experiment"). The frequency of intrusive memories and thoughts was rated on a scale from 0 to 7 (labeled: never, once, twice, three to four times, about every other day, nearly every day, more often than once a day), with intrusive memory frequency being the sum of the frequency ratings for images, feelings and dreams, and intrusive thought frequency being the sum of all thoughts.

Procedure

The procedure was, except for the following points, identical to the one in Experiment 1. Participants completed the first Mood Rating after the Past Experience Questionnaire, and the second and third Mood Rating after each block of the picture stories. Subsequent to the third Mood Rating, participants conducted either the experimental or the control task, after which the perceptual priming task, the recognition task, and the fourth Mood Rating followed. At the end of the session, participants were informed that they would receive a questionnaire one month later and that a detailed explanation about the experiment would be sent to them once they had filled in and returned the questionnaire.

Data analysis

Perceptual priming task. Incremental identification rates and priming index (i.e., the difference between the primed and unprimed incremental identification rates) were calculated as in Experiment I. In order to establish whether perceptual priming occurred, incremental identification rates for primed and unprimed objects were compared in a 2×2 repeated measures ANOVA with perceptual priming (objects from picture stories versus distracter objects) as the within-in subject factor and experimental group (elaboration versus control) as the between-subject factor.

A 2×2 repeated measures ANOVA with story context ("traumatic" versus neutral) as the within-subject factor and group (elaboration group, control group) as the between-subject factor examined the degree of perceptual priming in the four experimental conditions. As the conditions were expected to influence perceptual priming in distinct ways, a significant interaction effect was expected, which was followed up by planned comparisons testing our specific hypotheses. First, we examined whether within the control group objects from "traumatic" stories were more strongly primed than objects from neutral stories (Hypothesis 1), using a one-tailed test as this was a replication from Experiment 1. Second, we tested whether the elaboration group showed less perceptual priming for objects from "traumatic" stories than the control group (Hypothesis 3).

Reexperiencing. A 2×2 repeated measures ANOVA with recollection type (reexperiencing versus thoughts) as the within-in subject factor and experimental group as the between-subject factor tested whether the

elaboration group had fewer reexperiencing symptoms, but not fewer thoughts about the experiment, than the control group (Hypothesis 4).

All participants with intrusive memories described that these were about one or two of the scenes that they found personally relevant, and that they had found the other scenes less disturbing. The hypothesis that perceptual priming enhances the probability of intrusive memories (Hypothesis 2) is only relevant for those scenes that are sufficiently "traumatic" to induce intrusions. We therefore calculated the priming index only for those objects that corresponded to the scenes that were reexperienced, and calculated Pearson correlations between this specific priming index and reexperiencing frequency. In order to rule out the possibility that an association between perceptual priming for stimuli from "traumatic" stories and reexperiencing was mediated by explicit memory, we performed a parallel correlation analysis for recognition sensitivity for neutral objects from stories linked to intrusive memories.

Effect size. As in Experiment 1, measures of effect size were computed as partial Eta squared and evaluated according to Cohen's system (1988).

Results

Validity of picture stories

As in Experiment 1, the "traumatic" picture stories were experienced as moderately to very unpleasant, $M = -6.86$, SD = 1.89, and generated moderate arousal, $M = 4.82$, SD = 2.37. The neutral picture stories were neither experienced as unpleasant or pleasant $M = .94$, SD = 1.38, nor as relaxing or activating, $M = -.34$, SD = 1.63. The "traumatic" picture stories were significantly more unpleasant, F (1, 90) = 1390.80, $p < .001$, ES = 93.9%, and arousing than the neutral picture stories, F (1, 90) = 385.93, $p < .001$, ES = 81.1%.

Perceptual priming task

In line with a general perceptual priming effect, objects from the picture stories had greater incremental identification rates than unprimed objects, F (1, 90) = 28.18, $p < .001$, ES = 23.8%. There was no main effect of experimental condition, F (1, 90) = .44, $p = .51$, ES = .5%, or interaction, F (1, 90) = 1.29, $p = .26$, ES = 1.4%. The mean incremental identification rate for primed objects was $M = .08$, SD = .14, and for unprimed objects $M = .01$, SD = .13.

The results for the priming index for objects from "traumatic" versus neutral stories are presented in Table 2. The ANOVA showed the expected interaction between story context and experimental condition, F (1, 90) = 6.23, $p = .014$, ES = 6.5%, and no main effects of story context, F (1, 90) = .00, $p = .983$, ES = 0%, and experimental condition, F (1, 90) = 1.29, $p = .258$, ES = 1.4%. The experimental group showed, as expected, less perceptual perceptual priming for objects from "traumatic" stories than the control group, F (1, 90) = 6.67, $p = .01$, ES = 6.9% (Hypothesis 3). The control group showed more perceptual priming for objects from "traumatic" stories than for objects from neutral stories, F (1, 90) = 3.18, $p = .04$, ES = 6.6% (Hypothesis 1).

Table 2
Perceptual priming for preceding objects from picture stories, Experiment 2

Story context	Experimental condition	Priming index M (SD)
"Traumatic"	Elaboration group ($n = 46$)	.03 (.19)
	Control group ($n = 46$)	.11 (.13)
Neutral	Elaboration group	.08 (.17)
	Control group	.06 (.18)

Priming is quantified by difference in incremental identification rate between primed and unprimed objects.

Table 3
Effect of experimental manipulation on subsequent memories of the stories: frequency of reexperiencing versus thoughts, Experiment 2

	Experimental condition	*M* (SD)
Reexperiencing (images, intrusive feelings, dreams)	Elaboration group ($n = 46$)	1.38 (1.89)
	Control group ($n = 46$)	1.89 (2.27)
Thoughts	Elaboration group	.83 (1.20)
	Control group	.61 (1.11)

Reexperiencing symptoms

The following analyses are based on the 88 participants who returned the Memories and Thoughts Questionnaire. The results are presented in Table 3. A significant main effect of the factor type of recollection (reexperiencing vs. thoughts) indicated that all participants reported more reexperiencing symptoms than thoughts about the picture stories, F (1, 86) = 25.74, $p < .001$, ES = 23%. There was no main effect for experimental condition, F (1, 86) = .20, $p = .658$. As expected, there was a significant interaction between recollection type and experimental condition, F (1, 86) = 4.15, $p = .045$, ES = 4.6%, indicating that the experimental condition had a differential effect on subsequent reexperiencing versus thoughts. Participants in the elaboration group reported relatively fewer reexperiencing symptoms, but not fewer thoughts than the control group.

In line with Hypothesis 2, the priming index for objects from scenes that were reexperienced was positively associated with the frequency of reexperiencing, in the control group, r (19) = .47, $p = .045$, as well as for all participants, r (35) = .38, $p = .024$. In contrast, recognition sensitivity was not correlated with subsequent intrusive memories, r (19) = −.17, $p = .131$ in the control group; and negatively correlated with reexperiencing symptoms when all participants with intrusions were considered, r (35) = −.40, $p = .017$.

Further analyses

Recognition task. As in Experiment 1, there was no effect of story context on recognition sensitivity and the only significant effect was a main effect of object importance, F (1, 90) = 124.67, $p < .001$, ES = 58.1%. Objects central to the gist of the story were better discriminated from new objects than preceding objects. As in Experiment 1, the only significant effect for response bias was that participants had more liberal response criterion for objects from the unpleasant picture stories than for neutral stories, F (1, 90) = 7.58, $p = .007$, ES = 7.8%.

Mood ratings. All Mood Ratings changed over the course of the experiment, happiness F (3, 86) = 53.43, $p < .001$, ES = 65.3%, anger F (3, 86) = 19.68, $p < .001$, ES = 41%, depression, F (3, 86) = 13.28, $p < .001$, ES = 31.9%, and anxiety, F (3, 86) = 21.65, $p < .001$, ES = 34.1%. There were no main effects or interactions with experimental condition, all $p > .630$.[3]

Discussion

As in Experiment 1, the control group showed greater perceptual priming for neutral objects from a traumatic event than for parallel objects from a neutral context. The enhanced perceptual priming effect was slightly less strong in Experiment 2 than in Experiment 1. One possible reason is that the interval between exposure to the picture stories and the perceptual priming test was longer in Experiment 2. Furthermore, half the participants in Experiment 1 were selected to be high in trait dissociation, whereas the sample of Experiment 2 comprised unselected participants. High trait dissociation was associated with stronger priming, and the priming index for the unselected sample in Experiment 2 was more similar to the low dissociation group in Experiment 1 than to the high dissociation group. This may have restricted the range and led to a somewhat smaller enhanced priming effect in Experiment 2.

[3]A full description of the results of the recognition task and the mood rating is available on request.

As in Experiment 1, the results of the recognition test suggested that the enhanced perceptual priming effect cannot be attributed to differences in explicit memory. There was no difference in recognition sensitivity for objects from "traumatic" and neutral stories. As in Experiment 1, participants had a more liberal response criterion for objects from "traumatic" stories, suggesting a greater sense of familiarity for these objects, which is in line with an implicit memory effect. Experiment 2 not only corroborated the findings of Experiment 1, but extended them by showing the expected association between enhanced perceptual priming and subsequent reexperiencing. This correlation could not be explained by an association between explicit memory and reexperiencing. These findings are in line with earlier research linking reexperiencing symptoms in PTSD to perceptual priming (Amir et al., 1996; Ehlers et al., 2006; Michael, Ehlers, & Halligan, 2005), and with theories of PTSD that highlight the importance of implicit memory representations (Bower & Sivers, 1998; Brewin, 2001; Ehlers & Clark, 2000; Siegel, 1995). The current study used a relatively simple measure of reexperiencing and future studies might wish to use more detailed measures of intrusive memories and their triggers (e.g., Holmes, Brewin, & Hennessy, 2004).

As expected, the elaboration group showed less perceptual priming for objects from "traumatic" stories than the control group. Experiment 2 also found the expected interaction between experimental condition and the way the stories in the experiment were remembered. In comparison to the control group, the elaboration group tended to have relatively fewer reexperiencing symptoms and more thoughts. Both findings are in line with the hypothesis that elaboration leads to an inhibition of cue-driven retrieval (Conway & Pleydell-Pearce, 2000; Ehlers & Clark, 2000), and with the efficacy of treatments designed to enhance elaboration of trauma memories in reducing reexperiencing symptoms (e.g., Ehlers et al., 2003; Hackmann et al., 2004). According to the autobiographical memory theory of Conway and Pleydell-Pearce (2000), memories that are poorly connected with other information of the autobiographical knowledge base are triggered easily by perceptual cues. However, easy triggering is inhibited for memories that are well embedded in the knowledge base and are preferably generated in response to cues (e.g. answering a question about a past event). The integration of specific memories into the knowledge base is further assumed to ensure that a memory is recognized as a memory and not confused with present experiences or other mental images, as well as to allow the development of autonoetic consciousness about the past. In view of this theory, one might assume that the elaboration condition reduced perceptual priming by inhibiting memory retrieval through perceptual cues. However, further research will be necessary to determine the processes by which elaboration affects perceptual priming and subsequent recollections.

In order to examine whether the experimental manipulation had a differential impact on the mood in which participants conducted the perceptual priming task, we monitored mood during the experiment. The mood of participants changed, as expected, over the experimental session. Importantly, however, the experimental condition did not influence mood. Hence, the differences in the perceptual priming task between the elaboration and control group do not appear to be mediated by differential effects of the experimental manipulation on mood.

General discussion

Two experimental analogue studies investigated perceptual priming for neutral stimuli that immediately preceded a traumatic event. Both studies consistently showed that such objects are more strongly primed than similar objects that occur in a neutral context. Experiment 2 further showed that the degree of perceptual priming was related to the frequency of reexperiencing symptoms.

The results parallel clinical observations that reexperiencing symptoms often appear to be triggered by perceptual cues that bear physical similarity to stimuli featuring in intrusive memories and that intrusive memories often represent stimuli that signaled the onset of the trauma (e.g., Ehlers et al., 2002; Hackmann et al., 2004).

The theoretical basis for the observed enhancement of perceptual priming in a traumatic context remains unclear. One possibility is that during trauma, people are more likely to engage in perceptual processing than during other experiences. This, in turn, may enhance perceptual priming. Perceptual priming, as already indicated by its name, relies heavily on perceptual operations and should therefore benefit from encoding styles favoring the encoding of perceptual information. In the present investigation, there was some indirect support for this hypothesis (Experiment 1). Participants reported more state dissociation during the "traumatic" compared to the neutral stories. Further, state dissociation correlated with the degree of perceptual priming for objects from "traumatic" stories.

The enhanced perceptual priming for stimuli from a "traumatic" context observed in the present experiments may be adaptive in response to traumatic situations. Enhanced perceptual priming may facilitate the early identification of cues that resemble those perceived shortly before and during the trauma, which could indicate renewed danger (warning signals, Ehlers et al., 2002; Hackmann et al., 2004). This proposed function of enhanced perceptual priming is similar to the assumed function of fear conditioning. Fear conditioning, a form of classical conditioning, occurs when anxiety becomes associated with a neutral (conditioned) stimulus (CS) due to pairing of that stimulus with an aversive (unconditioned) stimulus (US) that is inherently fear-provoking, such as a traumatic event. Fear conditioning is considered essential for survival, as it is thought to be responsible for the detection of reliable predictors of significant events and for the promotion of preparatory responses (e.g., Davey, 1987; Dawson & Shell, 1987; Öhman, 1986). Further, our experimental stimuli that occurred in a "traumatic" context could be considered as CSs that are likely to provoke a fear response. Research on conditioning and memory has revealed that CSs function as retrieval cues for activating the corresponding CS and US nodes in memory (Bouton & Moody, 2004). Thus, fear conditioning and enhanced perceptual priming may not just have a similar function, but conditioning may also contribute to the enhanced perceptual priming effect.

Although enhanced perceptual priming and fear conditioning may be considered in most contexts as adaptive responses, their inappropriate activation may be linked with pathological anxiety. For example, it has been shown that PTSD patients exhibit stronger acquisition and reduced extinction, as well as larger responses to unpaired cues in conditioning paradigms (Orr et al., 2000; Peri, Ben-Shakhar, Orr, & Shalev, 2000). Likewise, one may assume that people who develop PTSD after a trauma have particularly strong perceptual priming for stimuli associated with the trauma (Ehlers & Clark, 2000).

The current investigation had several limitations. First, the experiments used an analogue design and it remains unclear to what extent the results would generalize to traumatic events that would meet DSM-IV (American Psychiatric Association, 1994) criteria. Ethical considerations limit the induction of trauma in the laboratory. Participants rated the picture stories as moderately to strongly unpleasant, but nevertheless the stories remain relatively mild stressors compared to traumatic events. Similarly, it remains uncertain to what extent the reexperiencing symptoms that participants reported are comparable to reexperiencing in PTSD. The present experiments should therefore be interpreted in the context of emerging findings on enhanced perceptual priming in trauma survivors (e.g., Michael, Ehlers, & Halligan, 2005).

Second, the enhanced perceptual priming effect provides only a suitable explanation for intrusive memories in PTSD if it remains stable over time. This is likely to be the case, as many laboratory studies have demonstrated that visual priming is remarkably durable (Schacter, Chiu, & Ochsner, 1993), but to date it is unclear whether this applies equally to the enhancement of perceptual priming by traumatic context.

Third, it remains unclear whether the enhanced perceptual priming effect is specific to traumatic context. It is conceivable that an equally arousing positive emotional context would have the same effect, and that enhanced perceptual priming is also involved in cue-driven retrieval of extremely positive emotional, absorbing memories.

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Appendix. Contents of the picture stories

The eight "traumatic" stories show:

an execution
a woman being raped by a man
a man being drowned in a bath tub

a dog killing a man
a plane crash
a woman being strangled by a man
a warehouse owner being robbed and tortured
a man being stabbed and decapitated

The eight neutral stories show:
teenagers discussing basketball
a couple snuggling up in bed together
a nun welcoming a couple to a nursing home
a cat stealing its owner's sandwich
a house move
a woman making a telephone call
a man coming home and seeing his wife repairing a boot on the dining table
a worker washing himself at the end of his shift

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